Viktig informationsfusionsforskning i omvärlden 2006

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Sammanfattning

Denna rapport redovisar sammanfattningar av de forsknings- och tillämpningsartiklar inom området informationsfusion som bedömts som mest intressant under 2006. Förutom ren informationsfusion tas också angränsande forskningsområden upp i några fall. Rapporten innehåller också en bibliografi med artiklar som bedömts som intressanta men inte tillräckligt viktiga för att motivera en sammanfattning.

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Report title (In translation)

A survey of information fusion research in 2006

Abstract

This report collects some of the most important research articles dealing with information fusion and related subjects published during 2006.

Keywords

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Inledning

Den här rapporten är tänkt att ge en översiktlig bild av forskningen inom (främst) området informationsfusion i omvärlden under 2006. Den innehåller en bibliografi på över 100 forskningsartiklar som valts ut av oss som relevanta för försvarsmaktens framtida ledningssystemutveckling. Artiklarna kommer från konferenser och tidskrifter som vi vanligtvis bevakar. Vid urvalet har ämnesområdet informationsfusion getts en vid tolkning. Forskning som bedrivits vid FOI har medvetet inte tagits med i sammanställningen, inte heller har de artiklar som publicerats av doktorander finansierade av FOI tagits med.

De 27 mest intressanta artiklarna redovisas utförligare genom en kort sammanfattning av dem. Urvalet av artiklar har skett genom bedömningar av främst abstracts för samtliga artiklar. Sammanfattningarna är tänkta att vara en introduktion till artiklarna och hjälpa läsaren att avgöra om hela artikeln är värd att läsas. För de artiklar som vi inte skriver sammanfattningar om redovisar vi abstract, i förhoppningen att detta ska göra det lättare att hitta intressant material även här.

I sammanfattningarna har vi undvikit tekniska detaljer och istället fokuserat på idén och de möjliga tillämpningarna av den forskning som beskrivs i artikeln. Den målgrupp vi vill nå med rapporten är tekniskt intresserad personal i FM och FMV som arbetar med ledningssystemutveckling. Fler detaljer om samtliga artiklar kan fås genom att kontakta författarna, enklast genom att skicka e-post till ponsve@foi.se.

Sammanfattningar av särskilt utvalda artiklar

Detta kapitel innehåller sammanfattningar av de artiklar som vi bedömt vara särskilt intressanta för försvarsmaktens ledningssystemsutveckling. Varje artikel har getts ett eget avsnitt nedan i vilket vi först ger information om var artikeln är publicerad, därefter listas abstract från artikeln och slutligen ger en kort sammanfattning av det viktigaste i den.

Sammanfattningarna har delats in i olika kategorier, men eftersom många artiklar kan vara relevanta för flera av kategorierna uppmanar vi läsaren att åtminstone skumma även de avsnitt som den inte tycker är relevanta.

The Implications of Complex Adaptive Systems Theory for C2, Anne-Marie Grisogono , CCRTS 2006

Abstract: The study of Complex Adaptive Systems (CAS) has developed within a wide range of subject domains over the last couple of decades, spanning the biological sciences, economics, organisational science, public policy, environmental sciences, computer science, cognitive and social sciences, and lately, defence sciences. We have been researching how application of a CAS perspective to the most pressing and complex problems that defence faces can provide more effective tools and techniques to enable higher levels of success in dealing with these challenging problems. This approach has proved very fruitful and has generated insights that could lead to implementable and testable strategy options in a wide range of defence areas – from strategic policy, the capability development process, and defence enterprise management to the design and evolution of complex defence systems and the command and control of tactical to strategic levels of operations. In this paper we will focus on the implications of CAS theory for C2, drawing on the understanding we have developed of what it is possible to do in the face of complexity, how adaptive mechanisms arise spontaneously in complex systems, how we may recognise them and influence their operation to better align with our purposes, and how we may develop additional adaptive mechanisms to foster more effective outcomes. The CAS we will address include not just the complex networked systems within our own forces, but also those of our allies and adversaries, and those existing in the overall environment in which we operate. All these systems influence both what we are expected to do and what we are able to do, therefore understanding how the adaptive mechanisms already operating in them shape their behaviour and how to harness those mechanisms to our purposes is potentially a very valuable and powerful strategy.

Sammanfattning: Artikeln tar upp det relativt nya forskningsområdet komplexa adaptiva system och undersöker hur resultat från detta område kan anpassas till det militära området. Vid DSTO, Australiens motsvarighet till FOI, har det sedan några år bedrivits ett stort forskningsprojekt om detta. Motiveringen för att starta forskningsprojektet var både den ökade komplexiteten i de problem som mötte det australiensiska försvaret och de allt fler tekniska lösningar som föreslås som lösning på dem (RMA, NCW etc). Artikeln inleder med att definiera ett komplext adaptivt system. I korthet kan sägas att ett stort system som har krångliga samband mellan orsak och verkan och där de regler som gäller till synes ändras från dag till dag är komplext. För att systemet dessutom ska sägas vara adaptivt krävs det att det finns någon form av utvärdering ("fitness", jfr evolutionen) och att systemet på något sätt förändras så att fitnessen ökar. Många system i naturen är komplexa adaptiva system, och de uppvisar ett flertal positiva egenskaper: de verkar vara intelligenta, eftersom de utnyttjar de möjligheter till ökad fitness som uppstår. De återhämtar sig fort från skador och är robusta mot störningar. De är flexibla och "agile", d v s de prövar och byter nya strategier för att lösa problem. För militära ändamål kan man definiera både motståndarna (särskilt i OOTW-situationer) och sitt eget system som ett komplext adaptivt system. Australiensarna har framförallt studerat adaptivitet och föreslår flera olika sätt att använda detta konkret. Arbete pågår med att testa detta i praktiken. En mycket viktig egenskap hos ett komplext adaptivt system är dess fitness. Precis som för vanliga optimeringsproblem spelar det ingen roll hur bra algoritm man har för att lösa problemet om fitnessen är felaktig. Artikeln ger en mycket bra introduktion till området och väcker många intressanta tankar om hur teori och metoder från komplexa adaptiva system kan användas för ledningssystem. En av de kanske viktigaste lärdomarna från forskningsområdet är att även om ett system är komplicerat och ser ut att vara totalt oförutsägbart så kan man ändå påverka det till viss grad. Genom att modellera t ex en insats med flera olika motståndare som ett komplext adaptivt system kan vi lära oss om mer om vad som egentligen går att styra och förutse i systemet. I slutet av artikeln fokuserar författaren återigen på adaptivitet och påpekar att det finns en stark koppling mellan detta och uppdragstaktik: i uppdragstaktik formulerar man målet (d v s fitness-funktionen), men överlåter åt deltagarna att genom adaptivitet lösa uppgiften.

Taxonomic and Faceted Classification for Intelligent Tagging and Discovery, D E Lichtblau, Andrew W Trice, Steven P. Wartik, Proc CCRTS 2006

Abstract: The success of Net-Centric Operations and Warfare (NCOW) depends upon the ability of net-centric environment (NCE) users—both human and automated—to readily discover useful information and services. Effective discovery requires, in turn, good semantic metadata "tagging" (i.e., indexing the functions of the services). Good tagging reflects the contextual relationships among the discoverable artifacts. It derives its value from the soundness—and intuitiveness—of its underlying approach to information and services classification. Unfortunately, classification "soundness" is mostly in the eye of the beholder, particularly for services that can be deployed for many different purposes, and not all necessarily foreseen by their initial developers. Ultimately, therefore, what is needed for more rapid and effective tagging and discovery is a services classification approach that accommodates multiple perspectives as to what constitutes a natural and intuitive characterization, plus tools that enable NCE users to take advantage of these capabilities without being overwhelmed by the sheer multiplicity of different classification perspectives. This paper presents a proposed structure for the semantic metadata that we believe will facilitate service and information discovery in the NCE, and will easily accommodate use by intelligent agents.

Sammanfattning: Inom Department of Defense i USA är nyttjandet av tjänster enligt SOA (Service Oriented Architecture) en fastlagd väg för att förverkliga Network Centric Operations and Warfare (NCOW). Lichtblau et al hävdar i sin artikel att en förutsättning för att NCOW ska bli framgångsrikt är att tjänsterna är lätta att upptäcka. De framför argument för att sökning av tjänster kan stödjas genom strukturerad taggning och föreslår en lösning för hur man kan hantera taggning av stora mängder tjänster av användare från olika COIs (Community of Interest). Lösningen går ut på att tillåta taggning enligt flera taxonomier samtidigt, plus något de kallar "faceted classification". Med faceted classification menar de klassificering som svar på olika frågor. Frågor de identifierat är:

1. Who uses the service?
2. What does the service do?
3. On what does the service act?
4. To whom is the service generally directed?
5. Where is the service used?
6. When is the service used?
7. Why is the service used?

Som svar på några eller alla av dessa frågor taggas tjänsten enligt någon lämplig taxonomi. Det blir sedan lättare att hitta lämpliga tjänster när det går att söka enligt frågornas indelning.

Countering Terrorism through Information and Privacy Protection Technologies, Robert Popp, John Poindexter, IEEE Security & Privacy November/December 2006 (Vol. 4, No. 6) pp. 18-27

Abstract: Security and privacy aren't dichotomous or conflicting concerns--the solution lies in developing and integrating advanced information technologies for counterterrorism along with privacy-protection technologies to safeguard civil liberties. Coordinated policies can help bind the two to their intended use.

Sammanfattning: Detta papper tar upp såväl potentiella problem med skydd av personlig integritet som nyttan av av dataanalys för anti-terrorism. Pappret nämner speciellt skillnaderna mellan s k data mining för kommersiella ändamål och det författarna kallar dataanalys för anti-terrorism. Kommersiell data mining används t ex för att hitta mönster hos konsumenter för att

föreslå produkter för dem i webb-butiker, eller för att avgöra hur en reklamkampanj ska inriktas. Pappret påpekar att dessa metoder ofta inte går att använda rakt av för anti-terrorism, eftersom problemområdena är väsensskilda. T ex så kan man inte använda samplingsmetoder, eftersom samplingen förstör de förbindelser man är ute efter att hitta. Det finns också viktiga skillnader vad gäller vilken sorts mönster man letar efter i datamängden. Eftersom dataanalys för ant-terrorism är ett känsligt område är det också nödvändigt med mer mänsklig medverkan i analysprocessen än för kommersiell data mining. De metoder som författarna föreslår ska ses som ett stöd till analytikernas arbete, inte som ett automatiskt system. Författarna argumenterar för att det går att hitta spår av terroristverksamhet i diverse öppna datakällor: planering av ett terroristattentat förutsätter att människor kommunicerar och interagerar. För att upptäcka dessa spår måste ett flertal utmaningar lösas: man måste förstå hur spåren kan se ut, spåren måste upptäckas när de är dolda bland bruset som genereras av vanliga människors kommunikation och interaktion, den personliga integriteten hos allmänheten måste skyddas. Pappret tar upp ett flertal tekniker som är nödvändiga ingredienser i ett analyssystem, t ex verktyg för samarbete på distans, statistiska metoder för textanalys, metoder för att känna igen och analysera naturligt språk, översättning mellan olika språk, mönsterigenkänning. Att kunna modellera hypoteser om hur mönstren ser ut är viktigt. Ett mycket intressant resultat i pappret visar hur arbetsbelastningen för analytiker förändras om de får tillgång till relativt enkla datorhjälpmedel. Två grupper av analytiker fick arbeta med frågan "What is the threat of Al Qaeda's weapons of mass destruction capabilities to several cities in the US?". Gruppen som inte hade tillgång till IT-hjälpmedel ägnade endast 17% av sin tid åt själva analysen av materialet, medan huvuddelen av tiden gick åt till att sortera fram vilket material som var mest relevant. Den grupp som hade tillgång till kommersiella hjälpmedel kunde istället ägna 67% av sin tid åt analysarbetet. Pappret tar också upp ett exempel från förhör med fångar som använder lite mer avancerade/forskningsnära hjälpmedel, och ett exempel där tiden som krävdes för att analysera en stor mängd dokument kunde reduceras från 117 manår till 0,05 manår med hjälp av avancerade verktyg för statistiskt textanalys. Problemet med falsklarm är en viktig invändning mot användning av automatiska metoder för att hitta terrorister. Författarna påpekar detta och menar att det måste finnas mänskliga analytiker inblandade i processen, och jämför också med ubåtsjakt, där det enligt författarna också förekommer en stor mängd falsklarm som måste hanteras av mänskliga operatörer. Man påpekar också att domstolar måste vara inblandade och godkänna de bevis som tagits fram med hjälp av dataanalys innan någon åtgärd vidtas.

A Gaming Perspective on Command and Control, Joel Brynielsson.. PhD thesis, School of Computer Science and Communication, Royal Institute of Technology, 2006.

Abstract: In emergency management and in military operations, command and control comprises the collection of functions, systems and staff personnel that one or several executives draw on to arrive at decisions and seeing that these decisions are carried out. The large amount of available information coupled with modern computers and computer networks brings along the potential for making well-informed and quick decisions. Hence, decision-making is a central aspect in command and control, emphasizing an obvious need for development of adequate decision-supporting tools to be used in command and control centers. However, command and control takes place in a versatile environment, including both humans and artifacts, making the design of useful computer tools both challenging and multi-faceted. This thesis deals with preparatory action in command and control settings with a focus on the strategic properties of a situation, i.e., to aid commanders in their operational planning activities with the utmost goal of ensuring that strategic interaction occurs under the most favorable circumstances possible. The thesis highlights and investigates the common features of interaction by approaching them broadly using a gaming perspective, taking into account various forms of strategic interaction in command and control. This governing idea, the command and control gaming perspective, is considered an overall contribution of the thesis. Taking the gaming perspective, it turns out that the area ought to be approached from several research directions. In particular, the persistent gap between theory and applications can be bridged by approaching the command and control gaming perspective using both an applied and a theoretical research direction. On the one hand, the area of game theory in

conjunction with research findings stemming from artificial intelligence need to be modified to be of use in applied command and control settings. On the other hand, existing games and simulations need to be adapted further to take theoretical game models into account. Results include the following points: (1) classification of information with proposed measurements for a piece of information's precision, fitness for purpose and expected benefit, (2) identification of decision help and decision analysis as the two main directions for development of computerized tools in support of command and control, (3) development and implementation of a rule based algorithm for map based decision analysis, (4) construction of an open source generic simulation environment to support command and control microworld research, (5) development of a generic tool for prediction of forthcoming troop movements using an algorithm stemming from particle filtering, (6) a non-linear multi-attribute utility function intended to take prevailing cognitive decision-making models into account, and (7) a framework based on game theory and influence diagrams to be used for command and control situation awareness enhancements. Field evaluations in cooperation with military commanders as well as game-theoretic computer experiments are presented in support of the results.
Sammanfattning: I denna avhandling förklaras hur spelteorin kan användas i lednings- och beslutsstödsammanhang. Spelteorin är ett sätt att beskriva resonerande om andras handlingar när man fattar beslut. Så fort man får en mekanism som handlar om resonerande om resonerande har man spelteoretiskt problem. Ett spel består av *strategier* som varje av spelare har, regler för ordningen hur strategierna väljs, informationsunderlaget och nyttan (rankningen av utfall, d.v.s. vilka utfall föredras framför vilka utfall). Ett av huvuddragen av spelteorin är att bästa draget inte alltid kan härledas från en optimering.

Inbäddade simuleringar anser författaren är en viktig del av framtida lednings- och beslutsstödssystem. Både simuleringar och spel har använts av militära beslutsfattare sedan flera tusen år sedan. Givet att man har en modell som återspeglar de viktigaste egenskaper av ett verkligt system och situationsbeskrivningen kan man göra ”vad-händer-om” analyser. Dagens teknologi erbjuder datorstöd som till exempel GECCO. Skillnaden mellan spel och simuleringar är att spelteoretiska resonemanget inkluderar strategiska interaktioner mellan handlingar av olika parter och osäkerheten på hur spelarna kommer att agera. I (inbyggda) simuleringar anges ett besluts alternativ eller en sekvens av beslutsalternativ (en strategi) som fixa och simulerar fram utfall. Å andra sidan kan spelandet (oavsett om det är datoriserat eller inte) då spelet väl är slutfört betraktas som en simulering som leder till en förbättrad förståelse av en (simulerad) situation. Ett exempel är krigsspelandet innan man genomför insatser. I avhandlingens förord går författaren igenom olika typer av speluträckning (mixad strategi, bästa respons, Nashjämvikt och informationsmängd) och avslutar med ett exempel på hur spelteorin skulle kunna användas i ett taktiskt invasionsscenario.

Beslutsstöd

Operator in the Loop? Adaptive decision support for military air missions, Rob J Cottrell, Dave G Dixon, Tom Hope, Robert M Taylor, Proc HCI 2006
Abstract: Military decision makers must make timely decisions under conditions of high stress. Recent advances in decision support technology offer the opportunity to improve operator decision effectiveness through real-time processing of mission data to offer consistent, timely advice. Applied properly, decision support technology will enable human decision makers to take on roles that no single person could fulfill unaided. To realize this vision, decision support systems must encode the tactical knowledge and reasoning processes of the personnel they support. This development will challenge our traditional concepts of human-computer interaction, posing complex problems that demand novel solutions. This paper will consider two key issues – 'Adaptation' and 'Critiquing', as they apply to decision support for military air missions involving ground attack or reconnaissance roles. The need for adaptation stems from the dynamic nature of modern military operations, with the ability to tactically re-plan and re-prioritize while maintaining strategic objectives being of paramount importance. The need for critiquing stems

from recognition of the fundamental limits applying to decision support systems - even comprehensive systems will be limited by knowledge-base constraints and by variations in the prevailing decision context which can potentially affect decision correctness. Thus there is a need for human operators to augment system behavior, bringing their inevitably greater understanding of the mission – or decision - context to bear. For effective critiquing, the Decision Support System (DSS) needs to be transparent such that an operator can easily discover why particular advice was offered. These issues will be explored with specific reference to ongoing work in the development of an Adaptive Decision Support System (ADSS) for military air missions.

Sammanfattning: Det finns många faktorer som påverkar nyttan av ett beslutsstödssystem. Cottrell et al. beskriver två idéer för att hantera problem kring automationsnivå och systemtilltro i ett ruttplaneringsverktyg för piloter och operatörer av UAVer.

Den första idén, *adaptation*, bygger på att ha ett system som anpassar automationsnivån beroende på vilken situation piloten/operatören befinner sig i. En för piloten pressad situation kan kräva att systemet tar större ansvar och agerar mer självständigt. Hur pressad situationen är kan avgöras dels genom att analysera den taktiska situationen (t ex beräkna mängden hot), dels genom att observera pilotens agerande och/eller fysiska status. Ramarna inom vilka systemet kan agera i ett mer autonomt tillstånd bestäms innan uppdraget påbörjats. Operatören sätter värden på en mängd parametrar och avgör vilka som systemet kan få förändra i ett senare skede. Parametrarna aggregeras också till tre hög-nivå-parameterar, *survivability*, *effectivness* och *timeliness*, vilka kan användas av operatören för att styra ruttplaneringen utan att behöva gå in på detaljstyrning.

Den andra idén som presenteras bygger på s k *critiquing*, där system och operatör tillåts ifrågasätta varandras agerande. Om ett ruttförslag som genererats av systemet verkar ologiskt för operatören kan denne kritisera förslaget. Systemet presenterar då motiven för att förslaget ser ut som det gör och operatören kan avgöra om det fortfarande verkar orimligt. På motsvarande sätt ska sedan systemet kunna poängsätta operatörens planeringsförslag. Det framgår inte av artikeln om critiquing har implementerats i något testsystem än.

Cognitive complexities impacting army intelligence analysis, Pfautz, J., Fichtl, T., Guarino, S., Carlson, E., Powell, G., & Roth, E., Proceedings of the Human Factors and Ergonomics Society 50th annual meeting, 2006

Abstract: The primary goal of this effort was to understand the problems faced by military intelligence analysis personnel as well as how, and to what degree, the identification of these problems could guide the development of computational support systems. To develop this understanding, we performed a literature review, knowledge elicitation interviews and a cognitive task analysis (CTA) in the domain of Army Intelligence Analysis at the Brigade Combat Team. This effort consisted of identifying: (1) the major functions or cognitive tasks entailed in Army Intelligence Analysis; and (2) the complexities in the domain that pose challenges to performance of these cognitive tasks. Identifying the cognitive tasks and the challenges faced in performing those tasks provided a basis for determining opportunities for more effective support of human information processing and decision-making. In this paper, we document selected results of this analysis effort.

Sammanfattning: Denna artikel handlar om hur man kan hantera komplexitet i underrättelseanalys för armé. Författarna studerar underrättelseprocessen på brigadnivå bl a genom att genomföra en kognitiv uppgiftsanalys. Första steget var att undersöka standardprocessen för underrättelsehantering som den beskrivs i doktriner. Härnäst identifierade man komplexiteter i riktiga situationer som orsakade flaskhalsar i analysarbetet. Detta gjordes med hjälp av domänexperter. Bland de viktiga faktorer som identifierades i pappret kan nämnas **a priori information, formulation of information needs, information context, reasoning about time and space, the "open world" of events, adversary behaviors, the distributed nature of**

intelligence analysis, demands of the operational environment, och **limitations of human processing.**
Författarna påpekar två viktiga faktorer som skiljer arméunderrättelseanalys från andra komplexa domäner:

- brist på domänerfarenhet. Jämför med en operatör i ett kraftverk eller en kirurg, som har mycket bättre mentala modeller över vad de gör. Underrättelseanalytiker har en god allmän förståelse för domänen, men saknar specifik kunskap om en viss fiende eller ett visst område
- det faktum att systemet är distribuerat. Analytikerna har inte direkt tillgång till rådata, som kraftverksoperatören och kirurgen har. Risken för missförstånd när informationen ska kommuniceras är hög.

Författarna efterlyser ett system som gör det möjligt att effektivt kommunicera kontextuell information upp och ner i beslutshierarkin för att göra det möjliga att uppnå en gemensam lägesförståelse.

Parsimonious Analogical Reasoning for Smart Decision Support in Network-enabled Environments: Managing Situational Awareness, Panos Louvieris, Andreas Gregoriades, Natasha Mashanovich, Gareth White, Christos Papathanassiou, Proc. International Command and Control Research Symposium (ICCRTS 2006)
Abstract: How information is managed and exploited to support commanders' intuitive decision making during the execution of a plan is a key consideration in the development of a true networked enabled capability (NEC). While the benefits of NEC are laudable i.e. better networks, better information sharing and situational awareness, better decisions, better actions and better effects, commanders and their staff are nevertheless faced with an overwhelming amount of data; in practice, this can often lead to inconsistent perspectives and tempo stagnation impeding decision and operational effectiveness. Therefore reducing the information volume requirement and servicing commanders' critical information requirements (CCIRs) through parsimonious information fusion is fundamental to maintaining situational awareness (SA) in the battlespace and achieving decision effectiveness. This paper outlines and demonstrates an analogical reasoning approach for smart decision support in NEC which employs soft Case Based Reasoning (CBR) techniques incorporating Critical Success Factors (CSFs). The effectiveness of this approach is illustrated using a war-gaming case study implemented on a Computer Generated Forces (CGF) test-bed.

Sammanfattning: Den kända forskaren Mica Endsleys uppfattning att situationsförståelsen kraftigt förbättras genom reduktion och fusion av en allt för stor mängd visualiserad information och genom att få användaren att fokusera på den viktigaste informationen adresseras. Begreppet Critical Success Factors (CSF) omnämns som det begränsade antal faktorer som är de viktigaste för lyckat utförande av en uppgift, och utifrån dem kan man formulera Commanders' Critical Information Requirements (CCIR). Enligt Kleins beslutsteori jämför en expert omedvetet ett aktuellt fall mot de han tidigare varit med om, känner igen det mest likartade, och agerar utifrån hans sätt att agera i detta, snarare an att utvärdera ett antal handlingsalternativ. Case Based Reasining (CBR, fallbaserat lärande. Se "CBR" på Wikipedia) formaliserar sådant resonerande i faserna: Retrieval, Reuse, Revise, Review and Retain.

I artikeln används CBR genom att olika karaktäristika (features) som identifierats i tidigare inträffade scenarion lagras i en Case-databas genom att modellera de olika karaktäristikas inbördes relationer i form av en ontologi. Denna bryts därefter ner till en mer lätthanterlig "vektor" av karaktäristika. Uppfattade karaktäristika för ett aktuellt scenario jämförs så med de hos de lagrade scenariona med en metod för likhets- (eller mera korrekt, närhets-) uppskattningar (K-nearest Neighbourhood metoden är den som används i artikeln) varpå det scenario som mest påminner om det aktuella presenteras. För varje scenario har också deras identifierade CSF lagrats (var och en

representerade i form av struktur och vikter i ett s.k. Bayesianskt Nätverk), vilka presenteras för det mest snarlika scenariot.

Metoden illustreras med ett exempel där egen trupp efter en attack följt av en minröjningsinsats skall tränga igenom ett minfält som försvaras av fientlig trupp. CSF är i exemplet: Relativa styrkeförhållandet, Logistikläge samt Rörlighet. Exemplet är väpnad strid, men CBR är en generell metod, varför metodiken torde kunna användas även vid andra typer av insatser. Idén med CBR är att formalisera sökandet av analogier i en erfarenhetsdatabas genom att matematiskt hitta likheter mellan olika avgränsade delkomponenter i erfarenhetsscenarierna och motsvarande i aktuellt scenario. Problemet ”stjälps över” på hur dessa ”likheter” skall beräknas, och viktas – vissa delkomponenter i ett scenario är ofta viktigare för dess utveckling än andra.

Preventing Knowledge Transfer Errors: Probabilistic Decision Support Systems Through the Users' Eyes, Hermina J.M. Tabachneck-Schijf and Petra L. Geenen, The Fourth Bayesian Modelling Applications Workshop during UAI 2006

Abstract: Development and use of probabilistic decision support systems benefit by a good communication between the developer on the one hand, and the user and the domain expert on the other hand. Communication is difficult because large differences in training and experience exist between the two. This necessitates user-centered design of the representations used in this communica tion, and attention to the translation of user terms to model terms. A systematic approach to developing user-centered representations and pre- venting knowledge transfer errors is outlined in this paper. We demonstrate how five heuristic guidelines can be fruitfully applied in different developer-user interaction situations in different phases of decision-support system construction.

Sammanfattning: Den här artikeln behandlar de svårigheter som uppstår vid skapandet och användandet av bayesianska nätverk i expertsystem. Orsaken till svårigheterna är de stora kunskapsskillnader som finns mellan mjukvaruutvecklaren å sin sida och domänexpert och användare å sin sida. Utvecklaren är antagligen expert på sannolikhetslära men har enbart ytlig förståelse för begreppen inom problemdomänen. För användaren och experten råder det omvända. Detta gap gör att det finns risk för att kunskap modelleras felaktigt och att modellerna används på ett felaktigt sätt.

För att råda bot på dessa problem presenterar författarna fem heuristiska rikitlinjer som man bör följa för att minimera riskerna för fel:

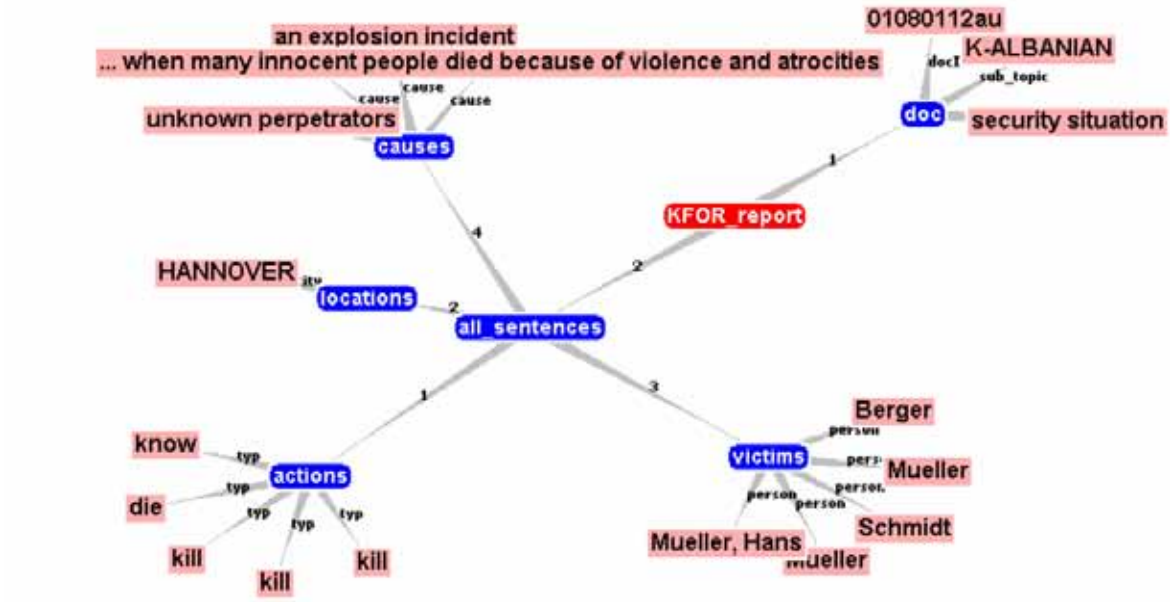
1. Bevara precision. När experten ser begreppen i nätverket mappar han/hon dessa mot sin begreppsapparat som i regel är betydligt mer imprecis. Därför måste tid ägnas åt att formulera om begrepp så att experten och utvecklaren får en gemensam förståelse med delad uppfattning om precision.
2. Användarkompatibilitet. Se till att använda begrepp matchar användarens mentala modeller, bl a genom att använda rätt begreppsapparat.
3. Naturligt språk. Använd i så hög grad som möjligt språk som alla kan förstå. Undvik t ex matematiska begrepp.
4. Osynlig teknologi. Göm matematiken för användaren och ersätt om nödvändigt med mer intuitiva och vardagliga begrepp.
5. Effektivt system. Gör systemet så snabb som möjligt. Användarna har som regel ont om tid och ett effektivt beslutsstöd kommer att användas mer.

Författarna exemplifierar sina fem principer i den medicinska domänen. De identifierar också fem kunskapsöverföringfaser som uppkommer vi skapandet och användandet av expertsystem och där de heuristiska riktlinjerna bör användas.

Navigation through the Meaning Space of HUMINT Reports, M Hecking, Proc 11th ICCRTS 2006

Abstract: The new deployments of the German Federal Armed Forces cause the necessity to analyze large quantities of Human Intelligence (HUMINT) reports. These reports are characterized by a large topical and linguistic variety. Therefore, they are good candidates for applying natural language processing techniques. In this paper, an approach to realize a graphical navigation through the meaning of HUMINT reports is presented. This meaning space navigation is realized as a graphically navigatable Entity Action-Network and is part of the ZENON project. In this project an information extraction approach is used for the (partial) content analysis of English HUMINT reports from the KFOR (Kosovo Force) deployment of the Bundeswehr. The information about the actions and named entities are identified from each sentence and the content of the sentences is represented in formal structures. These structures can be combined and presented in the network. After a short introduction, the information extraction as an approach to process natural language and the ZENON project are explained. In the main part of the paper, the navigation through the meaning space of HUMINT reports is described in detail. Different techniques for doing this are presented. The Information Extraction Presentation System is used to realize the Entity-Action-Network. This presentation system is introduced and various examples are given.

Sammanfattning: Artikeln beskriver pågående arbete med ZENON-projektet på FGAN/FKIE. Projektet bygger på resultat från ett tidigare projekt, SOKRATES, som har utvecklat tekniker för automatisk informationsextraktion från dokument i fritext. Informationsextraktionen utnyttjar metoder från Natural Language Processing för att översätta fritext till semantiskt väldefinierade (formella) strukturer uttryckta i XML. I dessa strukturer är aktörer identifierade, tid och plats markerade, och händelser kategoriserade. ZENON-projektet använder dessa tekniker för att extrahera information från HUMINT-rapporter från Kosovo. Informationen kombineras och visualiseras sedan som Entity-Action-nätverk i en nyutvecklad modul kallad IEPS (Information Extraction and Processing System). Syftet är att informationen från HUMINT-rapporterna ska gå snabbare att ta till sig när man kan kombinera kortfattad information i konceptform från flera rapporter och visualisera den i ett interaktivt verktyg (se Figur 1).



Figur 1 Visualisering i IEPS av extraherad information från en HUMINT-rapport.

A Survey of Web Information Extraction Systems, Chia-Hui Chang, Mohammed Kayed, Moheb Ramzy Girgis, Khaled F. Shaalan, IEEE Transactions on Knowledge and Data Engineering, 10(18):1411-1428, October 2006.
Abstract: The Internet presents a huge amount of useful information which is usually formatted for its users, which makes it difficult to extract relevant data from various sources. Therefore, the availability of robust, flexible Information Extraction (IE) systems that transform the Web pages into program-friendly structures such as a relational database will become a great necessity. Although many approaches for data extraction from Web pages have been developed, there has been limited effort to compare such tools. Unfortunately, in only a few cases can the results generated by distinct tools be directly compared since the addressed extraction tasks are different. This paper surveys the major Web data extraction approaches and compares them in three dimensions: the task domain, the automation degree, and the techniques used. The criteria of the first dimension explain why an IE system fails to handle some Web sites of particular structures. The criteria of the second dimension classify IE systems based on the techniques used. The criteria of the third dimension measure the degree of automation for IE systems. We believe these criteria provide qualitatively measures to evaluate various IE approaches.

Sammanfattning: Denna tämligen tekniska översiktsartikel listar och bedömer att antal verktyg för Information Extraction (IE), ofta kallade Extractors eller Wrappers, från stora mängder semistrukturerade textdokument (här websidor på Internet). Det vill säga verktyg som omvandlar innehållet i dokumenten till strukturerad information. Bedömningen görs utifrån tre huvuddimensioner: Svårighetsgrad på uppgiften verktyget försöker lösa (såsom att kunna tolka den strukturinformation som HTML- och XML-taggar o.dyl. utgör i semistrukturerad text), verktygets automatiseringsgrad (såsom i vilken utsträckning användaren måste vara med för att skapa urvalsregler, eller på annat sätt lära upp verktygets förmåga), samt vilken eller vilka tekniker och algoritmer verktyget bygger på. Andra egenskaper nämns också, såsom eventuell tillgänglighet till ett API som gör programmet anropbart eller inbäddbart i andra informationssystem.

Generellt sett innehåller artikeln en både bred och detaljerad genomgång av åtskilliga varianter av IE-verktyg betraktade och jämförda ur många intressanta synvinklar, vilket gör den svårrefererbar här. Det relaterade området ”Information Retrieval”, dit verktyg såsom exempelvis Autonomy hör, (eller för den delen ”Content Management Systems”, dit exempelvis Documentum hör), tas inte upp i artikeln som har ett rent IE-fokus.

Högre nivåers informationsfusion

Pedigree Information for Enhanced Situation and Threat Assessment, Marion G. Ceruti, Adam Ashenfelter, Richard Brooks, Genshe Chen, Subrata Das, Gary Raven, Moises Sudit, and Edward Wright, Proc 9th Int Conf Information Fusion, Paper 43, 2006.
Abstract: This paper describes how pedigree is used to support and enhance situation and threat assessment. It is based on the findings of the technology group of the Data Fusion Levels Two and Three Workshop sponsored by the Office of Naval Research held in Arlington, VA from 15-18 Nov. 2005. It identifies areas that need improvement in situation assessment and threat assessment, such as interoperability, automation, pedigree management, system usability, reliability, and uncertainty. The concept of pedigree must include "standard" metadata, lineage, plus a computational model of the quality of the information. The system must automatically propagate changes and update to derived products when source information or sourcepedigree information changes. Several other processes must be automated: generate pedigree, identify and auto fill gaps, fuse pedigree, update pedigree, display of information quality and confidence. The paper concludes with suggestions for future research and development.

Sammanfattning: Den här artikeln är ett resultat av ett grupparbete på en workshop organiserad av Office of Naval Research med syfte att undersöka status och problem kring datafusion på nivå 2 och 3, dvs situations- och hotanalys. Fokus är på det som kallas *pedigree*-metadata, data som beskriver en instans ursprung och historia (”pedigree” betyder stamtavla). Pedigree-metadata är tänkt att möjliggöra bedömning av trovärdigheten hos information samt tydliggöra relationer mellan olika informationsinstanser. Om någon parameter hos en instans förändras ska pedigree-metadata kunna användas för att propagera förändringen till andra instanser som bygger på samma information.

I artikeln beskrivs två sätt att inkorporera trovärdighet av information i högre nivåers fusion. Det ena är att integrera trovärdigheten med osäkerhetsmått. En säker observation från en källa med låg trovärdighet kan då jämföras med en osäker observation från en källa med hög trovärdighet. Det andra sättet är att hantera trovärdigheten separat från osäkerhetsmåtten. Det blir då upp till analytikern att göra tolkningar vid behov.

Artikelförfattarna förutspår att bättre hantering av pedigree-metadata (en standardisering förespråkas) kommer att leda till att nivåerna i datafusionsprocessen kan närma sig varandra. En förändring hos indata på nivå 0 skulle automatiskt kunna få korrekt effekt på t ex nivå 3. Pedigree-metadata skulle också kunna användas för att tolka s k negativ information (en sensor som rapporterar att den vid en viss tidpunkt *inte* ser fienden), genom att planen för sensorallokeringen hanteras som pedigree-metadata.

Role of Meta-Information in C2 Decision-Support Systems, J Pfautz, Emilie Roth, Ann Bisantz, Gina Thomas-Meyers, James Llinas, Adam Fouse, Proc. Command and Control Research Symposium (CCRTS 2006).
Abstract: Command and control (C2) in complex, dynamic, high-risk warfighting environments is clearly challenging, particularly because of the increasing complexity of available technology for processing and presenting information. Commanders need to understand and act on large volumes of information from a variety of sources and are particularly challenged by the need to reason about the qualifiers of that information, which we will refer to as meta-information (e.g., uncertainty, recency, pedigree). We have explored the role of meta-information in C2 using Cognitive Task Analysis (CTA) techniques to identify when and how, in current practice, human interaction with meta-information impacts decision-making, especially when that decision-making is supported by automation. Too often critical meta-information is not processed, ineffectively displayed, or not displayed at all in existing C2 decision support systems. The result of our analyses is a number of design recommendations for C2 decision-support systems and guidelines for identifying and recognizing the need for meta-information processing and display. In this paper, we present the results of our analyses and discuss their implications with respect to the design of human-system interfaces and the development of computational information processing methods.

Sammanfattning: Här beskrivs olika aspekter på metainformation. Metainformation kan enklast sägas vara information som beskriver information. Först diskuteras en av de viktigaste typerna av metainformationen: osäkerhetsuppskattningen av den egentliga informationen, och på vilket sätt denna osäkerhet kan beskrivas. Många olika sätt att grafiskt beskriva osäkerheter av olika slag i lednings- och beslutsstödssystem har prövats med varierande framgång. Författarna diskuterar olika beslutsfattares behov, tolkningsmöjligheter och tolkningssvårigheter av metainformation. De använder Cognitive Systems Engineering, CSE, i ett försök att studera metainformationens inverkan på beslutsfattande. Man studerar det i olika stödsystem för exempelvis planering av underrättelseinhämtning, sensorstyrning, och insatser vid naturkatastrofer. Man diskuterar vidare olika aspekter av begreppen ”data”, ”metadata”, ”information” och ”metainformation”, och listar olika typer av metainformation som förekommer i de olika informationsdomäner som förekommer i C2-system. Vad som kan definieras som information respektive metainformation är till stor

utsträckning situationsberoende. Slutligen konstaterar man att den metainformation som man vanligtvis visualiserar i C2-system är informationsosäkerheten, medan jämförelsevis litet är gjort avseende mer generella metoder för att visualisera eller på annat sätt förmedla metainformation.

Situational Awareness Object (SAO), A Simple, Yet Powerful Tool for Operational C2 Systems, Michael Anhalt, Proc. Command and Control Research Symposium (CCRTS 2006)
Abstract: The U. S. Joint Forces Command (USJFCOM), J9 Modeling and Simulation (M&S) Support Team advanced the capability of distributed simulation in support of Urban Resolve 05 (UR05), a collaborative effort conducted by USJFCOM and the Institute for Defense Analyses (IDA). Using real-world data, the scenarios in UR05 realistically replicated current operations and situations faced by warfighters in Baghdad. Experiment subjects use Situational Awareness Objects (SAOs) to share their awareness of the battlespace regarding activities of the adversaries, blue forces and civilian population. SAOs are logged and support real-time, postexperiment evaluation and comprehensive after-action reviews. Throughout each JUO experiment, the SAOs structure evolved to include new options that were based on the operator's needs. The benefit of SAOs is that they are easy to create and modify to fit varied operational missions. They are shared instantly among operators with access to the database and they are displayed on the terrain map as symbolic objects. SAOs contain the author's identification, location coordinates, and time created or modified, SAO category, player's confidence level, free-text comments, associated tracks and the ability to attach graphics and text files to the object. USJFCOM's success in using SAOs to enable the JUO series of experiments and the enthusiasm and innovation that operators show in using them, indicates this simple, yet powerful tool would be useful if implemented in various operational C2 systems.

Sammanfattning: I denna artikel presenteras en metod att vid en stab gruppera samman relaterad lägesinformation i så kallade Situational Awareness Objects (SAO). Idén realiserades som experiment vid Urban Resolve -04 och -05. Bilder, filer, fritext, sensorspår, subjektiva lägesbedömningar, länkar till andra SAO m.m. som av en operatör alla anses anknyta till en specifik situation eller objekt samlas i ett informations”paket” för enkel befordran och bearbetning mellan medarbetare. Informationen kan beskriva såväl eget och bedömt fientligt läge som civilläge. SAO kan visas på en lägeskarta då de är associerade med en viss plats. Endast vissa SAO – kategorier kan visualiseras utifrån inställningar av olika filter. Möjlighet finns att snabbt bygga ett SAO utifrån mallar genom att i en ”SAO-editor” välja olika vanligt förekommande komponenter och primitiver av SAO, och komplettera dem med exempelvis fritext eller bilder. Detta var i experimentet en viktig framgångsfaktor vilket uppmuntrade och underlättade skapandet av SAO. SAO kan loggas och kan enkelt i efterhand användas vid lessons-learned briefningar. Regler för hur skapande, underhållande, och avslutande – processen för ett SAO skall se ut nämns i slutet, men beskrivs inte i detalj. Ej heller den informationsfusion som måste till för att effektivt associera relaterade SAO när deras mängd börjar bli ohanterligt stor, och då deras informationsinnehåll är mer eller mindre överlappande.

Effective Behavioral Modeling and Prediction Even When Few Exemplars are Available, Terrance Goan, Neelakantan Kartha, Ryan Kaneshiro, Proc. SPIE Vol. 6235, Signal Processing, Sensor Fusion, and Target Recognition XV, 623511, May 17, 2006.
Abstract: While great progress has been made in the lowest levels of data fusion, practical advances in behavior modeling and prediction remain elusive. The most critical limitation of existing approaches is their inability to support the required knowledge modeling and continuing refinement under realistic constraints (e.g., few historic exemplars, the lack of knowledge engineering support, and the need for rapid system deployment). This paper reports on our ongoing efforts to develop Propheteer, a system which will address these shortcomings through two primary techniques. First, with Propheteer we abandon the typical consensus-driven modeling approaches that involve infrequent group decision making sessions in favor of an approach that solicits asynchronous knowledge contributions (in the form of alternative future scenarios and

indicators) without burdening the user with endless certainty or probability estimates. Second, we enable knowledge contributions by personnel beyond the typical core decision making group, thereby casting light on blind spots, mitigating human biases, and helping maintain the currency of the developed behavior models. We conclude with a discussion of the many lessons learned in the development of our prototype Propheteer system.

Sammanfattning: Verktyget Propheteer beskrivs. Systemets syfte är att tillhandahålla förvarningar om framträdande hot alternativt möjligheter. Olika svårigheter högnivåinformationsfusionssystem ställs inför då de skall börja användas skarpt beskrivs. Exempelvis användares ovilja att tillföra information och kunskap till systemet för det kollektivas bästa om de själva inte ser att de har någon snar nytta av det. Även problematiken med ”grupptänkande” som kan uppstå kommenteras flera gånger, man leds omedvetet av andras åsikter och får svårt att tänka fritt, vilket kan leda till ”blinda fläckar” i omvärldsanalysen. Det beskrivna verktyget sägs vara ett försöka att minska dessa risker och en möjlighet att utnyttja ett kollektivs samlade breda kunskap och vidsyn snarare än ett fåtal experters kunskap. Experter kan tendera att fastna inom sina omrården där deras kunskap förvisso är stor, men missa "mellanliggande" viktiga områden.

Propheteer i sig är ett verktyg för ett antal medarbetares kollektiva uppbyggande av kausala nätverk (liknande ett förenklat Bayesianskt nätverk) med s.k. indikatorer som noder. Händelsemallar och typiska kausala relationsmönster mellan dessa (i princip ontologier) finns lagrade i ett arkiv och dessa kan instantieras för ett nytt fall som skall studeras. Detta för att återutnyttja existerande kunskap om typiska händelsers relationer. Observerade händelser påverkar ”signalstyrkan” i lövnoderna längst ut i nätverket som sedan kan trigga mellanliggande noder. Dessa motsvarar följdhändelser som typiskt inträffar då de händelser som representeras av lövnoderna har inträffat. Högst upp i nätverket finns den ”rotnod” vars motsvarande händelse är den man vill få förvarning om. Medarbetare i systemet kan prenumerera på information om att förändringar inträffat i någon nod vederbörande är intresserad av. Artikeln avslutas med en informativ genomgång av andra forskares relaterade arbeten.

Reasoning about situations in the early post-disaster response environment, Galina L. Rogova, Peter D. Scott, Carlos Lollett, and Rashmi Mudiyanur, in *Proceedings of the 9th International Conference on Information Fusion,* Paper 211, 2006,.

Abstract: The purpose of situation and impact assessment is to infer and approximate the critical characteristics of the environment in relation to the particular goals, capabilities and policies of the decision makers. The process of situation and impact assessment involves dynamic generation of hypotheses about the states of the environment and evaluation of their plausibility via reasoning about situational items, their aggregates at different levels of granularity, relationships between them, and their behavior within a specific context. This paper addresses the problem of reasoning for situation and impact assessment to support early-phase crisis management. Special attention is paid to “inference for best explanation” aimed at discovery of the underlying causes of observed situational items and their behavior, an important component of situation and impact assessment. The presented method of discovery of underlying causes is illustrated by the discovery of an unreported HAZMAT incident within an early-phase earthquake response scenario.

Sammanfattning: I detta konferensbidrag redovisar Galina Rogova m.fl. (Univ. Buffalo, USA) metodik för att utföra situationsbedömning och “impact”-bedömning vid krishantering. Metodik syftar till att sluta sig till och approximera karakteristiken hos kritiska händelser i omgivningen i relation till beslutfattarens egna mål. En dynamisk lägesbild skapas genom att analysera spatiala och temporala relationer mellan händelser och aggregerade händelser på olika aggregeringsnivåer och deras dynamik inom ramen för den aktuella situationen. Speciellt uppmärksamhet ägnas slutsatser kring bästa möjliga bakomliggande förklaring till de observerade händelserna. Metodiken baseras på resonerande med ett Probabilistic Argumentation System där rationell tilltro

tilldelas till olika hypoteser och man söker argument både för och emot de alternativa hypoteserna. Genereringen av hypoteser görs av människor och experter anger subjektiva omdömen baserat på karakteristiken och "beteendet" hos lägesbilden. Sådana omdömen kombineras och alla alternative hypoteser utvärderas baserat på till vilken grad de anses möjliga (*plausibility*). Dessa värderingar görs på så sätt att det alltid, i varje ögonblick, finns en bästa bedömning som successivt uppdateras och förfinas (sk *anytime* algoritmer) och ställs till förfogande till beslutsfattaren.
Metodiken som presenteras är generell till sin natur (inom ramen krishantering) och tycks vara mycket lämplig för resonerade om vad som orsakar rådande händelser. Det torde därför vara ett utmärkt hjälpmedel att så fort som möjligt få en bra överblick i initialskedet av en större kris. Metodiken som presenteras är resultatet av 5-6 års forsking sponsrad av amerikanska flygvapnets forskningsorganisation (ASFOSR) som har ett speciellt ansvar för forskning om krishantering.

Plan-Driven Fusion: Shaping the Situation Awareness Process using Empirical Plan Data, Phil DiBona, Nadya Belov, and Angela Pawlowski, , in *Proceedings of the 9th International Conference on Information Fusion,* Paper 243, 2006.
Abstract: Historically, in a tactical C4ISR environment, information fusion processing and plan understanding and execution monitoring have been performed without regard to one another. In particular, plan execution monitoring assumes that an accurate "world state" is available, while information fusion processing assumes that "operational context" is available. Because operational context allows information fusion to develop an accurate representation of world state, and world state is the basis from which plan execution monitoring assesses the status of plans, a loose coupling between information fusion and plan understanding and execution monitoring results in less-than-optimal situational awareness for a commander. Leveraging plan understanding and Levels 1-4 information fusion techniques, Lockheed Martin Advanced Technology Laboratories (LM ATL) has developed a concept design and prototype, plan-driven fusion, which enables iterative, closed-loop cooperation between planning and fusion components within a C4ISR environment.

Sammanfattning: I detta konferensbidrag beskriver Phil DiBona och kolleger en föreslagen systemdesign och en prototyp utvecklad vid Lockheed Martin i USA för plan-driven fusion. Traditionellt har fusion och planuppföljning bedrivits som två separata processer. Vid planuppföljning antas att det finns en korrekt lägesbild (skapad av fusion) och vid bearbetning inom informationsfusion antas att det finns en plan som styr inhämtningen. Som exempel kan sensorer inte förse fusionsprocessen med tillräcklig och relevant indata om det saknas information om den egna planen. Sensorerna kanske inte helt övervakar det relevanta geografiska området. De kan ha fel upplösning, t.ex. fel nogrannhet om klassificering, identitet och kinematik givet det aktuella beslutsproblemet. I detta förslag beskrivs hur kunskap om den egna planen ska kunna guida fusionsprocessen för att så bra som möjligt stöda beslutsfattaren. Den utvecklade prototypen använder *Core Plan Representation* (CPR) ontologi för att modellera och instansiera planer. Den första uppgiften inom plan-drivenfusion är att förstå och vidmakthålla C4ISR-planer, inklusive taktiska manövrar, logistik, inhämtningsplaner representerade med CPR. För att förstå informationsbehov är det nödvändigt att förstå aktioner, agerande enheter, resurser och spatiella och temporala bivillkor i dessa planer. Genom att analysera planen kan man undersöka informationsbehovet hos beslutsfattaren och prioritera olika informationsbehov för beslutsfattaren givet läget i informationsfusionsprocessen och vilken information som redan finns tillgänglig.
Den beskrivna metodiken att styra inhämtningen givet egna planer är ett exempel på *offensiv informationsfusion*. De utgör en måldriven inhämtningsprocess och resonerade på samma sätt som underrättelsefunktionens ställande av underrättelsefråga är ett måldrivet sökande av information. Denna måldrivning är förstås lämplig för den som själv agerar proaktivt, den bör dock ändå inte utesluta inhämtning av mer övervakande karraktär, ett datadrivet perspektiv, som kan svara mot behovet att inte överraskas av det oväntade som inte ligger direkt framför den egna planutvecklingen. För den som konstant ligger i en övervakningsmod (*defensiv fusion*) tycks metodiken inte vara lämplig annat än när angrepp konstateras.

A Markov Random Field Model of Context for High-Level Information Fusion, Robin Glinton, Joseph Giampapa and Katia Sycara, Proceedings 9th International Conference on Information Fusion, 2006

Abstract: This paper presents a method for inferring threat in a military campaign through matching of battlefield entities to a doctrinal template. In this work the set of random variables denoting the possible template matches for the scenario entities is a realization of a Markov Random Field. This approach does not separate low level fusion from high level fusion but optimizes both simultaneously. The result of the added high level context is a method that is robust to false positive and false negative, or missed, sensor readings. Furthermore, the high level context helps to direct the search for the best template match. Empirical results illustrate the efficacy of the method both at identifying threats in the face of false negatives, and at negating false positives, as well as illustrating the reduced computational effort resulting from the incorporation of additional high-level context.

Sammanfattning: Här presenteras en metod för intentionsigenkänning. Metoden baseras på spatiotemporala data och klustringsmallar. En fördel med den här metoden är att den på ett konsekvent sätt (med hjälp av markovianska slumpässiga fält) kombinerar osäkra data om positioner, relationer mellan positioner av entiteter och automatiska måligenkännings algoritmen som innehåller en sammanblandningsmatris där osäkerheten om identiteter representeras. Dessa kan m.h.a. markovianska slummässiga fält används för matchning mot intentions (plan) mallar. Resultaten presenteras i ett simulerad scenario.

Foresight for commanders: a methodology to assist planning for effects-based operations, Paul K. Davis and James P. Kahan, Proceedings of SPIE -- Volume 6227 Enabling Technologies for Simulation Science X2006

Abstract: Looking at the battlespace as a system of systems is a cornerstone of Effects-Based Operations and a key element in the planning of such operations, and in developing the Commander's Predictive Environment. Instead of a physical battleground to be approached with weapons of force, the battlespace is an interrelated super-system of political, military, economic, social, information and infrastructure systems to be approached with diplomatic, informational, military and economic actions. A concept that has proved useful in policy arenas other than defense, such as research and development for information technology, addressing cybercrime, and providing appropriate and cost-effective health care, is foresight. In this paper, we provide an overview of how the foresight approach addresses the inherent uncertainties in planning courses of action, present a set of steps in the conduct of foresight, and then illustrate the application of foresight to a commander's decision problem. We conclude that foresight approach that we describe is consistent with current doctrinal intelligence preparation of the battlespace and operational planning, but represents an advance in that it explicitly addresses the uncertainties in the environment and planning in a way that identifies strategies that are robust over different possible ground truths. It should supplement other planning methods.

Sammanfattning: Artikeln tar upp hur metoder som används för planering på strategisk nivå av t ex forskningsinvesteringar och hälsovård kan användas militärt. Skillnaderna mellan olika sorters osäkerhet vad gäller framtida utvecklingar inom ett stridsområde tas upp. Förutom skillnaden mellan osäkerhet som beror på brister i situationsuppfattning och osäkerhet som beror på bristande kunskap om motståndarnas mål och planer klassificerar man också osäkerhet som antingen beroende på miljö/nuläge (hur ser lägesbilden ut nu?, vad gör fienden nu?) och effekter/framtid (vad får det vi gör nu för konsekvenser som inte beror på motståndarens handlingar?, vad kommer motståndaren göra?). Man tar upp några olika tekniker som kan användas för att hantera dessa osäkerheter, t ex naturalistiskt beslutsfattande, spelteori. För effektberoende osäkerhet för man fram "foresight" som ett möjligt betraktelsesätt. Foresight handlar enligt författarna om att identifiera de faktorer som kommer spela störst roll för den framtida händelseutvecklingen. En viktig del är att hitta möjliga förändringskatalysatorer: saker som kan inträffa och som helt

omkullkastar tidigare planer. För att hitta dessa föreslår författarna att möjliga scenarier för framtiden ska konstrueras på ett systematiskt sätt. För dessa scenarier gör man sedan planer. Artikeln är intressant, men det är inte uppenbart att det författarna föreslår är något väsentligt nytt för den militära planeringsprocessen. Det är en brist att inga tekniska hjälpmedel som kan göra det lättare att hitta förändringskatalysatorer och scenarier beskrivs.

An Approach for Level 2/3 Fusion Technology Development in Urban/Asymmetric Scenarios, Rakesh Nagi, Moises Sudit, James Llinas, Proc 9th Int Conf Information Fusion, Paper 235, 2006.
Abstract: Asymmetric/urban warfare, improvised explosive devices (IEDs), and dirty bombs are dominating over conventional warfare, and there is an urgent need to deal with them systematically. Effective strategies of thwarting terrorism continue to be the top priority for international communities. This paper presents a research approach for Situation Awareness and Threat/Impact Assessment strategies for a genre of UW problems. The approach is based on a formal domain ontology and a scenario authoring and simulation environment. A class of hybrid deductive (model-based) and inductive reasoning approaches are applied to the scenario simulation and performance evaluation studies are conducted. Such an approach can be used for training purposes as well as fusion technology development. An example will be presented.

Sammanfattning: Denna artikeln beskriver ett pågående forskningsprojekt om fusion för urban krigföring. Istället för att utveckla fusionsmetoder i största allmänhet är forskningen som beskrivs inriktad på att ta fram några use-cases och se hur fusion kan användas för dessa. Man fokuserar på urban krigföring och fusionshjälpmedel för relativt små förband. Scenariot som används som use-case handlar om hur en rebellstyrka angriper en infrastrukturfacilitet för att få tillgång till nukleärt material. För att skapa ett relevant scenario och anpassa fusionsmetoderna till det krävs att en ontologi utvecklas. Artikeln beskriver hur man genom kommersiellt tillgängliga verktyg för statistisk textanalys extraherar information från en stor mängd bakgrundsdokument. Denna information vidareutvecklas sedan manuellt till en ontologi. Den fusionsmetod som används är ett system för att med hjälp av grafiska modeller förvandla sensordata till utsagor om möjliga hot och planigenkänning som man tidigare utvecklat.

Algoritmer

Knowledge Perception Analysis in a Social Network, Nishith Pathak, Sandeep Mane, Jaideep Srivastava, Noshir S. Constractor, Proceedings 4th workshop on Link Analysis, Counterterrorism and Security 2006.
Abstract: Knowledge management in organizations is gaining in importance, especially with the advent of computer networks. Networks foster interaction between individuals, and have become the medium of choice for all types of interactions, both professional and social. In this research, we study the perception of knowledge in an organization's email network. An important aspect of an individual's knowledge is that it may be incomplete and hence any analysis approach must handle knowledge uncertainty. We propose an approach based on the Dempster-Shafer theory of evidence for modeling individuals' perceptions about knowledge, thus enabling the understanding of knowledge in an organization. We show how correlating the knowledge of two or more individuals can help identify the discrepancies between them, and thus identify sources of organizational misperceptions. The proposed approach has been evaluated on the publicly available e-mail logs from the Enron Corporation. For the present study, meaning extraction from e-mail content was done manually. Initial results show that the approach is very promising. Our continuing research is focusing on applying techniques for automated identification of knowledge from email as well as sentiment analysis techniques for automated evaluation of individuals' sentiments.

Sammanfattning: Artikeln använder den databas med e-post från Enron som gjorts offentlig av amerikanska myndigheter i samband med domstolsförhandlingarna om bedrägeri i företaget. Idén är att studera hur kunskapsnätverket inom företaget förändras med tiden. Kunskapsnätverket definieras som ett bipartit nätverk med personer och "kunskaper", och där det finns en länk mellan en person och olika kunskaper om personer tror att den har kännedom om den specifika kunskapen. Att en länk finns behöver inte betyda att kunskapen är sann, utan tolkas istället som att personen just nu tror att kunskapen är sann. För att hantera detta använder pappret Dempster-Shafer-teori och tilldelar trolighets- och plausibilitetsvärden till varje länk. Ett exempel på ett sådant nätverk skulle kunna vara ett nätverk där personerna representeras av riksdagsledamöter och kunskaperna av utsagor i stil med "N N blir utbildningsminister". I varje givet ögonblick efter ett val har riksdagsledamöterna gissningar om vilka ministrarna ska bli, och allteftersom de får ny information ändras deras gissningar. Pappret använder en samling manuellt klassificerade e-post-meddelanden för att uppdatera de enronanställdas uppfattning om kunskapsutsagan "the company image is good", och visar hur den allmänna uppfattningen inom företaget ändras med tiden. Artikeln presenterar en mycket intressant idé, men lyckas tyvärr inte genomföra den fullt ut. Det största felet i artikeln är att den inte använder statistiska metoder för textanalys för att automatiskt räkna ut hur de anställdas åsikter ska ändras när de får ett nytt e-post-meddelande. Det vore intressant att se resultatet från en motsvarande studie som gör detta och som också tittar på flera olika kunskapsutsagor.

On exploiting 'negative' sensor evidence for target tracking and sensor data fusion, Wolfgang Koch, *Information Fusion* **8**(1):28–39 (Special Issue on The Seventh International Conference on Information Fusion; P. Svensson and J. Schubert, Eds.).

Abstract: In various applications of target tracking and sensor data fusion all available information related to the sensor systems used and the underlying scenario should be exploited for improving the tracking/fusion results. Besides the individual sensor measurements themselves, this in particular includes the use of more refined models for describing the sensor performance. By incorporating this type of background information into the processing chain, it is possible to exploit 'negative' sensor evidence. The notion of 'negative' sensor evidence covers the conclusions to be drawn from expected but actually missing sensor measurements for improving the position or velocity estimates of targets under track. Even a failed attempt to detect a target is a useful sensor output, which can be exploited by appropriate sensor models providing background information. The basic idea is illustrated by selected examples taken from more advanced tracking and sensor data fusion applications such as group target tracking, tracking with agile beam radar, ground moving target tracking, or tracking under jamming conditions.

Sammanfattning: Denna artikel av Wolfgang Koch (FGAN, Tyskland) beskriver hur man kan utnyttja s k negativ sensorinformation vid målföljning. Utöver sensormätningar så inkluderar detta synsätt även en förfinad modell för att beskriva sensorprestanda. Genom att inkludera sensorprestanda tillsammans med sensormätningar i processkedjan blir det möjligt att utnyttja negativ sensorinformation, t.ex. att dra de slutsatser som är möjliga att göra utifrån förväntade men frånvarande sensorobservationer. Sådan negativ information uppträder ofta i form av en artificiell sensorobservation. Om man inkluderar denna typ av observationer i processkedjan kan man förbättra både positions- och hastighetsbedömningar av målet. För att göra så inom ramen för den Bayesianska formalismen behövs en problemspecifik *likelihood*-funktion. Utifrån en frånvarande men förväntad sensorobservation kan vi dra slutsatsen att målet tycks röra sig på så sätt att det är dolt i bruset och därav dra slutsatser om dess kinematiska tillstånd. Detta kan till exempel vara speciellt användbart för att hjälpa till med tidig upptäckt av stannande mål vid markmålföljning, förbättrad prestanda av målföljningen utan möjliga gruppmål, etc. Användningen av negativ information studeras i artikeln i tre olika tillämpningar: gruppmålföljning, IMM-målföljning med *electronically scanned array* (ESA) *radar* respektive målföljning med *ground moving target*

indicator (GMTI). Metodiken är speciellt tillämplig under de svåra förhållanden när den behövs som mest och där frånvaro av förväntade sensorobservationer vanligen uppträder.

Strategies to Manage Ignorance Situations in Multiperson Decision Making Problems, S. Alonso, E. Herrera-Viedma, F. Chiclana, F. Herrera, and C. Porcel, in V. Torra, Y. Narukawa, A. Valls, J. Domingo-Ferrer (Eds.), *Modelling Decisions for Artificial Intelligence, Proceedings of the Third International Conference,* pp. 34–45, Springer (LNCS 3885), 2006.
Abstract: Multiperson decision making problems involve using the preferences of some experts about a set of alternatives in order to find the best of those alternatives. However, sometimes experts cannot give all the information that they are required. Particularly, when dealing with fuzzy preference relations they can avoid giving some of the preference values of the relation. In the literature these incomplete information situations have been faced giving procedures which are able to compute missing information from the preference relations. However, these approaches usually need at least a piece of information about every alternative in the problem. In this paper, several strategies to manage total ignorance situations, that is, situations where an expert does not provide any information on at least one alternative are presented, and their advantages and disadvantages analised.

Sammanfattning: I denna artikel studerar Enrique Herrera-Viedma m.fl. (Univ. Granada, Spanien) ett viktigt beslutsproblem när flera beslutsfattare med olika preferenser ska sammarbete för att komma fram till ett gemensamt beslut. Varje beslutsfattare kan välja att angripa problemet utifrån sina egna utgångspunkter, men de förutses ha ett gemensamt intresse att tillsammans finna en bästa lösning. Under dessa förutsättningar studerar författarna metoder för att hantera beslutsproblemet när den information som beslutsfattarna lämnar är partiellt eller totalt inkomplett. En sådan situation kan lätt uppstå om någon beslutsfattare saknar en precis uppfattning om något alternativ eller saknar tillräcklig kunskap inom del av problemområdet. Idealt skulle varje beslutsfattare lämna information om preferensen mellan alla beslutsalternativ.
Partiell inkomplett information anses råda när minst en av beslutsfattarna inte kan lämna preferenser mellan alla beslutsalternativ, men ändå lämnar viss information om varje beslutsalternativ där varje alternativ är jämfört med åtminstone ett annat alternativ. *Totalt inkomplett information* å andra sidan anses råda då åtminstone en beslutsfattare inte kan lämna preferenser mellan alla beslutsalternativ, och dessutom inte lämnar någon information alls om åtminstone ett alternativ. Andra författare har tidigare studerat problemlösning med partiellt inkomplett information medan totalt inkomplett information har tidigare saknat lösning. Författarna presenterar här flera olika strategier för att hantera beslutsfattande med *totalt inkomplett information*. Bland dessa strategier finns så kallade *konsistensbaserade strategier* som estimerar saknade preferenser utifrån *fuzzy additive transitivity*. Metodiken som presenteras i detta konferensbidrag är lämplig vid gruppbeslutsfattande då flera beslutfattare med olika bakgrund och kunskap sammarbetar med att lösa ett problem. Tillämpningar torde finnas inom underrättelseprocessen och dess koppling till beslutsprocessen. Av speciellt intresse borde metodiken vara vid distribuerat beslutsfattande då olika beslutsfattare inte ser alla beslutsalternativ utan uttrycker preferenser mellan beslutsalternativ inom olika delmängder av alla möjliga alternativ.

Constructing belief functions from sample data using multinomial confidence regions, Thierry Denoeux, *International Journal of Approximate Reasoning* **42**(3):228–252, 2006.
Abstract: The transferable belief model is a subjectivist model of uncertainty in which an agent's beliefs at a given time are modelled using the formalism of belief functions. Belief functions that enter the model are usually either elicited from experts, or must be constructed from observation data. There are, however, few simple and operational methods available for building belief

functions from data. Such a method is proposed in this paper. More precisely, we tackle the problem of quantifying beliefs held by an agent about the realization of a discrete random variable X with unknown probability distribution P_x, having observed a realization of an independent, identically distributed random sample with the same distribution. The solution is obtained using simultaneous confidence intervals for multinomial proportions, several of which have been proposed in the statistical literature. The proposed solution verifies two "reasonable" properties with respect to P_x source: it is less committed than P_x source with some user-defined probability, and it converges towards P_x source in probability as the size of the sample tends to infinity. A general formulation is given, and a useful approximation with a simple analytical expression is presented, in the important special case where the domain of X is ordered.

Sammanfattning: Sedan slutet av 1960-talet har Dempster-Shaferteori utvecklats till ett ramverk för att modellera partiell kunskap och resonera med osäker information. Till skillnad från traditionell sannolikhetslära tillåter Dempster-Shaferteori tilldelning av sannolikhet till både enskilda element och godtyckliga delmängder av alla element (traditionellt endast enskilda element). Att lösa ett problem inom Dempster-Shaferteori utförs vanligen i två steg: man modellerar varje information med en s k belief function över ett lämpligt utfallsrum, samt manipulerar alla belief functions genom marginalisering, extension kombination. Medans mycken forskning har rört den senare delen har lite forskning hanterat frågan om den initiala tilldelningen av sannolikhet till belief functions. I denna artikel visar Thierry Denoeux (Univ. Technologie de Compiègne, Frankrike) en metod att tilldela sannolikhet till belief functions utifrån gjorda observationer.
Metodiken kan enkelt beskrivas på några få rader. Utifrån information om antalet observationer N_k för varje kategori k kan vi enkelt beräkna så kallade konfidensregioner

$$(p_k^-, p_k^+)$$

för varje kategori. Från dessa kan vi därefter beräkna den undre enveloppen till varje delmängd av alla kategorier,

$$P^-(A) = \max\left(\sum_{\xi_A \in A} P_k^-, 1 - \sum_{\xi_A \notin A} P_k^+ \right)$$

Om den så kallade Möbius inversen m^- till den undre enveloppen P^-,

$$m^-(A) = \sum_{B \subseteq A} (-1)^{|A-B|} P^-(A)$$

,
är en *basic belief assignment*, dvs bivillkoren

$$m^-(A) \geq 0$$

och

$$\sum_{A \subseteq \Theta} m^-(A) = 1$$

är uppfyllda, då är också den undre enveloppen P^- den eftersökta belief function. Om så inte är fallet så kan man ändå skapa en belief function genom maximering av summan

$$\sum_{A \subseteq \Theta} \mathrm{bel}(A)$$

genom linjärprogrammering under ovanstående villkor samt det ytterligare villkoret

$$\sum_{B \subseteq A} m(B) \leq P^{-}$$

.

Genom att använda metodiken blir det möjligt att modellera både statistisk osäkerhet (scattering) och osäkerhet genom bristande specificitet (nonspecifity). Man skulle t.ex. kunna koncentrera en sannolikhetsdistribution från en sensorer med denna metodik till en belief function som tilldelar sannolikhet till delmängder som har en direkt konceptuell betydelse. På detta sätt kan man erhålla en bättre förståelse av vad som egentligen observeras. Om man t.ex. observerar ett objekt med viss karakteristik och med hög sannolikhet så framkommer det nu direkt, i stället för att få en mängd små sannolikheter för alla olika objekt som har denna sannolikhet.

Planigenkänning

Detecting Stochastically Scheduled Activities in Video, Octavian Udrea, Massimiliano Albanese, Vincezo Moscato, Antonio Picariello, V.S. Subrahmanian, Proc IJCAI, 2007.
Abstract: The ability to automatically detect activities in video is of increasing importance in applications such as bank security, airport tarmac security, baggage area security and building site surveillance. We present a stochastic activity model composed of atomic actions which are directly observable through image understanding primitives. We focus on answering two types of questions: (i) what are the minimal sub-videos in which a given action is identified with probability above a certain threshold and (ii) for a given video, can we decide which activity from a given set most likely occurred? We provide the MPS algorithm for the first problem, as well as two different algorithms (naiveMPA and MPA) to solve the second. Our experimental results on a dataset consisting of staged bank robbery videos show that our algorithms are both fast and provide high quality results when compared to human reviewers.
Sammanfattning: Inom området datorseende vill man upptäcka invecklade mönster. I detta papper vill man ge svar på två huvudfrågor:

- Vilka aktiviteter (händelser) kan identifieras från olika videosekvenser
- Vilka av händelserna är mest sannolika

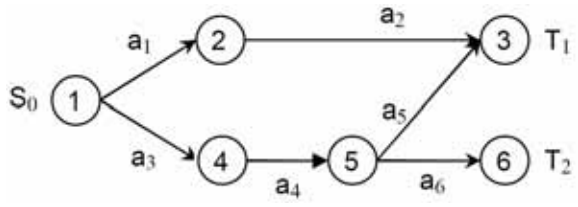
Nyheten i det här pappret är introduktion av en algoritm vars syfte är att hitta aktiviteter vars sannolikhet är högre än en viss tröskel. Det andra bidraget är algoritmen som hittar mest troliga aktiviteten givet mängden par av identifierade aktiviteter och videosekvenser och hitta mest troliga aktiviteten i den hela videon. Författarna demonstrerar sitt koncept på videosekvenser från en bankomat. Deras orsakssambands a priori modell är stokastiskt och ganska enkel. Författarna har lagt ner tid på att implementera och testa sin modell mot verkliga data. Resultaten visar hög prestanda men algoritmen är inte helt robust mot avvikande beteenden. Dessutom är beräkningstiden beroende av modellbeskrivningen. Ju mera komplex beteendemodell desto längre beräkningstid krävs det.

Human–Machine Interaction Based on Dynamic Bayesian Networks Probabilistic Intention Recognition, KARIM A. TAHBOUB, Journal of Intelligent and Robotic Systems (2006) 45: 31–52
Abstract: In this article, a novel human–machine interaction based on the machine intention recognition of the human is presented. This work is motivated by the desire that intelligent machines as robots imitate human–human interaction, that is to minimize the need for classical direct human–machine interface and communication. A philosophical and technical background for intention recognition is discussed. Here, the intention–action–state scenario is modified and modeled by Dynamic Bayesian Networks to facilitate for probabilistic intention inference. The recognized intention, then, drives the interactive behavior of the machine such that it complies

with the human intention in light of the real state of the world. An illustrative example of a human commanding a mobile robot remotely is given and discussed in details
Sammanfattning: I detta papper presenteras ett tillvägagångssätt att förenkla människa-maskin interaktionen. Den förbättras genom att maskinen känner igen vad användare vill åstadkomma istället för att styras direkt. Modellen av användare kapslas in i ett dynamisk bayesianskt nätverk som maskinen använder för igenkänningen.

On Natural Language Processing and Plan Recognition, Christopher W. Geib and Mark Steedman, Proceedings of IJCAI 2007.
Abstract: The research areas of plan recognition and natural language parsing share many common features and even algorithms. However, the dialog between these two disciplines has not been effective. Specifically, significant recent results in parsing mildly context sensitive grammars have not been leveraged in the state of the art plan recognition systems. This paper will outline the relations between natural language processing(NLP) and plan recognition(PR), argue that each of them can effectively inform the other, and then focus on key recent research results in NLP and argue for their applicability to PR
Sammanfattning: I detta papper lyfter man upp behovet att utvinna synergieffekter mellan NLP (natural language processing) och planigenkänning. Författarna ser båda metoderna som system som producerar hierarkiska data. Planigenkänningen ses som en process där man hittar *förklaringar* och NLP producerar förklaringar mha språklig analys. I denna process utgår båda metoderna ifrån regler. I planigenkänningen är reglerna lagrade som bibliotek av planer medan NLP använder grammatiska regler. Metoderna tar som indata observationer och en mängd av regler som specificerar vilka av observationerna som är acceptabla. I nästa steg matchar metoderna observationer till förklaringarna. Ett exempel på samspelet och behovet av att komplettera de båda metoderna är ”Vet du vad klockan är” exemplet. Man kan mena olika i olika situationer. Man kan undra om tiden eller förebrå någon att komma sent på mötet. Planigenkänningen skulle kunna ta en kompletterande roll till NLP som att sätta agentens uttalande i rätt kontext som i exemplet. Att uttrycka planer på PROLOG (production rule) formen skulle vara smidigt och lätt att implementera i den kontextfria grammatiken. Däremot är att utrycka kausaliteten där pre-conditions och post-conditions finns kan göra leda till ökad komplexitet av beräkningar. Slutsatsen av pappet är en rekommendationen för vidare arbetet att undersöka användningen av ”midly context sensitive grammars” i planigenkänning.

Adversarial Planning and Plan Recognition: Two Sides of the Same Coin, Sviatoslav Braynov, Proceeding of The Second Secure Knowledge Management Workshop (SKM), 2006.
Abstract: Effective adversarial plan recognition requires in- formation about how the adversary is planning his actions and vice versa, the way the adversary is planning his actions is affected by how those actions are going to be detected. In this paper, we develop a game-theoretic model that in- tegrates adversarial planning with adversarial plan recognition. The model considers planning and plan recognition to be in Nash equilibrium. The papers also shows how plan recognition could be ma- nipulated to the advantage of the adversary in the presence of incomplete information
Sammanfattning: In artikeln utgår man ifrån premissen att planigenkänning är en invers av processen av planering. Det poängteras att fientliga sidan med avsikt kan försöka vilseleda vår planigenkänningsprocess. Här utvecklas en enkel planigenkänningsmodell som baseras på spelteorin. Man antar att fienden tar hänsyn till våra planer och planigenkänningen och vice versa. Syftet med planigenkänningen är att förutse kommande attacker och med detta som underlag generera effektiva motattacker. Författaren utgår ifrån en tillståndsgraf mellan tillstånd och presumtiva mål.



Figur 2. (Deterministisk) anfallsgraf

Handlingar (a_i) gör så att systemet kan hamna i olika tillstånd och så småningom kunna attackera mål som är i vårt fall i grafen tillstånd 3 och 6. Denna graf anger planer som en sekvens av handlingar. En försvarares strategi är att hindra angriparen att uppnå sina mål. En möjlig strategi vore att blockera alla möjliga sätt för angriparen att uppnå sina mål med hjälp av t ex grafoptimering. I artikeln föreslås användning av spelteorin som i kombination med planigenkänningen ger försvararen en resurssparande strategi samtidigt som försvararen lyckas att skydda mål. Processen att uppnå en Nash jämvikt är iterativ och jämvikten existerar endast om fienden inte lyckas helt lura planigenkänningen, d.v.s. att metoden sätter sannolikheten för det planalternativ som angriparen genomför till noll. När man modellerar fienden ska man ta hänsyn hur skicklig den är. För mer skickliga angripare krävs det mera ansträngning att modellera för att planigenkänningen ska vara tillförlitlig. Metodiken är ny och skulle kunna användas vid både av analyser av händelseutvecklingar och som beslutsstöd on-line. Den kan ses som ett första steg att integrera en kognitiv process som planigenkänning med en interaktiv process som spelteori. Metodiken borde utvecklas att bli mera robust. Första steget i denna riktning, skulle vara att introducera en icke-deterministisk anfallsgraf. Problemet med dagens sorts hot är att det är svårt även på ett probabilistiskt sätt säga vilken sekvens av handlingar som måste genomföras för att exekvera en plan. I stället skulle man kunna använda indicier om fiendens olika planer att attackera olika mål för att dra slutsatserna om hans planer.

Appendix: Lista över samtliga utvalda artiklar

I detta appendix listas samtliga de artiklar som vi upptäckt under året och som vi tyckt vara särskilt viktiga. Artiklarna är sorterade efter vilken källa vi funnit dem i.

1) **Level 2/3 Fusion in Conceptual Spaces,** John T. Rickard, Proc 9th Int Conf Information Fusion, Paper 16, 2006.
   a) **Abstract:** This paper presents a novel approach to data fusion knowledge representation using conceptual spaces. Conceptual spaces represent knowledge geometrically in multiple domains, each domain consisting of multiple dimensions with an associated distance metric and corresponding similarity measure. Complex concepts such as those required for Level 2/3 fusion are described by multiple property regions within these domains, along with the property correlations and salience weights. These concepts are mapped into points in the unit hypercube that capture all of their essential elements. Observations are also mapped into points in the same unit hypercube. The relative similarity of observations to concepts can then be calculated using the fuzzy subsethood measure.
2) **Pedigree Information for Enhanced Situation and Threat Assessment**, Marion G. Ceruti, Adam Ashenfelter, Richard Brooks, Genshe Chen, Subrata Das, Gary Raven, Moises Sudit, Edward Wright, Proc 9th Int Conf Information Fusion, Paper 43, 2006.
   a) **Abstract:** This paper describes how pedigree is used to support and enhance situation and threat assessment. It is based on the findings of the technology group of the Data Fusion Levels Two and Three Workshop sponsored by the Office of Naval Research held in Arlington, VA from 15-18 Nov. 2005. It identifies areas that need improvement in situation assessment and threat assessment, such as interoperability, automation, pedigree management, system usability, reliability, and uncertainty. The concept of pedigree must include "standard" metadata, lineage, plus a computational model of the quality of the information. The system must automatically propagate changes and update to derived products when source information or sourcepedigree information changes. Several other processes must be automated: generate pedigree, identify and auto fill gaps, fuse pedigree, update pedigree, display of information quality and confidence. The paper concludes with suggestions for future research and development.
3) **Rethinking Level 5: Distributed Cognition and Information Fusion**, Maria Nilsson, Tom Ziemke, Proc 9th Int Conf Information Fusion, Paper 98, 2006.
   a) **Abstract:** The focus of most information fusion research, so far, has been on the technology i.e. information processing in machines. However, the importance of also understanding human information processing, and the interaction between humans and machines, is gaining increasing recognition. This position paper argue that a distributed cognition perspective, which considers cognitive processes not as taking place solely inside people's heads, but as distributed over human thought processes and the material, social and organizational environment they are embedded in, may help to provide a deeper understanding of information fusion processes.
4) **An Adaptive Situation Assessment Based Decision Making System**, F. Mirmoeini, V. Krishnamurthy, Proc 9th Int Conf Information Fusion, Paper 132, 2006.
   a) **Abstract:** This paper describes the development of a hierarchical situation assessment system using Bayesian networks and also a situation assessment based decision making system for battlespace environment. The situation assessment system consists of two levels of recon¯gurable Bayesian networks that are adapted with changes that occur in the battlespace on two di®erent timescales. The decision making system uses this adaptive situation assessment system to make decisions that in turn affect the battlespace dynamics. An algorithm is provided to model these interactions and dynamics of the battlespace. Furthermore, a Markovian model for the battlespace dynamics is provided.
5) **Complex Event Processing approach for strategic intelligence**, Nicolas Museux, Juliette Mattioli, Claire Laudy, Helene Soubaras, Proc 9th Int Conf Information Fusion, Paper 200, 2006.
   a) **Abstract:** One of the key issues of strategic intelligence within a crisis situation is to build an early assessment of the situation, based on a context sensitive information interpretation and through a well constructed situation representation. Our proposal is based on the conjunction of a conceptual modelling to represent situations out of document analysis and a reactive rule-based modelling to analyse them according to a domain knowledge and a goal. This paper focuses on this **Situation Analysis** process. But we present our global approach and sum-up the **Situation Representation** and its objectives. We introduce the Complex Event Processing formalism used for the analysis and dynamic recognition of such situations. We illustrate our approach through a case study taken from what happened during the energy crisis in California in 2001.
6) **The Hats Information Fusion Challenge Problem**, Clayton Morrison, Paul Cohen, Proc 9th Int Conf Information Fusion, Paper 210, 2006.
   a) **Abstract:** We describe the Hats Simulator as an information fusion challenge problem. Hats is a virtual world in which many agents engage in individual and collective activities. Most agents are benign, some intend harm. Agent activities are planned by a generative planner. Playing against the simulator, the goal of

the analyst is to identify and arrest harmful agents before they carry out their plans. The simulator provides both scalar and categorical information. Information fusion tasks in the Hats domain include assessing information value, choosing information collection strategies, tracking individuals and resources, identifying events, hypothesizing group membership, ascribing suspicion, and identifying plans. After each game, the analyst is assessed a set of scores including the cost of acquiring information, the cost of falsely accusing benign agents, and the cost of failing to detect harmful agents. The simulator is implemented and currently manages hundreds of thousands of agents.

7) **Reasoning about situations in the early post-disaster response environment**, Galina L. Rogova, Peter D. Scott, Carlos Lollett, Rashmi Mudiyanur, Proc 9th Int Conf Information Fusion, Paper 211, 2006.
   a) **Abstract:** The purpose of situation and impact assessment is to infer and approximate the critical characteristics of the environment in relation to the particular goals, capabilities and policies of the decision makers. The process of situation and impact assessment involves dynamic generation of hypotheses about the states of the environment and evaluation of their plausibility via reasoning about situational items, their aggregates at different levels of granularity, relationships between them, and their behavior within a specific context. This paper addresses the problem of reasoning for situation and impact assessment to support early-phase crisis management. Special attention is paid to "inference for best explanation" aimed at discovery of the underlying causes of observed situational items and their behavior, an important component of situation and impact assessment. The presented method of discovery of underlying causes is illustrated by the discovery of an unreported HAZMAT incident within an early-phase earthquake response scenario.
8) **An Approach for Level 2/3 Fusion Technology Development in Urban/Asymmetric Scenarios**, Rakesh Nagi, Moises Sudit, James Llinas, Proc 9th Int Conf Information Fusion, Paper 235, 2006.
   a) **Abstract:** Asymmetric/urban warfare, improvised explosive devices (IEDs), and dirty bombs are dominating over conventional warfare, and there is an urgent need to deal with them systematically. Effective strategies of thwarting terrorism continue to be the top priority for international communities. This paper presents a research approach for Situation Awareness and Threat/Impact Assessment strategies for a genre of UW problems. The approach is based on a formal domain ontology and a scenario authoring and simulation environment. A class of hybrid deductive (model-based) and inductive reasoning approaches are applied to the scenario simulation and performance evaluation studies are conducted. Such an approach can be used for training purposes as well as fusion technology development. An example will be presented.
9) **Plan-Driven Fusion: Shaping the Situation Awareness Process using Empirical Plan Data**, Phil DiBona, Nadya Belov, Angela Pawlowski, Proc 9th Int Conf Information Fusion, Paper 243, 2006.
   a) **Abstract:** Historically, in a tactical C4ISR environment, information fusion processing and plan understanding and execution monitoring have been performed without regard to one another. In particular, plan execution monitoring assumes that an accurate "world state" is available, while information fusion processing assumes that "operational context" is available. Because operational context allows information fusion to develop an accurate representation of world state, and world state is the basis from which plan execution monitoring assesses the status of plans, a loose coupling between information fusion and plan understanding and execution monitoring results in less-than-optimal situational awareness for a commander. Leveraging plan understanding and Levels 1-4 information fusion techniques, Lockheed Martin Advanced Technology Laboratories (LM ATL) has developed a concept design and prototype, plan-driven fusion, which enables iterative, closed-loop cooperation between planning and fusion components within a C4ISR environment.
10) **Game Theoretic Approach to Threat Prediction and Situation Awareness**, Genshe Chen, Dan Shen, Chiman Kwan, Jose B. Cruz, Jr., Martin Kruger, Proc 9th Int Conf Information Fusion, Paper 245, 2006.
   a) **Abstract:** The strategy of data fusion has been applied in threat prediction and situation awareness and the terminology has been standardized by the Joint Directors of Laboratories (JDL) in the form of a socalled JDL Data Fusion Model, which currently called DFIG model. Higher levels of the DFIG model call for prediction of future development and awareness of the development of a situation. It is known that Bayesian Network is an insightful approach to determine optimal strategies against asymmetric adversarial opponent. However, it lacks the essential adversarial decision processes perspective. In this paper, a highly innovative data-fusion framework for asymmetricthreat detection and prediction based on advanced knowledge infrastructure and stochastic (Markov) game theory is proposed. In particular, asymmetric and adaptive threats are detected and grouped by intelligent agent and Hierarchical Entity Aggregation in Level 2 and their intents are predicted by a decentralized Markov (stochastic) game model with deception in Level 3. We have verified that our proposed algorithms are scalable, stable, and perform satisfactorily according to the situation awareness performance metric.
11) **An Ontological Analysis of Threat and Vulnerability**, Eric Little, Galina Rogova, Proc 9th Int Conf Information Fusion, Paper 302, 2006.

a) **Abstract:** The overall goal of this paper is to provide a formal ontological analysis of threat. In particular, this paper discusses the formal ontological structure of threats as integrated wholes possessing three inter-related parts: intentions, capabilities and opportunities, and shows how these elements stand to one another, as well as to states of vulnerability. This discussion offers a means for understanding variations of threat conditions such as potential vs. viable threats and dispersed threats. A general, metaphysical, upper-level framework for the development of a formal threat ontology (ThrO) offers a necessary foundation for designing consistent and comprehensive models for threat prediction and mitigation.

12) **The Colab Mixed-Initiative Analysis Enviroment**, Clayton Morrison, Paul Cohen, Proc 9th Int Conf Information Fusion, Paper 314, 2006.
   a) **Abstract:** COLAB is an analysis environment in which multiple human analysts in different physical locations can collaborate to build hypotheses of unfolding scenarios. COLAB consists of two components: an instrumented analysis working environment built on a blackboard system, and a web-based user interface that integrates the Trellis hypothesis authoring and management tool with a query language. On the blackboard, analysts collect data and perform analyses using relational database queries and a set of analysis tools that include group identification and suspicion scoring algorithms. Evidence extracted from data analysis on the blackboard may then be incorporated in hierarchical argument structures in the Trellis tool, combining evidence sources with user-supplied free text. Trellis arguments may then be shared between analysts and collaboratively authored. COLAB has been integrated with the Hats Simulator challenge domain and serves as a prototype mixed-initiative information fusion system.

13) **A Markov Random Field Model of Context for High-Level Information Fusion**, Robin Glinton, Joseph Giampapa, Katia Sycara, Proc 9th Int Conf Information Fusion, Paper 375, 2006.
   a) **Abstract:** This paper presents a method for inferring threat in a military campaign through matching of battlefield entities to a doctrinal template. In this work the set of random variables denoting the possible template matches for the scenario entities is a realization of a Markov Random Field. This approach does not separate low level fusion from high level fusion but optimizes both simultaneously. The result of the added high level context is a method that is robust to false positive and false negative, or missed, sensor readings. Furthermore, the high level context helps to direct the search for the best template match. Empirical results illustrate the efficacy of the method both at identifying threats in the face of false negatives, and at negating false positives, as well as illustrating the reduced computational effort resulting from the incorporation of additional high-level context.

14) **Extending BDI Multi-Agent Systems with Situation Management**, John Buford, Gabriel Jakobson, Lundy Lewis, Proc 9th Int Conf Information Fusion, Paper 383, 2006.
   a) **Abstract:** We extend the BDI (Belief, Desire, Intention) agent model by enabling agent beliefs to be based on real-time complex situations that are generated by a situation management (SM) system. This has several advantages for multi-agent systems using BDI agents. First, because of the use of event correlation and data fusion techniques in situation management, agents and agent platforms can support highly reactive distributed applications. Second, the situation manager provides a semantically rich representation of the world and can dynamically adapt its representation for situations over time. From the system architecture perspective, we discuss several alternatives for how existing BDI-capable agent platforms can incorporate this extension. These alternatives range from complete SM functionality in each agent to having SM functionality only in the agent platform. We also consider environments where multiple different agent platforms use our Situation-Based BDI (SBBDI) Agent method and must interoperate. We include an example of using an SBBDI agent system for homeland security threat assessment.

15) **A general theory of conditional decomposable information measures**, Bernadette Bouchon-Meunier, Giulianella Coletti, Christophe Marsala, Proc Eleventh Int Conf Information Processing and Management of Uncertainty in Knowledge-based Systems (IPMU 2006), pp. 97–104, 2006.
   a) **Abstract:** We start from a general concept of conditional event in which the "third" value is not the same for all conditional events, but depends on E|H. Following the same line adopted in previous papers to point out conditional uncertainty measurs ([8], [9], [3], [4]), we obtain in a natural way the axioms defining a generalized ($\odot$, $\otimes$)-decomposable conditional information measure, which, for any fixed conditioning event H is a $\odot$-decomposable information measure in the sense of Kampé de Feriet and Forte ([15], [17]).

16) **Fuzzy Evidential Approximate Reasoning Scheme for fault diagnosis of complex processes**, Messaoud Ramdani, Gilles Mourot, José Ragot, Proc Eleventh Int Conf Information Processing and Management of Uncertainty in Knowledge-based Systems (IPMU 2006), pp. 189–196, 2006.
   a) **Abstract:** In this paper, a fuzzy evidential model based fault detection and diagnosis method is presented for the supervision of nonlinear and complex processes. The powerfull multi-modeling methodology is used to detect changes of the current process behavior and generate analytical symptoms. The diagnosis task is accomplished by fuzzy evidential approximate reasoning scheme to handle different kinds of uncertainty that are inherently present in many real word processes, and to make decision under conflicting data. The validity

of the method is illustrated on the well-known benchmark of three tanks and different faults can be detected and isolated continuously, over all ranges of operation.

17) **One-against-all Classifier Combination in the Framework of Belief Functions**, Benjamin Quost, Thierry Denoeux, Mylène Masson, Proc Eleventh Int Conf Information Processing and Management of Uncertainty in Knowledge-based Systems (IPMU 2006), pp. 356–363, 2006.
    a) **Abstract:** Classifier combination is an interesting approach for solving multi-class classification problems. We study here the combination of one-against-all binary classifiers, in the framework of belief functions. Our approach is first formalized; its performances are then compared to that of two other methods, on various datasets. We conclude with perspectives on future work.
18) **On Walley's Combination Rule for Statistical Evidence**, Esma Nur Cinicioglu, Prakash Shenoy, Proc Eleventh Int Conf Information Processing and Management of Uncertainty in Knowledge-based Systems (IPMU 2006), pp. 386–394, 2006.
    a) **Abstract:** Dempster's rule of combination is the commonly used rule for combining independent belief functions. In 1987, Peter Walley proposed an alternative rule for combining belief function representations of independent statistical evidence that result in partially consonant belief functions. In this paper, we examine in detail Walley's combination rule and compare it with Dempster's rule. We illustrate the commonalities and differences between the two rules using a simple coin tossing example. Also, we characterize the class of partially consonant belief functions. Finally we show that if we reduce a belief function to a probability distribution using the plausibility transformation, the two combination rules result in the same probability distribution function.
19) **Novelty detection in the belief functions framework**, Astride Arégui and Thierry Denoeux, Proc Eleventh Int Conf Information Processing and Management of Uncertainty in Knowledge-based Systems (IPMU 2006), pp. 412–419, 2006.
    a) **Abstract:** The problem of testing whether an observation may be deemed to correspond to a given model is a difficult issue. Variants of the problem have been widely studied in Statistics and Pattern Recognition. We build a solution in the belief function framework and demonstrate its advantages over other approaches in situations where the available information is particularly scarce.
20) **An Incremental Hierarchical Fuzzy Clustering Algorithm Supporting News Filtering**, Gloria Bordogna, Marco Pagani, Gabriella Pasi, Fabio Invernizzi, Luca Antoniolli, Proc Eleventh Int Conf Information Processing and Management of Uncertainty in Knowledge-based Systems (IPMU 2006), pp. 1016–1023, 2006.
    a) **Abstract:** A hierarchical fuzzy clustering algorithm is proposed to support category based news filtering. The advantage of a hierarchical organization of news is to offer users an overview of the topics reported by media at different levels of granularity. The proposed clustering algorithm is based on the Fuzzy C Means (FCM) extended in various aspects. Since filtering is a dynamic process, the clustering algorithm can updade the hierarchy of existing news. To build the hierarchy, it is iteratively applied to the clusters of a level to identify fuzzy clusters of the higher level. Further, it uses a cosine similarity, and automatically estimates the optimum number of clusters to generate. This way the main drawbacks of application of the FCM to document filtering are overcome. Finally, some results of application of the algorithm are also discussed.
21) **Methods to apply operators in a steady state evolutionary algorithm**, Louis Gacogne, Proc Eleventh Int Conf Information Processing and Management of Uncertainty in Knowledge-based Systems (IPMU 2006), pp. 2690–2697, 2006.
    a) **Abstract:** A particular steady-state strategy of evolution with a small sized population is studied in this paper. After comparison with GA and ES, we specially focus our attention on the choice of genetic operators, and the way to apply them. Knowing that it is possible to reach an optimal heuristic able to choose the genetic operators for all problems and to manage them, we present methods where the genetic operators themselves are evaluated according to their performance.
22) **A comparative study of multicriteria methodologies**, M. Socorro García, M. Teresa Lamata, Proc Eleventh Int Conf Information Processing and Management of Uncertainty in Knowledge-based Systems (IPMU 2006), pp. 2841–2846, 2006.
    a) **Abstract:** The industrial organization needs to develop better methods for evaluating the performance of its projects. We are interested on the problems related to pieces with diverse degrees of dirt. In this direction, we propose and evaluate a maintenance decision problem of maintenance in an engine factory that is specialized in production, sale and maintenance of four stroke engines; medium and slow speed. The main purpose of this paper is the study of two ways of obtaining rating/ranking of alternatives, when the information was gives in linguistic terms.
23) **A description of competing fusion systems**, Steven N. Thorsen, Mark E. Oxley, Information Fusion 7(4):346–360, 2006.
    a) **Abstract:** A mathematical description of fusion is presented using category theory. A category of fusion rules is developed. The category definition is derived for a model of a classification system beginning with an

event set and leading to the final labeling of the event. Functionals on receiver operating characteristic (ROC) curves are developed to form a partial ordering of families of classification systems. The arguments of these functionals point to specific ROCs and, under various choices of input data, correspond to the Bayes optimal threshold (BOT) and the Neyman–Pearson threshold of the families of classification systems. The functionals are extended for use over ROC curves and ROC manifolds where the number of classes of interest in the fusion system exceeds two and the parameters used are multi-dimensional. Choosing a particular functional, therefore, provides the qualitative requirements to define a fusor and choose the best competing classification system.

24) **Kalman filter and joint tracking and classification based on belief functions in the TBM framework**, Philippe Smets, Branko Ristic, Information Fusion 8(1):16–27, 2006.

a) **Abstract:** The paper develops an approach to joint tracking and classification based on belief functions as understood in the transferable belief model (TBM). The TBM model is identical to the classical model except all probability functions are replaced by belief functions, which are more flexible for representing uncertainty. It is felt that the tracking phase is well handled by the classical Kalman filter but that the classification phase deserves amelioration. For the tracking phase, we derive a minimal set of assumptions needed in the TBM approach in order to recover the classical relations. For the classification phase, we distinguish between the observed target behaviors and the underlying target classes which are usually not in one-to-one correspondence. We feel the results obtained with the TBM approach are more reasonable than those obtained with the corresponding Bayesian classifiers.

25) **On exploiting 'negative' sensor evidence for target tracking and sensor data fusion**, Wolfgang Koch, Information Fusion 8(1):28–39, 2006.

a) **Abstract:** In various applications of target tracking and sensor data fusion all available information related to the sensor systems used and the underlying scenario should be exploited for improving the tracking/fusion results. Besides the individual sensor measurements themselves, this in particular includes the use of more refined models for describing the sensor performance. By incorporating this type of background information into the processing chain, it is possible to exploit 'negative' sensor evidence. The notion of 'negative' sensor evidence covers the conclusions to be drawn from expected but actually missing sensor measurements for improving the position or velocity estimates of targets under track. Even a failed attempt to detect a target is a useful sensor output, which can be exploited by appropriate sensor models providing background information. The basic idea is illustrated by selected examples taken from more advanced tracking and sensor data fusion applications such as group target tracking, tracking with agile beam radar, ground moving target tracking, or tracking under jamming conditions.

26) **A Dynamic Model for Identifying Enemy Collective Behaviour,** E Gelenbe, V. Kaptan, Y. Wang, N.S. Walmsey, P. Gardiner, P.V. Pearce, J. Moffat, Proc. 11th ICCRTS, Paper 12, 2006.

a) **Abstract:**Recent advances in Command and Control (C2) modelling have developed algorithmic representations of the command decision making process at both the tactical (Rapid Planning) and operational (Deliberate Planning) levels of command. In this paper, the development of methods by which indicators of enemy/group behaviour can be extracted is discussed. The aim of this work is to use the grouping techniques to establish, with more certainty, force size and direction. We describe a multi-agent model approach, based on a hierarchical framework, suitable for identifying indicators of collaborative behaviour associated with enemy agile mission groups that commonly feature in the modern Networked Era.

27) **Navigation through the Meaning Space of HUMINT Reports**, Matthias Hecking, , Proc. 11th ICCRTS, Paper 13, 2006.

a) **Abstract:** The new deployments of the German Federal Armed Forces cause the necessity to analyze large quantities of Human Intelligence (HUMINT) reports. These reports are characterized by a large topical and linguistic variety. Therefore, they are good candidates for applying natural language processing techniques. In this paper, an approach to realize a graphical navigation through the meaning of HUMINT reports is presented. This meaning space navigation is realized as a graphically navigatable Entity-Action-Network and is part of the ZENON project. In this project an information extraction approach is used for the (partial) content analysis of English HUMINT reports from the KFOR (Kosovo Force) deployment of the Bundeswehr. The information about the actions and named entities are identified from each sentence and the content of the sentences is represented in formal structures. These structures can be combined and presented in the network. After a short introduction, the information extraction as an approach to process natural language and the ZENON project are explained. In the main part of the paper, the navigation through the meaning space of HUMINT reports is described in detail. Different techniques for doing this are presented. The Information Extraction Presentation System is used to realize the Entity-Action-Network. This presentation system is introduced and various examples are given.

28) **Experiences from implementing dynamic and secure Web Services,** Raymond Haakseth, Dinko Hadzic, Ketil Lund, Anders Eggen, Rolf E. Rasmussen, Proc. 11th ICCRTS, Paper 24, 2006.

a) **Abstract:** The principles of Network Enabled Capability (NEC) highlight the need for seamless and secure information exchange. To achieve this, Service Oriented Architecture (SOA) has been recognized as one of the key enablers. At the same time Web Services has become the de-facto technology for implementing a SOA. This paper presents our approach to and experience from implementing a proof-of-concept C2 system using Web Services standards. The goal has been to develop a system that provides secure and dynamic web services, with dynamic discovery of services and effective information exchange. The focal points of the developed architecture are end-to-end security, Service Registry and communication using publish/subscribe patterns in Web Services. This paper also briefly surveys the theories and standards that our work is based on, and it describes the considerations and delimitations that had to be made to achieve a system that could actually run. Further we describe the unclassified results from the use of this experimental system for demonstrations during NATO CWID 2006. Finally we present our preliminary evaluation of the successfulness of the approach of demonstrating a dynamic and secure SOA using Web Services.

29) **Development of Formal Grammars to Support Coalition Command and Control: A Battle Management Language for Orders, Requests and Reports,** Ulrich Schade, Michael R. Hieb, Proc. 11th ICCRTS, Paper 69, 2006.

a) **Abstract:** Coalition Operations are characterized by the diversity of organizations involved. This diversity can cause challenges, in particular, with Command and Control (C2) due to 1) the difference in military doctrine between forces, and 2) the incompatibility of their Information Technology (IT) and their IT systems. The majority of current IT solutions do not address differences in military doctrine. Current emerging solutions include the Command and Control Information Exchange Data Model (C2IEDM) developed by the Multinational Interoperability Programme (MIP) as a NATO standard. However, while C2 information can be stored in the C2IEDM, exchange relies upon a specific exchange mechanism. A large number of ad hoc business rules enforce consistency and semantic coherence. To incorporate military doctrine, orders, requests and reports should be conserved and exchanged as such. Therefore, development of a C2 language for military messages is clearly preferable. The keystone of such a language is a formal grammar. A formal grammar ensures that the messages can be processed automatically, a necessity under the network-centric perspective. In this paper we propose an initial C2 grammar which not only unifies military doctrine with current IT in a network-centric approach, but is also applicable to a wide range of civil operations.

30) **Parsimonious Analogical Reasoning for Smart Decision Support in Network-enabled Environments: Managing Situational Awareness**, Panos Louvieris, Andreas Gregoriades, Natasha Mashanovich, Gareth White, Christos Papathanassiou, Proc. 11th ICCRTS, Paper 109, 2006.

a) **Abstract:** How information is managed and exploited to support commanders' intuitive decision making during the execution of a plan is a key consideration in the development of a true networked enabled capability (NEC). While the benefits of NEC are laudable i.e. better networks, better information sharing and situational awareness, better decisions, better actions and better effects, commanders and their staff are nevertheless faced with an overwhelming amount of data; in practice, this can often lead to inconsistent perspectives and tempo stagnation impeding decision and operational effectiveness. Therefore reducing the information volume requirement and servicing commanders' critical information requirements (CCIRs) through parsimonious information fusion is fundamental to maintaining situational awareness (SA) in the battlespace and achieving decision effectiveness. This paper outlines and demonstrates an analogical reasoning approach for smart decision support in NEC which employs soft Case Based Reasoning (CBR) techniques incorporating Critical Success Factors (CSFs). The effectiveness of this approach is illustrated using a war-gaming case study implemented on a Computer Generated Forces (CGF) test-bed.

31) **The Implications of Complex Adaptive Systems Thinking on Future Command and Control,** Donald Low, Simon Ng, Proc. 11th ICCRTS, Paper 123, 2006.

a) **Abstract:** Complexity is an old problem *and* a new way of thinking. The natural world and human societies are replete with systems that are complex in structure and behaviour. The world is becoming an even more complex place: globalisation and technological advances mean that the world is more connected and changing more rapidly than ever before in human history. Modern militaries, including the Australian Defence Force (ADF), are not immune to these influences: terrorism, information technology and more complex tasks all challenge the way they operate and their Command and Control (C2) systems. Simultaneously, a relatively new science has appeared, called Complexity Science, that illuminates aspects of this complexity. This paper introduces some of the ideas emerging from Complexity Science that have

implications for current and future C2 systems. These suggest there is great advantage to be gained from further investigation of the following areas:

i) • More flexible organisational C2 structures and processes, able to deal with a wider range and greater variability of environments.
ii) • Processes that autonomously generate working C2 structures from the bottom up
iii) • Schemes for the education and training of individuals to operate in such flexible C2 systems under greater uncertainty and changeability.

32) **Command and Control Information Systems for Little Units: SIMACOP, a Research System to test New Concepts,** Manuel Esteve Domingo, Carlos E. Palau Salvador, Israel Pérez, Federico Carvajal Rodrigo, Proc. 11th ICCRTS, Paper 130, 2006.

a) **Abstract:** Generally, current military command and control information systems aim is to elaborate the Common Operational Picture (COP) focused on the higher hierarchical levels, from battalion level and upwards. However, in majority of present conflicts, including peacekeeping missions, many operations are carried by small units like platoons and downwards. It would be extremely useful a command and control tool which:

i) • Allows obtaining the COP at platoon and squad level, virtually locating friend, neutral and enemy units over an operations theatre cartographic database with the suitable scalability at each level.
ii) • Facilitates command and control decisions from one or from many tactical command and control locations, forward or rear.
iii) • Allows shared awareness based self-synchronization among platoons.
iv) • Acquires individualized data from troop units, particularly video flows and position.
v) In this paper, a practical research in this field is described based on the development of SIMACOP ©. SIMACOP © is an experimental C4ISR multimedia system, developed at the Technical University of Valencia, Spain. SIMACOP © is a useful tool designed and implemented for researching on the most advanced concepts in the current C2IS development: agility, information power in the mission border (Power to the Edge), self-synchronization and coalition interoperability.

33) **A Distributed Collaboration Architecture for Global Optimization,** Thomas Castelli, Joshua Lee, Waseem Naqvi, Proc. 11th ICCRTS, Paper 133, 2006.

a) **Abstract:** In contemporary multi-tiered command structures, we expect the individual federated systems to have local jurisdiction and autonomy of decision-making, i.e. as in the case of future unmanned vehicles. This allows a distributed command structure that is vastly more scalable than traditional centralized structures. However, as the individual federated systems make decisions pertinent to their situations; we need to ensure that the overall mission is satisfied. A mechanism allowing the federated systems to achieve their goals individually, while satisfying the global mission, is desirable. An approach to achieving this solution state uses techniques from the field of economic game theory. We present a generalized optimization framework for distributed command and control that can be applied to several domains, such as unmanned vehicle control, incident command or network traffic algorithms. Our framework is based on commercially available multi agent systems. We have built upon our previously reported work[5, 22, 23] on route optimizations and airspace sector design in an air traffic control network, by including the goals of interested entities, thus maximizing the "payoff" to each agent. The work reported herein will be used as the basis for command and control tasks where rapid solving of large-scale optimization problems is needed, e.g. for flow management in air transportation, coordination between unmanned vehicles, and mission aware networks and protocols.

34) **On coherence intervals and the control paradox,** Jens-Olof Lindh , Proc. 11th ICCRTS, Paper 142, 2006.

a) **Abstract:** Based on explorative empirical studies, this paper suggests that data coherence is a necessary but not sufficient prerequisite for shared information and shared situation awareness in cooperating but physically distributed asynchronous cognitive systems (DAC-systems). A temporal model of DAC system interaction has been developed and a corresponding method for post operations analysis of temporal data has been tested. Results show that interaction between nodes shall occur within a temporal interval, if internal coherence and external relevance shall be maintained: We call this the coherence interval. Loss of coherence (decoherence) may be caused by overuse of available means for communication and/or lack of common domains and/or technologies. Also, DAC systems exhibit an observability horizon, at which attempts to increase control by increasing the amount of observations in fact cause a loss of control. We call this the control paradox. It also appears that our findings about DAC systems correlate well with aspects such as information-time vectors, relative simultaneity and the information-system uncertainty principle, normally discussed in modern physics. The coherence interval can also be used to indicate if cooperating groups are able to share a common and relevant dataset.

35) **Content Analysis of HUMINT Reports,** Matthias Hecking, Proc. 2006 CCRTS, Paper 12, 2006.

a) **Abstract:** The new deployments of the German Federal Armed Forces cause the necessity to analyze large quantities of Human Intelligence (HUMINT) reports. These reports are characterized by a large topical and linguistic variety. Therefore, they are good candidates for applying techniques fromcomputational linguistics. In this paper, the ZENON project is described, in which an information extraction approach is used for the (partial) content analysis of English HUMINT reports from the KFOR (Kosovo Force) deployment of the Bundeswehr. The overall objective of this research is to realize a graphically navigatable Entity-Action-Network. The information about the actions and named entities are identified from each sentence and the content of the sentences are formally represented in typed feature structures. These structures can be combined and presented in a navigatable network. After a short introduction, the information extraction approach is explained. The ZENON project is described in detail. English HUMINT reports from the KFOR deployment form the basis for the development of the experimental ZENON system. These reports are used to build a specialized text micro-corpus with semantic annotations. This KFOR text corpus is described as well.

36) **Situational Awareness Object (SAO), A Simple, Yet Powerful Tool for Operational C2 Systems,** Michael Anhalt, Proc. 2006 CCRTS, Paper 14, 2006.

a) **Abstract:** The U. S. Joint Forces Command (USJFCOM), J9 Modeling and Simulation (M&S) Support Team advanced the capability of distributed simulation in support of Urban Resolve 05 (UR05), a collaborative effort conducted by USJFCOM and the Institute for Defense Analyses (IDA). Using real-world data, the scenarios in UR05 realistically replicated current operations and situations faced by warfighters in Baghdad. Experiment subjects use Situational Awareness Objects (SAOs) to share their awareness of the battlespace regarding activities of the adversaries, blue forces and civilian population. SAOs are logged and support real-time, postexperiment evaluation and comprehensive after-action reviews. Throughout each JUO experiment, the SAOs structure evolved to include new options that were based on the operator's needs. The benefit of SAOs is that they are easy to create and modify to fit varied operational missions. They are shared instantly among operators with access to the database and they are displayed on the terrain map as symbolic objects. SAOs contain the author's identification, location coordinates, and time created or modified, SAO category, player's confidence level, free-text comments, associated tracks and the ability to attach graphics and text files to the object. USJFCOM's success in using SAOs to enable the JUO series of experiments and the enthusiasm and innovation that operators show in using them, indicates this simple, yet powerful tool would be useful if implemented in various operational C2 systems.

37) **An architecture for experimenting with secure and dynamic Web Services,** Rolf E. Rasmussen, Anders Eggen, Raymond Haakseth, Proc. 2006 CCRTS, Paper 28, 2006.

a) **Abstract:** Service Oriented Architectures (SOA) implemented by Web Services are promising technologies for dynamic information sharing between military units. Among the many important requirements in such environments, are dynamic discovery of services and information exchange using publish/subscribe. In addition to addressing these two challenges, we have looked at related end-to-end security solutions. In order to gain some hands-on experience with available technologies, we have built an experimental demonstration system that is referred to in the discussions. The Service Registry was based on UDDI, with additional functionality in areas like run-time discovery and termination policies, geographical search and security. To obtain end-to-end security we have focused on XML and Web Services security solutions with the addition of XML Security Labels and a Public Key Infrastructure. This paper describes an experimental implementation of secure and dynamic Web Services. It briefly surveys the theories and standards that our work is based on, and argues that publish/subscribe is an important technique for military purposes. Further, it describes some considerations and delimitations that had to be made, and finally we present our preliminary evaluation of this approach in the direction of secure and dynamic SOA using Web Services.

38) **Collaboration Technology in Military Team Operations: Lessons Learned from the Corporate Domain,** Stacey D. Scott, M. L. Cummings, David A. Graeber, W. Todd Nelson, Robert S. Bolia, Proc. 2006 CCRTS, Paper 29, 2006.

a) **Abstract:** Collaboration technologies used in current military operations, such as email, instant messaging, and desktop conferencing, assist explicit communications between distributed team members. However, research in corporate environments has shown that explicit communication, while an important aspect of collaboration, is often used together with more subtle interactions to help teams communicate and coordinate their joint work. For example, monitoring other team members' on-going task activities help teams integrate related task activities, identify appropriate interruption opportunities, and provide assistance when necessary. When physically distributed, as is often the case in command and control environments, it is difficult to engage in such subtle behaviors because team members' activities are not visibly accessible. Instead, people must resort to explicit methods, such as asking for a status update. These explicit methods require effort from both parties and can be disruptive. To address these issues in corporate work settings, collaboration technologies have been developed to help people remain apprised of remote colleagues' activities, while minimizing disruption. This paper examines the suitability of these corporate technologies for supporting military team interactions, with a focus on identifying aspects of military teamwork that are well supported by these approaches and aspects requiring new methods.

39) **A Review of Team Collaboration Tools for Crisis Response in the Military and Government,** George Edw. Seymour, Michael B. Cowen, Proc. 2006 CCRTS, Paper 37, 2006.

a) **Abstract:** The military operates today both administratively and tactically using collaboration tools. The purpose of this report is to explore the recent past and current status of collaboration tools use in order to provide recommendations for the future with respect to crisis reaction. In other words, what are the "best" webbased tools to support small team interaction and work when team members cannot reside in the same physical workspace? Two methods, ad hoc research and systematic document search, were used to identify commercial and proprietary collaboration tools that deserve review and consideration for military and government crisis response. In this report we report on 64 collaboration technologies and tools, 37 in use by the United States (U.S.) Military and Government. The collaborative technologies and tools are grouped into three categories: (a) Modern collaboration technologies for the design, development, or enhancement of collaboration tools, (b) collaboration tools being used in the military or government, and (c) collaboration tools recommended for consideration by the military or government for crisis response. The identified tools or technologies are described in terms of capabilities and are analyzed for potential to improve collaboration for crisis actions teams

40) **A Framework for Understanding the IO:C4ISR Relationship,** Maxwell Thibodeaux, Richard Kaplan, Anthony Smith, Joe K. Clema, Proc. 2006 CCRTS, Paper 62, 2006.

a) **Abstract:** The US military rubric of Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) expands the concept of command and control (C2) to include communications and computers (C4) plus intelligence functions. This has had wide-ranging practical implications on the Land Component Commander and his staff. Similarly, efforts to establish information operations (IO) as a core competency have caused some confusion in the battle command, intelligence operations, and signal support disciplines.1 IO activities are now undergoing increased focus and attention to realize their full utilization in command and control operations. The Army has established the G7/S7 staff officer, vis-à-vis the G3/S3, to accomplish this coordination. Similarly, other services have modified their staff and personnel structures in order to achieve information superiority, which has been part of battle command ever since Sun Tzu's operational doctrine (500 B.C.). Since then several layers of complexity have been added as the understanding and utilization of IO has evolved and matured. We offer a framework for understanding the evolving theory, doctrine and practice of C4ISR with respect to IO. We do this by clearly describing what occurs in the modern information environment, and how it relates to traditional C2 which occurs in that environment.

41) **Sensor Ontology Integration for the Knowledge Management for Distributed-Tracking (KMDT) Program,** Marion G. Ceruti, Dwight R. Wilcox, Proc. 2006 CCRTS, Paper 72, 2006.

a) **Abstract:** This paper describes Knowledge Management for Distributed-Tracking (KMDT), which is an ongoing research and development project to explore methods to improve military functions in the battle space, such as command, control, and decision support. It features a hypothetical use-case scenario that shows how knowledge-management technologies, such as ontologies and intelligent agents, can be used to improve battle-space awareness and the decision-making process in command centers with respect to distributed tracking and threat identification of platforms. The KMDT sensor ontology is based partly on concepts described in the MIL-STD-2525B and STANAG 4420 specifications, which define symbology to represent level-one data-fusion information, such as the classification of platforms and targets in the battle space. The paper includes a discussion of ontologyintegration examples of this with this symbology as it relates to fusion and tracking.

42) **Exchanging PMESII Data to Support the Effects-Based Approach,** Daniel Snyder, Andreas Tolk, Proc. 2006 CCRTS, Paper 81, 2006.

a) **Abstract:** United States Joint Forces Command (USJFCOM) Experimentation Directorate (J9) models the political, military, economic, societal, information, and infrastructure (PMESII) aspects of populations to investigate Effects-Based Approach in coalition environments. Current JC2 systems evolved from the need to more efficiently and effectively exchange data among military organizations; however, forces must now interact with non-governmental organizations under the auspices of the effects-based approach. The universe of discourse that JC2 systems concern themselves is extending beyond what has traditionally been called the battle-space. The J9 uses an Agent-based Simulation (ABS) called Synthetic Environment for Analysis Simulation (SEAS) to model the non- military aspects of the battle-space. By investigating taxonomies for capturing SEAS generated data in JC3IEDM (Joint Consultation, Command and Control Information Exchange Data Model), developers may be able to extend JC2 systems to include an increased number of non-military data exchange requirements. Hence, by adapting the JC3IEDM to the effects-based approach may accelerate the development of future C4ISR capabilities towards covering a wider spectrum of threats and deployment scenarios. This paper will outline the reasons why ABS may be useful to evolve the JC3IDEM model, and may assist in defining what is meant by taxonomy in the context of web-enabled ABS.

43) **An Anticipatory Environment Framework,** Steve P. Colenzo, William E. McKeever, Chad C. DeStefano, Duane A. Gilmour, Proc. 2006 CCRTS, Paper 98, 2006.

a) **Abstract:** In today's volatile world, it is necessary to provide decision makers with every advantage when dealing with a dynamic and changing adversary. Decision makers require a capability that would enable them to anticipate and shape the battlespace, i.e. an anticipatory environment (AE). This capability would lead to more proactive, vice reactive, decision making in future military missions. An AE proof of concept framework has been developed that encompasses the first four phases of the Joint Air Estimate Process (JAEP), as defined in Joint Publication 3-30, 'Command and Control for Joint Air Operations' [1]. The framework provides the foundation to perform mission analysis, situation and course of action (COA) development, COA analysis, COA comparison, and aids in COA selection. This paper presents the tools, technologies and the integration of the necessary capabilities to create an AE. Utilizing a simple scenario, containing friendly and adversary entities, the AE framework will be demonstrated along with a discussion of the results.

44) **The Role of Meta-Information in C2 Decision-Support Systems,** Jonathan Pfautz, Emilie Roth, Ann Bisantz, Gina Thomas-Meyers, James Llinas, Adam Fouse, Proc. 2006 CCRTS, Paper 100, 2006.

a) **Abstract:** Command and control (C2) in complex, dynamic, high-risk warfighting environments is clearly challenging, particularly because of the increasing complexity of available technology for processing and presenting information. Commanders need to understand and act on large volumes of information from a variety of sources and are particularly challenged by the need to reason about the qualifiers of that information, which we will refer to as meta-information (e.g., uncertainty, recency, pedigree). We have explored the role of meta-information in C2 using Cognitive Task Analysis (CTA) techniques to identify when and how, in current practice, human interaction with meta-information impacts decision-making, especially when that decision-making is supported by automation. Too often critical meta-information is not processed, ineffectively displayed, or not displayed at all in existing C2 decision support systems. The result of our analyses is a number of design recommendations for C2 decision-support systems and guidelines for identifying and recognizing the need for meta-information processing and display. In this paper, we present the results of our analyses and discuss their implications with respect to the design of human-system interfaces and the development of computational information processing methods.

45) **Transferring Insights from Complex Biological Systems to the Exploitation of Netted Sensors in Command and Control Enterprises,** Jennifer Mathieu, Grace Hwang, James Dunyak, Proc. 2006 CCRTS, Paper 127, 2006.

a) **Abstract:** Exploiting data from a network of sensors (netted sensors) is an Enterprise System Engineering challenge. Successfully meeting this challenge will contribute significantly to improving the agility of today's Command and Control (C2) Enterprise by achieving its goal of decision superiority through better situational awareness. There is a pressing need to design fusion algorithms that combine data from heterogeneous sensors, with the goal of identifying well-defined Force Protection and Border Security threats. Data fusion for netted sensors requires sensor-to-sensor communication, as well as communication tipping points between the netted sensors and the C2 Enterprise. Solutions are needed that fluidly respond to this multi-scale challenge. Quorum sensing or cell-to-cell "communication" in microbial populations has shown that bacteria can indeed act as a collective rather than only as individuals (Taga and Bassler, 2003). Analogously, an Enterprise has both individual and collective behavior. Decisions that are made at the collective scale (e.g. force) rely on information that is obtained at the individual scale (e.g. unit); this information must be communicated effectively. In this paper, insight gained from the mechanism used in a robust, adaptable biological system is applied to the technical challenge of data fusion for netted sensors.

46) **Support for Dynamic Collaborative Action Teams,** R. Scott Cost, Markus E. Dale, David P. Glock, James Mayfield, Christine O. Salamacha, David P. Silberberg, Proc. 2006 CCRTS, Paper 115, 2006.

a) **Abstract:** An essential step in fielding a timely and effective response to events of global importance is the ability to rapidly identify and integrate a crisis action team. This group should consist of exactly those individuals best qualified to manage the situation. Often, the organization of such a team follows identifiable patterns. Thus, it is important to rapidly identify the type of team, or pattern, required, and to identify the individuals that meet the requirements specified by this pattern. This is a challenging task, as information about people is often distributed across multiple locations, inconsistent or out-of-date, and phrased in the language of different domains. We present a framework that facilitates the rapid integration of teams by identifying scenario-based patterns, and using agent-based search across enterprise boundaries to identify people and assist in their assignment.

47) **Technologies for Augmented Collaboration,** Linda Pierce, Janet Sutton, Peter Foltz, Noelle Lavoie, Shelly Scott-Nash, Ursula Lauper, Proc. 2006 CCRTS, Paper 131, 2006.

a) **Abstract:** Teams have always been important in military operations, but the nature of military teamwork is changing to accommodate an increasing number of missions in stability, security, transition, and reconstruction (SSTR). These missions often require that diverse, distributed experts from multinational forces, non-governmental organizations, and other government agencies work together. Although team

member diversity should improve mission performance by increasing access to a broader pool of knowledge, it is more likely to increase conflict and decrease trust, which may result in less information exchange, a lack of shared situation awareness, little team commitment, and ultimately poor team performance. Collaborative technologies generally focus on establishing physical interoperability among distributed team members, to the exclusion of technologies that promote cognitive interoperability. The Army Research Laboratory is investing in technologies to augment collaboration. The first tool is diagnostic, designed to assess cultural preferences and provide instruction on effective interaction strategies. The second tool uses Latent Semantic Analysis, a natural language and machine learning technology to monitor, moderate, evaluate, and provide feedback on team processes based on team communication. An initial capability of these tools was demonstrated in a Sudanese simulation; a revised system will be used in U.S. and Singaporean experiments.

48) **Taxonomic and Faceted Classification for Intelligent Tagging and Discovery,** Dale E. Lichtblau, Andrew W. Trice, Steven P. Wartik, Proc. 2006 CCRTS, Paper 146, 2006.

a) **Abstract:** The success of Net-Centric Operations and Warfare (NCOW) depends upon the ability of net-centric environment (NCE) users—both human and automated—to readily discover useful information and services. Effective discovery requires, in turn, good semantic metadata "tagging" (i.e., indexing the functions of the services). Good tagging reflects the contextual relationships among the discoverable artifacts. It derives its value from the soundness—and intuitiveness—of its underlying approach to information and services classification. Unfortunately, classification "soundness" is mostly in the eye of the beholder, particularly for services that can be deployed for many different purposes, and not all necessarily foreseen by their initial developers. Ultimately, therefore, what is needed for more rapid and effective tagging and discovery is a services classification approach that accommodates multiple perspectives as to what constitutes a natural and intuitive characterization, plus tools that enable NCE users to take advantage of these capabilities without being overwhelmed by the sheer multiplicity of different classification perspectives. This paper presents a proposed structure for the semantic metadata that we believe will facilitate service and information discovery in the NCE, and will easily accommodate use by intelligent agents.

49) **A Framework for Supporting Teamwork between Humans and Autonomous Systems**, Elyon A.M. DeKoven, Anne K.G. Murphy, Proc. 2006 CCRTS, Paper 160, 2006.

a) **Abstract:** The US Army's vision of future warfare includes command and control (C2) of multiple manned and uninhabited assets in parallel. Central to this vision are human-robotic teams, in which uninhabited assets and human warfighters operate in a coordinated fashion toward shared objectives. Effective C2 will require user interface controls that allow an operator to integrate all types of elements in these heterogeneous teams in support of effective coordinated tactics and procedures.The Intelligent Control Framework (ICF) project at Soar Technology is exploring issues related to the design and development of operator interfaces for C2 of manned and uninhabited assets. We are presently focused on aspects of teamwork related to collaborative planning. In this context, the ICF architecture forms a communicative substrate for human-system negotiation about task responsibilities and levels of autonomy among assets. This paper describes three tiers of collaboration that need to be supported in such C2 interfaces and the system intelligence required to support those tiers. We describe our implementation of an Adjustable Autonomy Module (AAM) as a partial fulfillment of these reasoning requirements within the ICF system, and use the three tiers to discuss lessons we have learned concerning interaction design to support operator system communication about plans and asset autonomy.

50) **The Impact of Synchronous Text-Based Chat on Military Command and Control,** Bryan A. Eovito, Proc. 2006 CCRTS, Paper 198, 2006.

a) **Abstract:** This research assesses the impact of synchronous (real-time), text-based chat on military command and control (C2) processes. Chat use among the services, particularly among joint forces, has evolved in ad hoc fashion to fill gaps in currently fielded C2 systems. This growth-by-improvisation inhibits clear definition of the underlying requirements: precisely what C2 deficiencies are being addressed by text-based chat tools? Or, from a bottom-up perspective: what capabilities do text-based chat tools bring to the war fighter? In this study we employ a broad set of use-cases to further refine why operators use chat based on how they apply chat to their specific combat problems. These use cases include ongoing combat operations in ENDURING FREEDOM, counter-insurgency operations in IRAQI FREEDOM, and disaster relief operations with Joint Task Force - Katrina. The focus of this study is on establishing operators' perceived requirements in light of the current capabilities delivered by the existing text-based chat tools. From these "reverse-engineered" requirements we propose future work to establish these communication capabilities in the next-generation C2 systems.

51) **The Implications of Complex Adaptive Systems Theory for C2**, Anne-Marie Grisogono, Proc. 2006 CCRTS, Paper 202, 2006.

a) **Abstract:** The study of Complex Adaptive Systems (CAS) has developed within a wide range of subject domains over the last couple of decades, spanning the biological sciences, economics, organisational science, public policy, environmental sciences, computer science, cognitive and social sciences, and lately, defence sciences. We have been researching how application of a CAS perspective to the most pressing and complex problems that defence faces can provide more effective tools and techniques to enable higher levels of

success in dealing with these challenging problems. This approach has proved very fruitful and has generated insights that could lead to implementable and testable strategy options in a wide range of defence areas – from strategic policy, the capability development process, and defence enterprise management to the design and evolution of complex defence systems and the command and control of tactical to strategic levels of operations. In this paper we will focus on the implications of CAS theory for C2, drawing on the understanding we have developed of what it is possible to do in the face of complexity, how adaptive mechanisms arise spontaneously in complex systems, how we may recognise them and influence their operation to better align with our purposes, and how we may develop additional adaptive mechanisms to foster more effective outcomes. The CAS we will address include not just the complex networked systems within our own forces, but also those of our allies and adversaries, and those existing in the overall environment in which we operate. All these systems influence both what we are expected to do and what we are able to do, therefore understanding how the adaptive mechanisms already operating in them shape their behaviour and how to harness those mechanisms to our purposes is potentially a very valuable and powerful strategy.

52) **Fusion Sub-System Design From an Integrated Command, Decision Support and ISR Perspective,** Michael Senglaub, Proc. 2006 CCRTS, Paper 222, 2006.
   a) **Abstract:** What we have identified is a suite of technologies that together define a solution to fusion which captures a reasoning model that supports fusion. It is this approach that is needed if we are to capture the human capability of performing fusion which has at its core a reasoning function. It is a hybridization of formal and temporal concept reasoning, Peircean reasoning with an instantiation of Mills canons, Modal logic and coupled to an architecture based on Hawkins model of the neocortex. The solution concept will have significant impact on sensor development and a major impact on information architecture design. The effort supporting this effort is working towards a 70-80 percent solution to demonstrate the capabilities and the feasibility of linkage of the technologies.

53) **On Applying Point-Interval Logic to Criminal Forensics**, Mashhood Ishaque Abbas Mashhood Ishaque, Abbas K. Zaidi, Alexander H. Levis, Proc. 2006 CCRTS, Paper 233, 2006.
   a) **Abstract:** Application of a temporal logic to forensic analysis, especially in answering certain investigative questions relating to time-sensitive information, is presented. A set of temporal facts is taken from the London bombing incident that took place on July 7, 2005, to illustrate the approach. The information used in the illustration is gathered through the online news sites. A hypothetical investigation on the information is carried out to identify certain time intervals of potential interest to crime investigators. A software tool called Temper that implements temporal logic is used.

54) **Distributed Perception Networks: An Architecture for Information Fusion Systems Based on Causal Probabilistic Models,** Gregor Pavlin, Patrick de Oude, Marinus Maris, Thomas Hood, IEEE Conference on Multisensor Fusion and Integration, 3-6 September, 2006, Heidelberg, Germany
   a) We introduce Distributed perception networks (DPNs), a distributed architecture for efficient and reliable fusion of large quantities of heterogeneous and noisy information. DPNs consist of agents, processing nodes with limited fusion capabilities, which cooperate and can autonomously form arbitrarily large compound classifiers. DPNs make use of causal models, which often facilitate analysis, design and maintenance of complex information fusion systems. Namely, observations obtained from different information sources often result from causal processes which in turn can be modeled with relatively simple, yet mathematically rigorous and compact probabilistic causal models. Such models, in turn, facilitate decentralized world modeling and information fusion.

55) **A Bayesian Approach to Information Fusion for Evaluating the Measurement Uncertainty,** Klaus-Dieter Sommer, Olaf Kühn,), Fernando Puente León, Bernd R.L. Siebert, IEEE Conference on Multisensor Fusion and Integration, 3-6 September, 2006, Heidelberg, Germany
   a) The Bayesian approach to uncertainty evaluation is a classical example for information fusion. It is based on both, the knowledge about the mesurement process and the input quantities. Appropriate pobability density functions for describing the input quantities may be obtained by utilizing the principle of maximum information entropy and the Bayes theorem. The knowledge about the mesurement process is represented by the so-called model equation which forms the basis for the fusion of all involved input quantities. Compared to the ISO-GUM procedure, the (fully) Bayesian approach to uncertainty evaluation does not have any restrictions related to nonlinearity and determination of confidence intervals.

56) **Wearable Cognitive Monitors for Dismounted Warriors,** James B. Sampson, Proceedings of HCI 2006
   a) The ultimate goal of the Augmented Cognition (AugCog) program is to improve the warfighter's ability to process information while operating under stressful conditions of the battlefield. The mechanism for doing this is to monitor the combatant's psychophysiological state in real time, determine cognitive state, and then influence the information flow so as to maintain or enhance performance. Papers in this session deal with the challenge of taking the biometric indicators of user cognitive states developed from laboratory studies and

making them relevant to a user in an operational environment. The research completed to date and reported in this session represents incremental steps toward this objective. Two key questions to be asked for the dismounted warrior are "Can un-tethered wearable and rugged sensor systems be developed for military operations?" and "Are cognitive states of individuals measured in laboratory comparable to cognitive states of individuals moving about in operational environments?" The reliability and durability of sensors, signal-noise ratios, motion artifacts, and simplicity of operation are issues these investigators are pursuing to address the first question. The latter question calls for research on the expected differences in the psychophysiology of individuals in low mobility laboratory experiments to those of the physically more active tasks of missions in the field under stress. Thus, studies in the next phase of the program will have to investigate the more cognitively complicated processes of combat like activities. New classifications and measures of the cognitive dynamics will certainly be needed. Additional sensors may also be required to account for the operator's context in terms of tactical movements and engagement with rapidly changing events. The context monitors will also have to be part of the wearable system that are, at the same time, tough-durable, easy to don and doff and relatively invisible to the operator. These are some of the critical issues that need to be considered for making AugCog operationally viable for a dismounted operator.

57) **Assessing Influences of Verbal and Spatial Ability on Multimodal C2 Task Performance,** Leah M. Reeves, Ali Ahmad, Kay M. Stanney, Proceedings of HCI 2006

a) Due to the current lack of empirical evidence and principle-driven guidelines, designers often encounter difficulties when choosing the most appropriate modal display and interaction techniques for given users, applications, or specific military command and control (C2) tasks within C4ISR systems. The development of multimodal design guidelines from both a user and task domain perspective is thus critical to the achievement of successful Human Systems Integration (HSI) within military environments such as C2 systems. The present study focused on preliminary evidence indicating that how well a person processes spatial and/or verbal information may be a significant factor in determining how they will perform in multimodal, multi-task situations. The current results provide initial empirical support in identifying user attributes, such as spatial ability ($p < 0.02$) and learning style ($p < 0.03$), which may aid in developing principle-driven guidelines for how and when to effectively present taskspecific modal information to improve C2 operators' performance. Future research will examine more spatial and verbal ability tests that may be significant predictors of performance and thus likely candidates for incorporation into a Tool for Information Processing Capacity Assessment (TIPCA) currently under development (Stanney, Reeves, Hale, Samman & Buff, 2003).

58) **Assessing the Use of Virtual Environments to Train Soldiers1,** Bruce W. Knerr, Patrick J. Garrity, James R. Grosse, Proceedings of HCI 2006

a) This paper describes two research projects conducted in 2004 to facilitate the transition of virtual training systems for Infantry Soldiers from the research and development environment to field use. They took different approaches to creating a virtual training capability that could be used both in garrison and while deployed. One used wearable simulators and head-mounted displays. The other installed desktop and immersive simulators in a transportable shelter for integration with a live training facility. The procedures used to evaluate the usability of the technology by Soldiers, the results obtained using those procedures, and the implications of those results for the design of future systems are described. It appears that virtual simulation technology is sufficiently mature to provide a valuable addition to the dismounted Soldier training mix. It can provide additional practice in urban operations to supplement the use of a live training site. The factors it appears to be best suited for training are planning, situation assessment, and communication and coordination. The primary advantages of virtual simulation, relative to live simulation, are the variety of training environments and locations that it can represent, and the reduced time that is required to prepare for and conduct and exercise. Major technical challenges remaining are the improvement of precise movement (particularly in confined areas), the representation and recording of radio and face-to-face communications, and improved auditory presentation of battlefield sounds.

59) **AugCogifying the Army's Future Warfighter,** Patricia May Ververs, Stephen D. Whitlow, Michael C. Dorneich, Santosh Mathan, James B. Sampson, Proceedings of HCI 2006

a) The U.S. Army wants to ensure that the Future Force Warrior (FFW) will see first, understand first, act first and finish decisively as the means to tactical success. The Army of the future conceives of small combat units with netted communications enhanced with information from distributed and fused sensors, tactical intelligent assets enabling increased situation assessment, and on-the-move planning (FFW, 2004). The increase in information flow won't come without a cost, however. Information management will be a key aspect of this distributed system. The availability of such technologies as Augmented Cognition (AugCog), will allow the system to be tailored to the situational and cognitive needs of the warfighter. This paper describes an example of AugCog technology applied to a Communications System.

60) **Cognition, Teams, and Augmenting Team Cognition: Understanding Memory Failures in Distributed Human-Agent Teams**, Stephen M. Fiore, Florian Jentsch, Eduardo Salas, Neal Finkelstein, Proceedings of HCI 2006

a) Based upon the integration of constructs from organizational and cognitive science we present a theoretical framework for understanding memory function in the context of human-agent teams. To support the development of true Human Systems Integration, we use this approach to meld robust concepts in human cognition with human agent team research. Our goal is to illustrate the theoretical and practical importance of these concepts to team cognition in general and augmented cognition in particular. We discuss this through theory in human memory and memory failures and integrate approaches to illustrate their value to developing research plans for augmenting cognition.

61) **Beginning Design without a User Application of Scenario-Based Design** Dominic LaCava & Helena M. Mentis, Proceedings of HCI 2006

a) The user-centered design (UCD) process, much like any process, has to be adaptable to unknown situations and unconventional requirements. The following is a case study which exemplifies how the Human-Computer Interfaces group at Lockheed Martin pursued new endeavors in homeland security despite having no identifiable user by setting aside its UCD process and instead employing scenario-based design (SBD).

62) **Knowledge Explorer: An Interactive Tool for Supporting Cross-Community Discovery and Sharing of Knowledge,** Jasminko Novak, Michael Wurst, Proceedings of HCI 2006

a) Cross-community interactions have been recognized as critical source of knowledge creation and innovation. At the same time, most existing work has largely addressed the development of tools and systems for supporting knowledge sharing in teams or within communities. This paper discusses the design of the Knowledge Explorer, an interactive tool for supporting cross-community discovery and sharing of knowledge. We describe the developed model for unobtrusive construction of personalized knowledge maps and shared concept networks reflecting personal and community knowledge perspectives. We discuss how this has been realized in a concrete tool and present results of a formative usability evaluation applied to the Internet platform netzspannung.org.

63) **Virtual Environments for Training Decision Making,** T. Alexander, C. Winkelholz, H. Renkewitz, C. Schlick, Proceedings of HCI 2006

a) Virtual Environments are a promising and compelling tool for education and training. Compared to conventional simulators, VE-systems are smaller, more flexible, sometimes cheaper, and bring along a higher interactivity between trainee and educational content. But despite these advantages, unwanted negative side-effects (e.g. ocular strain, cybersickness) for the human trainee might occur, which limits their applicability. These effects are often caused by technological deficits like limited visual resolution, latency, and update rate. The occurrence and intensity of the side-effects are system-specific and have to be considered when selecting a special VE-system for an application. Consequently, some VE-systems might be better suited for special training objectives than others. The preferred VE-system should therefore be based primarily on the training objectives and not only on the subjective realism provided by the VE-system. This paper describes the capabilities of different Virtual and Augmented Environment technologies for training operators in decision making in Command and Control (C^2)

64) **Operator in the Loop? Adaptive decision support for military air missions**, Rob J Cottrell,Dave G Dixon, Tom Hope, Robert M Taylor, Proceedings of HCI 2006

a) Military decision makers must make timely decisions under conditions of high stress. Recent advances in decision support technology offer the opportunity to improve operator decision effectiveness through real-time processing of mission data to offer consistent, timely advice. Applied properly, decision support technology will enable human decision makers to take on roles that no single person could fulfill unaided. To realize this vision, decision support systems must encode the tactical knowledge and reasoning processes of the personnel they support. This development will challenge our traditional concepts of human-computer interaction, posing complex problems that demand novel solutions. This paper will consider two key issues – 'Adaptation' and 'Critiquing', as they apply to decision support for military air missions involving ground attack or reconnaissance roles. The need for adaptation stems from the dynamic nature of modern military operations, with the ability to tactically re-plan and re-prioritize while maintaining strategic objectives being of paramount importance. The need for critiquing stems from recognition of the fundamental limits applying to decision support systems – even comprehensive systems will be limited by knowledge-base constraints and by variations in the prevailing decision context which can potentially affect decision correctness. Thus there is a need for human operators to augment system behavior, bringing their inevitably greater understanding of

the mission – or decision - context to bear. For effective critiquing, the Decision Support System (DSS) needs to be transparent such that an operator can easily discover why particular advice was offered. These issues will be explored with specific reference to ongoing work in the development of an Adaptive Decision Support System (ADSS) for military air missions.

65) **Assisted Focus: Heuristic Automation for Guiding Users' Attention Toward Critical Information**, Mark St. John, Harvey S. Smallman, & Daniel I. Manes, Proceedings of HCI 2006

a) Theaters of operation are busy environments, and displays of tactical situations can quickly become congested and cluttered with military or other symbols. This clutter can distract users from critical information, unnecessarily increase workload, and delay responding. We have developed a concept called Assisted Focus that intelligently augments human attention by reducing clutter and helping users focus on critical information. In the domain of naval air warfare, this concept has required research into three related fields: 1) Algorithms for identifying high and low threat aircraft, 2) methods for directing users' attention toward high threats without reducing overall situation awareness, and 3) the design of human-automation interfaces to help users supervise and interact with realistically imperfect automated systems with sophistication and efficiency. Critically, our research indicates that the algorithms do not need to be perfect in order to significantly help users focus on important threats. The project culminated in an applied experiment to assess the concept within the domain of a realistic naval air defense task. In the experiment, 27 Navy air defense experts used Assisted Focus to identify threats and declutter a complex airspace. Assisted Focus decluttering improved response timeliness to threatening aircraft 25% compared with a baseline display, it was especially beneficial for threats in more peripheral locations, and 93% of the expert warfighters preferred the Assisted Focus display. In related work, we found that Assisted Focus and heuristic automation produced a 23% improvement in search times in a target detection task. Assisted Focus is applicable to a wide range of situation awareness and monitoring tasks.

66) **Augmenting Knowledge Flow and Comprehension in Command and Control (C2) Environments**, Ronald A. Moore, Proceedings of HCI 2006

a) The effective, efficient, and timely exchange of information in military command and control (C2) environments is vital to military operations in the 21st century. The amount and complexity of information that is made available to C2 decision makers and their support staffs by modern information technology presents unprecedented opportunities and challenges. However, despite decades of research and development in the domains of military C2 and decision making, three major human-related problems have consistently prevented true innovation. These problems are 1) information overload, 2) misplaced emphasis on information analysis and conscious thought, and 3) inappropriate focus on individuals/small teams versus larger groups within an environment. This paper describes an innovative approach to improving information processing and augmented communication which we refer to as Intelligent Aided Communication (iaC). The iaC concept holds much promise for meeting the current C2 challenges and affording new opportunities for improving military information exchange and decision making. The iaC concept and associated prototype address common C2 problems and lay the groundwork for more sophisticated, larger-scale efforts to develop an intelligent command center that is aware of, and better able to support its human symbiots in a complex C2 environment.

67) **On the Necessary and Sufficient Conditions of a Meaningful Distance Function for High Dimensional Data Space,** Chih-Ming Hsu, Ming-Syan Chen, Proceedings of the Sixth SIAM International Conference on Data Mining, 2006

a) The use of effective distance functions has been explored for many data mining problems including clustering, nearest neighbor search, and indexing. Recent research results show that if the Pearson variation of the distance distribution converges to zero with increasing dimensionality, the distance function will become unstable (or meaningless) in high dimensional space even with the commonly used Lp metric on the Euclidean space. This result has spawned many subsequent studies. We first comment that although the prior work provided the sufficient condition for the unstability of a distance function, the corresponding roof has some defects. Also, the necessary condition for unstability (i.e., the negation of the sufficient condition for the stability) of a distance function, which is required for function design, remains unknown. Consequently, we first provide in this paper a general proof for the sufficient condition of unstability. More importantly, we go further to prove that the rapid degradation of Pearson variation for a distance distribution is in fact a necessary condition of the resulting unstability. With the result, we will then have the necessary and the sufficient conditions for unstability, which in turn imply the sufficient and necessary conditions for stability. This theoretical result derived leads to a powerful means to design a meaningful distance function. Explicitly, in light of our results, we design in this paper a meaningful distance function, called Shrinkage-Divergence Proximity (abbreviated as SDP), based on a given distance function. It is empirically shown that the SDP

significantly outperforms prior measures for its being stable in high dimensional data space and robust to noise, and is thus deemed more suitable for distance-based clustering applications than the priorly used metric.

68) **Name Reference Resolution in Organizational Email Archives,** Christopher P. Diehl, Lise Getoory, Galileo Namataz, Proceedings of the Sixth SIAM International Conference on Data Mining, 2006

a) Online communications provide a rich resource for understanding social networks. Information about the actors, and their dynamic roles and relationships, can be inferred from both the communication content and tra±c structure. A key component in the analysis of online communications such as email is the resolution of name references within the body of the message. Name reference resolution relies on the context of the message; both the content of the message and the sender and recipients' relationships can help to resolve a reference. Here we investigate a variety of approaches which make use of the email traffic network to disambiguate email name references. The email traffic network serves as a proxy for inferring relationships. These relationships in turn help us infer likely candidates for the name references. Our initial findings suggest that simple temporal models can help us effectively resolve name references. For the class of models proposed, performance is maximized by exploiting long-term traffic statistics to rank candidates.

69) **Learning Bayesian Networks from Incomplete Data: An Efficient Method for Generating Approximate Predictive Distributions**, Carsten Riggelsen, Proceedings of the Sixth SIAM International Conference on Data Mining, 2006

a) We present an efficient method for learning Bayesian network models and parameters from incomplete data. With our approach an approximation is obtained of the predictive distribution. By way of this distribution any learning algorithm that works for complete data can be easily adapted to work for incomplete data as well. Our method exploits the dependence relations between the variables explicitly given by the Bayesian network model to predict missing values. Based on strength of influence and predictive quality, a subset of those predictor variables is selected, from which an approximate predictive distribution is generated by taking the observed part of the data into consideration. The approximate predictive distribution is obtained by traversing the data sample only twice and no iteration is required. Therefore our algorithm is more efficient than iterative algorithms such as EM and SEM. Our experiments show that the method performs well both for parameter learning and model learning compared to EM and SEM.

70) **Document Author Classification using Generalized Discriminant Analysis,** Todd K. Moon, Peg Howland, Jacob H. Gunther, Proceedings of the Sixth SIAM International Conference on Data Mining, 2006

a) Classification by document authorship based on statistical analysis — stylometry — is considered here by using feature vectors obtained from counts of all words in the intersecting sets of the training data. This differs from some previous stylometry, which used only selected “noncontextual” words with the highest counts, and also from conventional text search techniques, where noncontextual words are frequently left out when the term-by-document matrices are formed. The dimensionality of the resulting vector is reduced using a generalized discriminant analysis (GDA). The method is tested on three sets of documents which have been previously subjected to statistical analysis. Results show that the method is successful at identifying author differences and at classifying unknown authorship, consistent with previous techniques.

71) **Knowledge Perception Analysis in a Social Network,** Nishith Pathak, Sandeep Mane, Jaideep Srivastava, Noshir S.Contractor, Proceedings of the Sixth SIAM International Conference on Data Mining, 2006

a) Knowledge management in organizations is gaining in importance, especially with the advent of computer networks. Networks foster interaction between individuals, and have become the medium of choice for all types of interactions, both professional and social. In this research, we study the perception of knowledge in an organization’s email network. An important aspect of an individual’s knowledge is that it may be incomplete and hence any analysis approach must handle knowledge uncertainty. We propose an approach based on the Dempster-Shafer theory of evidence for modeling individuals’ perceptions about knowledge, thus enabling the understanding of knowledge in an organization. We show how correlating the knowledge of two or more individuals can help identify the discrepancies between them, and thus identify sources of organizational misperceptions. The proposed approach has been evaluated on the publicly available e-mail logs from the Enron Corporation. For the present study, meaning extraction from e-mail content was done manually. Initial results show that the approach is very promising. Our continuing research is focusing on applying techniques for automated identification of knowledge from email as well as sentiment analysis techniques for automated evaluation of individuals’ sentiments.

72) **The TOPHITS Model for Higher-Order Web Link Analysis,** Tamara Kolda, Brett Bader, Proceedings of the Sixth SIAM International Conference on Data Mining, 2006

a) As the size of the web increases, it becomes more and more important to analyze link structure while also considering context. Multilinear algebra provides a novel tool for incorporating anchor text and other information into the authority computation used by link analysis methods such as HITS. Our recently proposed TOPHITS method uses a higher-order analogue of the matrix singular value decomposition called the PARAFAC model to analyze a three-way representation of web data. We compute hubs and authorities together with the terms that are used in the anchor text of the links between them. Adding a third dimension to the data greatly extends the applicability of HITS because the TOPHITS analysis can be performed in advance and offline. Like HITS, the TOPHITS model reveals latent groupings of pages, but TOPHITS also includes latent term information. In this paper, we describe a faster mathematical algorithm for computing the TOPHITS model on sparse data, and Web data is used to compare HITS and TOPHITS. We also discuss how the TOPHITS model can be used in queries, such as computing context-sensitive authorities and hubs. We describe different query response methodologies and present experimental results.

73) **On Effectiveness of Wiretap Programs in Mapping Social Networks,** Maksim Tsvetovat, Kathleen M. Carley, Proceedings of the Sixth SIAM International Conference on Data Mining, 2006

a) On December 16, 2005, a New York Times article[31] revealed that in the immediate aftermath of the September 11th attacks, the National Security Agency began a broad program of domestic signal intelligence collection. As press reports indicated [28], NSA implemented its new collections program based on the snowball sampling methods, which is generally used in surveying hidden populations and networks. However, snowball method is known to be a biased toward highly connected actors[21] and consequently produces core-periphery networks when these may not necessarily be present. In case of terrorist networks, the last statement is particularly important in light of the "smoking gun" arguments presented by the government. In a further argument, the government argues that wiretaps on suspect terrorist operatives need to be put in place extremely fast and in large quantities, thus overloading the FISA[37] court system. In the use of snowball sampling, overload of information collection system does present a distinct problem due to exponential growth of the number of suspects to be monitored. In this paper, we will focus on evaluating the effectiveness of the wiretapping program in terms of mapping fastchanging networks of a covert organization. By running a series of simulation-based experiments, we are able to give a number of information gathering regimes a fair evaluation based on a consistent criteria. Further, we propose a set of information gathering programs that achieve higher effectiveness then snowball sampling, at a lower cost.

74) **Verifying Monotonicity of Bayesian Networks with Domain Experts**, Linda C. van der Gaag, Petra L. Geenen, and Hermina J.M. Tabachneck-Schijf, Proceedings of the 4th Bayesian Modelling Applications Workshop, 2006

a) In many real problem domains, the main variable of interest behaves monotonically in the ob- servable variables, in the sense that higher values for the variable of interest become more likely with higher-ordered observations. This type of knowledge appears to arise naturally during knowledge elicitation, without explicit prompting. The monotonicity properties declared by ex- perts, however, may not correspond to the mathematical concept of monotonicity in Bayesian net- works. We present a method for verifying, with the help of the experts, whether or not a network exhibits the implied properties of monotonicity. We illustrate the application of our method for a real Bayesian network in veterinary science.

75) **Modeling Human Reasoning about Meta-Information,** Sean Guarino, Jonathan Pfautz, Zach Cox, and Emilie Roth, Proceedings of the 4th Bayesian Modelling Applications Workshop, 2006

a) Information, as well as its qualifiers, or meta-information, forms the basis of human decisionmaking. Modeling human reasoning therefore requires the development of representations of both information and meta-information. However, while existing models and modeling approaches may include computational technologies that support meta-information analysis, they generally neglect its role in human reasoning. Herein, we describe the application of Bayesian Belief Networks to model how humans calculate, aggregate, and reason about meta- information when making decisions.

76) **Bayesian Model of the Effect of Personality in Predicting Decisionmaker Behavior,** Paul J. Sticha, Dennis M. Buede, and Richard L. Rees, Proceedings of the 4th Bayesian Modelling Applications Workshop, 2006

a) Predicting a leader's actions must take the Subject's personality into consideration in addition to relevant situational variables. This paper presents a methodology that enables the analyst to reason through a prediction of a Subject's decision making, to identify assumptions and determinant variables, and to quantify each variable's relative contribution to the prediction, producing a graphical representation of the analysis with explicit levels of uncertainty. The analyst builds Bayesian networks that integrate situational information with the Subject's personality and culture to provide a probabilistic prediction of the hypothesized actions a Subject might choose. The model development process allows the analyst to systematically develop hypotheses regarding potential actions, determine the Subject's most likely strategic objectives, identify relevant situational variables, estimate probabilistic relationships between variables, and assess the Subject's standing on several personality variables. The methodology has been applied to over a dozen historical and prospective situations.

77) **Applications of Bayesian Belief Networks in Social Network Analysis,** David Koelle, Jonathan Pfautz, Michael Farry, Zach Cox, Geoffrey Catto, and Joseph Campolongo, Proceedings of the 4th Bayesian Modelling Applications Workshop, 2006

a) In this paper, we discuss the use of Bayesian belief networks as a tool for enhancing social network analysis. Traditional social network analysis (SNA) primarily uses graph-theoretic algorithms to compute properties of nodes in a network. However, these algorithms assume a degree of completeness and reliability of the social network data, which cannot always be assured. Applying Bayesian belief networks to social network analysis provides additional capabilities for discovering new links and identifying particular nodes in the network that cannot be achieved using more traditional methods of social network analysis. We describe these applications of Bayesian belief networks and their implementation in a SNA tool.

78) **Bayesian Ontologies in AI Systems**, Paulo C. G. da Costa, Kathryn B. Laskey, and Ghazi AlGhamdi, Proceedings of the 4th Bayesian Modelling Applications Workshop, 2006

a) Ontologies have become ubiquitous in current- generation information systems. An ontology is an explicit, formal representation of the entities and relationships that can exist in a domain of application. Following a well-trodden path, initial research in computational ontology has neglected uncertainty, developing almost exclusively within the framework of classical logic. As appreciation grows of the limitations of ontology formalisms that cannot represent uncertainty, the demand from user communities increases for ontology formalisms with the power to express uncertainty. Support for uncertainty is essential for interoperability, knowledge sharing, and knowledge reuse. Bayesian ontologies are used to describe knowledge about a domain with its associated uncertainty in a principled, structured, sharable, and machine-understandable way. This paper considers Multi-Entity Bayesian Networks (MEBN) as a logical basis for Bayesian ontologies, and describes PR-OWL, a MEBN-based probabilistic extension to the ontology language OWL. To illustrate the potentialities of Bayesian probabilistic ontologies in the development of AI systems, we present a case study in information security, in which ontology development played a key role.

79) **Automated Knowledge Elicitation and Flowchart Optimization for Problem Diagnosis**, Alina Beygelzimer, Mark Brodie, Jonathan Lenchner, and Irina Rish, Proceedings of the 4th Bayesian Modelling Applications Workshop, 2006

a) The established procedure for problem diag- nosis in a wide variety of systems is often em- bodied in a flowchart or decision tree. These procedures are usually authored manually, which is extremely expensive and results in flowcharts that are difficult to maintain and often quite inefficient. A better diagnostic procedure would be one that automatically modifies itself in response to the frequency with which symptoms and underlying prob- lems occur, in order to minimize the average cost of diagnosis. We describe an approach to constructing a Bayesian network representation of diagnos- tic flowcharts, and demonstrate a system to support call center diagnostics based on this representation. One of the advantages of our approach is that it allows automated knowl- edge elicitation from "legacy" flowcharts. Us- ing the new representation, knowledge is eas- ier to author and maintain. By using in- formation gain as a search heuristic, nearly-optimal flowcharts can be generated in re- sponse to data about the frequency of sys- tem faults or symptoms. The approach al- lows both prior expert knowledge and train- ing data to be used to automatically generate and maintain flowcharts that respond flexibly to changing circumstances.

80) **Preventing Knowledge Transfer Errors: Probabilistic Decision Support Systems Through the Users' Eyes**, Hermina J.M. Tabachneck-Schijf and Petra L. Geenen, Proceedings of the 4th Bayesian Modelling Applications Workshop, 2006

a) Development and use of probabilistic decision support systems benefit by a good communica- tion between the developer on the one hand, and the user and the domain expert on the other hand. Communication is difficult because large differ- ences in training and experience exist between the two. This necessitates user-

centered design of the representations used in this communica- tion, and attention to the translation of user terms to model terms. A systematic approach to de- veloping user-centered representations and pre- venting knowledge transfer errors is outlined in this paper. We demonstrate how five heuristic guidelines can be fruitfully applied in different developer-user interaction situations in different phases of decision-support system construction.

81) **On Natural Language Processing and Plan Recognition**, Christopher W. Geib, Mark Steedman, Proceedings IJCAI-07, 2007
   a) **Abstract:** The research areas of plan recognition and natural language parsing share many common features and even algorithms. However, the dialog between these two disciplines has not been effective. Specifically, significant recent results in parsing mildly context sensitive grammars have not been leveraged in the state of the art plan recognition systems. This paper will outline the relations between natural language processing(NLP) and plan recognition(PR), argue that each of them can effectively inform the other, and then focus on key recent research results in NLP and argue for their applicability to PR.
82) **Holonic Multiagent Multilevel Simulation, Application to real-time pedestrians simulation in urban environment,** Nicolas Gaud, Franck Gechter, Stéphane Galland, Abderrafiâa Koukam Holonic, Proceedings IJCAI-07, 2007
   a) **Abstract:** Multi-Agent Systems (HMAS) are a convenient and relevant way to analyze, model and simulate complex and open systems. Accurately simulate in real-time complex systems, where a great number of entities interact, requires extensive computational resources and often distribution of the simulation over various computers. A possible solution to these issues is multilevel simulation. This kind of simulation aims at dynamically adapting the level of entities' behaviors (microscopic, macroscopic) while being as faithful as possible to the simulated model. We propose a holonic organizational multilevel model for real-time simulation of complex systems by exploiting the hierarchical and distributed properties of the holarchies. To fully exploit this model, we estimate the deviation of simulation accuracy between two adjacent levels through physics-based indicators. These indicators will then allow us to dynamically determine the most suitable level for each entity in the application to maintain the best compromise between simulation accuracy and available resources. Finally a 3D real-time multilevel simulation of pedestrians is presented as well as a discussion of experimental results.
83) **An Energy-Efficient, Multi-Agent Sensor Network for Detecting Diffuse Events,** Ronan Mac Ruairi, Mark T. Keane, Proceedings IJCAI-07, 2007
   a) **Abstract:** Monitoring a diffuse event with a wireless sensor network differs from well studied applications such as target tracking and habitat monitoring and therefore we suggest that new approaches are needed. In this paper we propose a novel low power technique based on a multiple agent framework. We show how a set of simple rules can produce complex behavior that encompasses event characterization and data routing. We demonstrate the approach and examine its accuracy and scalability using a simulated gaseous plume monitoring scenario.
84) **Opponent Modeling in Scrabble,** Mark Richards, Eyal Amir, Proceedings IJCAI-07, 2007
   a) **Abstract:** Computers have already eclipsed the level of human play in competitive Scrabble, but there remains room for improvement. In particular, there is much to be gained by incorporating information about the opponent's tiles into the decision-making process. In this work, we quantify the value of knowing what letters the opponent has. We use observations from previous plays to predict what tiles our opponent may hold and then use this information to guide our play. Our model of the opponent, based on Bayes' theorem, sacrifices accuracy for simplicity and ease of computation. But even with this simplified model, we show significant improvement in play over an existing Scrabble program. These empirical results suggest that this simple approximation may serve as a suitable substitute for the intractable partially observable Markov decision process. Although this work focuses on computer-vs-computer Scrabble play, the tools developed can be of great use in training humans to play against other humans.
85) **Detecting Stochastically Scheduled Activities in Video,** Octavian Udrea, Massimiliano Albanese, Vincezo Moscato, Antonio Picariello, V.S. Subrahmanian, Proceedings IJCAI-07, 2007
   a) **Abstract:** The ability to automatically detect activities in video is of increasing importance in applications such as bank security, airport tarmac security, baggage area security and building site surveillance. We present a stochastic activity model composed of atomic actions which are directly observable through image understanding primitives. We focus on answering two types of questions: (i) what are the minimal sub-videos in which a given action is identified with probability above a certain threshold and (ii) for a given video, can we decide which activity from a given set most likely occurred? We provide the MPS algorithm for the first problem, as well as two different algorithms (naiveMPA and MPA) to solve the second. Our experimental results on a dataset consisting of staged bank robbery videos show that our algorithms are both fast and provide high quality results when compared to human reviewers.
86) **Visually Tracking Football Games Based on TV Broadcasts,** Michael Beetz, Suat Gedikli, Jan Bandouch, Bernhard Kirchlechner, Nico v. Hoyningen-Huene, Alexander Perzylo, Proceedings IJCAI-07, 2007

a) **Abstract:** This paper describes ASPOGAMO, a visual tracking system that determines the coordinates and trajectories of football players in camera view based on TV broadcasts. To do so, ASPOGAMO solves a complex probabilistic estimation problem that consists of three subproblems that interact in subtle ways: the estimation of the camera direction and zoom factor, the tracking and smoothing of player routes, and the disambiguation of tracked players after occlusions. The paper concentrates on system aspects that make it suitable for operating under unconstrained conditions and in (almost) realtime. We report on results obtained in a public demonstration at RoboCup 2006 where we conducted extensive experiments with real data from live coverage of World Cup 2006 games in Germany.

87) **Structure Inference for Bayesian Multisensory Perception and Tracking,** Timothy M Hospedales, Joel J Cartwright, Sethu Vijayakumar, Proceedings IJCAI-07, 2007

a) **Abstract:** We investigate a solution to the problem of multi-sensor perception and tracking by formulating it in the framework of Bayesian model selection. Humans robustly associate multi-sensory data as appropriate, but previous theoretical work has focused largely on purely integrative cases, leaving segregation unaccounted for and unexploited by machine perception systems. We illustrate a unifying, Bayesian solution to multi-sensor perception and tracking which accounts for both integration and segregation by explicit probabilistic reasoning about data association in a temporal context. Unsupervised learning of such a model with EM is illustrated for a real world audio-visual application.

88) Adversarial Planning and Plan Recognition: Two Sides of the Same Coin, Sviatoslav Braynov, Proceedings of the The Second Secure Knowledge Management Workshop, 2006

a) Abstract: Effective adversarial plan recognition requires in- formation about how the adversary is planning his actions and vice versa, the way the adversary is planning his actions is affected by how those actions are going to be detected. In this paper, we develop a game-theoretic model that in- tegrates adversarial planning with adversarial plan recognition. The model considers planning and plan recognition to be in Nash equilibrium. The papers also shows how plan recognition could be ma- nipulated to the advantage of the adversary in the presence of incomplete information.

89) Controlled generation of hard and easy Bayesian networks: Impact on maximal clique size in tree clustering, Ole J. Mengshoela, David C. Wilkinsb, Dan Rothc, Artificial Intelligence, Vol 170, p 909-924, 2006

a) **Abstract:** This article presents and analyzes algorithms that systematically generate random Bayesian networks of varying difficulty levels, with respect to inference using tree clustering. The results are relevant to research on efficient Bayesian network inference, such as computing a most probable explanation or belief updating, since they allow controlled experimentation to determine the impact of improvements to inference algorithms. The results are also relevant to research on machine learning of Bayesian networks, since they support controlled generation of a large number of data sets at a given difficulty level. Our generation algorithms, called BPART and MPART, support controlled but random construction of bipartite and multipartite Bayesian networks. The Bayesian network parameters that we vary are the total number of nodes, degree of connectivity, the ratio of the number of non-root nodes to the number of root nodes, regularity of the underlying graph, and characteristics of the conditional probability tables. The main dependent parameter is the size of the maximal clique as generated by tree clustering. This article presents extensive empirical analysis using the Hugin tree clustering approach as well as theoretical analysis related to the random generation of Bayesian networks using BPART and MPART.

90) Analyzing the degree of conflict among belief functions, Weiru Liua, Artificial Intelligence, Vol 170, p 1137-1174, 2006

a) Abstract: The study of alternative combination rules in DS theory when evidence is in conflict has emerged again recently as an interesting topic, especially in data/information fusion applications. These studies have mainly focused on investigating which alternative would be appropriate for which conflicting situation, under the assumption that a conflict is identified. The issue of detection (or identification) of conflict among evidence has been ignored. In this paper, we formally define when two basic belief assignments are in conflict. This definition deploys quantitative measures of both the mass of the combined belief assigned to the emptyset before normalization and the distance between betting commitments of beliefs. We argue that only when both measures are high, it is safe to say the evidence is in conflict. This definition can be served as a prerequisite for selecting appropriate combination rules.

91) **New EM Derived from Kullback-Leibler Divergence,** Longin Jan Latecki, Marc Sobel, Rolf Lakaemper, Proc Twelfth ACM SIGKDD Int Conf Knowledge Discovery and Data Mining (KDD 2006), 20-23 August 2006, Philadelphia, USA.

a) **Abstract:** We introduce a new EM framework in which it is possible not only to optimize the model parameters but also the number of model components. A key feature of our approach is that we use nonparametric density estimation to improve parametric density estimation in the EM framework. While the classical EM algorithm estimates model parameters empirically using the data points themselves, we estimate them using nonparametric density estimates. There exist many possible applications that require optimal adjustment of model components. We present experimental results in two domains. One is polygonal approximation of laser range data, which is an active research topic in robot navigation. The other is grouping of edge pixels to contour boundaries, which still belongs to unsolved problems in computer vision.

92) **Group Formation in Large Social Networks: Membership, Growth, and Evolution,** Lars Backstrom, Dan Huttenlocher, Jon Kleinberg, Xiangyang Lan, Proc Twelfth ACM SIGKDD Int Conf Knowledge Discovery and Data Mining (KDD 2006), 20-23 August 2006, Philadelphia, USA.
   a) **Abstract**: The processes by which communities come together, attract new members, and develop over time is a central research issue in the social sciences—political movements, professional organizations, and religious denominations all provide fundamental examples of such communities. In the digital domain, on-line groups are becoming increasingly prominent due to the growth of community and social networking sites such asMySpace and LiveJournal. However, the challenge of collecting and analyzing large-scale timeresolved data on social groups and communities has left most basic questions about the evolution of such groups largely unresolved: what are the structural features that influence whether individuals will join communities, which communities will grow rapidly, and how do the overlaps among pairs of communities change over time? Here we address these questions using two large sources of data: friendship links and community membership on LiveJournal, and co-authorship and conference publications in DBLP. Both of these datasets provide explicit user-defined communities, where conferences serve as proxies for communities in DBLP. We study how the evolution of these communities relates to properties such as the structure of the underlying social networks. We find that the propensity of individuals to join communities, and of communities to grow rapidly, depends in subtle ways on the underlying network structure. For example, the tendency of an individual to join a community is influenced not just by the number of friends he or she has within the community, but also crucially by how those friends are are closely aligned with changes in the topics of interest within the communities.

93) **Center-Piece Subgraphs: Problem Definition and Fast Solutions,** Hanghang Tong, Christos Faloutsos, Proc Twelfth ACM SIGKDD Int Conf Knowledge Discovery and Data Mining (KDD 2006), 20-23 August 2006, Philadelphia, USA.
   a) **Abstract**: Given Q nodes in a social network (say, authorship network), how can we find the node/author that is the centerpiece, and has direct or indirect connections to all, or most of them? For example, this node could be the common advisor, or someone who started the research area that the Q nodes belong to. Isomorphic scenarios appear in law enforcement (find the master-mind criminal, connected to all current suspects), gene regulatory networks (find the protein that participates in pathways with all or most of the given Q proteins), viral marketing and many more. Connection subgraphs is an important first step, handling the case of Q=2 query nodes. Then, the connection subgraph algorithm finds the b intermediate nodes, that provide a good connection between the two original query nodes. Here we generalize the challenge in multiple dimensions: First, we allow more than two query nodes. Second, we allow a whole family of queries, ranging from 'OR' to 'AND', with 'softAND' in-between. Finally, we design and compare a fast approximation, and study the quality/speed trade-off. We also present experiments on the DBLP dataset. The experiments confirm that our proposed method naturally deals with multi-source queries and that the resulting subgraphs agree with our intuition. Wall-clock timing results on the DBLP dataset show that our proposed approximation achieve good accuracy for about 6 : 1 speedup.

94) Learning to Rank Networked Entities, Alekh Agarwal, Soumen Chakrabarti, Sunny Aggarwal, Proc Twelfth ACM SIGKDD Int Conf Knowledge Discovery and Data Mining (KDD 2006), 20-23 August 2006, Philadelphia, USA.
   a) Abstract: Several algorithms have been proposed to learn to rank entities modeled as feature vectors, based on relevance feedback. However, these algorithms do not model network connections or relations between entities. Meanwhile, Pagerank and variants find the stationary distribution of a reasonable but arbitrary Markov walk over a network, but do not learn from relevance feedback. We present a framework for ranking networked entities based on Markov walks with parameterized conductance values associated with the network edges. We propose two flavors of conductance learning problems in our framework. In the first setting, relevance feedback comparing node-pairs hints that the user has one or more hidden preferred communities with large edge conductance, and the algorithm must discover these communities. We present a constrained maximum entropy network flow formulation whose dual can be solved efficiently using a cutting-plane approach and a quasi-Newton optimizer. In the second setting, edges have types, and relevance feedback hints that each edge type has a potentially different conductance, but this is fixed across the whole network. Our algorithm learns the conductances using an approximate Newton method**.**

95) **Robust Recognition of Physical Team Behaviors using Spatio-temporal Models,** G. Sukthankar, K. Sycara, Proceedings of Fifth International Joint Conference on Autonomous Agents and Multi-Agent Systems (AAMAS), May, 2006.
   a) **Abstract:** This paper presents a framework for robustly recognizing physical team behaviors by exploiting spatio-temporal patterns. Agent team behaviors in athletic and military domains typically exhibit an observable structure characterized by the relative positions of teammates and external landmarks, such as a team of soldiers ambushing an opponent or a soccer player moving to receive a pass. We demonstrate how complex team relationships that are not easily expressed by region-based heuristics can be modeled from data and domain knowledge in a way that is robust to noise and spatial variation. To represent team behaviors in our domain of MOUT (Military Operations in Urban Terrain) planning, we employ two classes of spatial

models: 1) team templates that encode static relationships between team members and external landmarks; and 2) spatially-invariant Hidden Markov Models (HMMs) to represent evolving agent team configurations over time. These two classes of models can be combined to improve recognition accuracy, particularly for behaviors that appear similar in static snapshots. We evaluate our modeling techniques on large urban maps and position traces of two-person human teams performing MOUT behaviors in a customized version of Unreal Tournament (a commercially available first-person shooter game).

96) **Simultaneous Team Assignment and Behavior Recognition from Spatio-temporal Agent Traces,** G. Sukthankar, K. Sycara, Proceedings of Twenty-First National Conference on Artificial Intelligence (AAAI-06), July, 2006

a) **Abstract**: This paper addresses the problem of activity recognition for physically-embodied agent teams. We define team activity recognition as the process of identifying team behaviors from traces of agent positions over time; for many physical domains, military or athletic, coordinated team behaviors create distinctive spatio-temporal patterns that can be used to identify low-level action sequences. This paper focuses on the novel problem of recovering agent-to-team assignments for complex team tasks where team composition, the mapping of agents into teams, changes over time. Without a priori knowledge of current team assignments, the behavior recognition problem is challenging since behaviors are characterized by the aggregate motion of the entire team and cannot generally be determined by observing the movements of a single agent in isolation. To handle this problem, we introduce a new algorithm, Simultaneous Team Assignment and Behavior Recognition(STABR), that generates behavior annotations from spatio-temporal agent traces. STABR completely annotates agent traces with 1) the correct sequence of low-level actions performed by each agent and 2) an assignment of agents to teams over time. Our algorithm employs a randomized search strategy, RANSAC, to efficiently identify candidate team assignments at selected timesteps; these hypotheses are evaluated using dynamic programming to derive a parsimonious explanation for the entire observed spatio-temporal sequence. The proposed approach is able to perform accurate team behavior recognition without an exhaustive search over the combinatorial space of potential team assignments. Experiments on simulated military maneuvers demonstrate that STABR outperforms spatial clustering, both in assignment and recognition accuracy.

97) **Bayesian networks implementation of the Dempster-Shafer theory to model reliability uncertainty,** Christophe Simon, Philippe Weber, Proc First Int Conf Availability, Reliability and Security, pp. 6, 20-22 April 2006

a) **Abstract**: In many reliability studies based on data, reliability engineers face incompleteness and incoherency problems in the data. Probabilistic tools badly handle these kinds of problems thus, it is better to use formalism from the evidence theory. From our knowledge, there is a lack of industrial tools that implement the evidence theory. In this paper, the implementation of Dempster Shafer theory in a Bayesian network tool is proposed in order to compute system reliability and manage epistemic uncertainty propagation. The basic concepts used are presented and some numerical experiments are made to show how uncertainty is propagated.

98) **Evaluating risk from acts of terrorism with belief and fuzzy sets,** J. Darby, Proc 40th Annual 2006 Int Carnahan Conf Security Technology, pp. 273-280, 16-19 October 2006, Lexington, KY, USA. (IEEE Cat. No. 06CH37768)

a) **Abstract**: Risk consists of the likelihood of an event combined with the concequence of that event. There is uncertainty associated with an estimate of risk for an event that may happen in the future. For random, 'dumb' events, such as an eartquake, this uncertainty is aleatory (stochastic) in nature and can be addressed with the probability measure of uncertainty. A terrorist act is not a random event; it is an intentional act by a thinking malevolent adversary. Much of the uncertainty in estimating the risk of a terrorist act is epistemic (state of knowledge); the adversary knows what acts will be attemted, but we as a defender have incomplete knowledge to know those acts with certainty. To capture the epistemic uncertainty in evaluating the risk from acts of terrorism, we have applied the belief/plausibility measure of uncertainty from the Dempster-Shafer theory of evidence. Also, to address how we as a defender evaluate the selection of scenarios by an adversary, we have applied approximate reasoning with fuzzy sets. We have developed software to performe these evaluations.

99) **Handling Uncertainty and Ignorance in Databases: A Rule to Combine Dependent Data,** Sunil Choenni, Henk Ernst Blok, Erik Leertouwer, Proc 11th Int Conf Database Systems for Advanced Applications (DASFAA 2006), pp. 310-324, Springer (LNCS 3882) 12-15 April 2006, Singapore

a) **Abstract**: In many applications, uncertainty and ignorance go hand in hand. Therefore, to deliver database support for effective decision making, an integrated view of uncertainty and ignorance should be taken. So far, most of the efforts attempted to capture uncertainty and ignorance with probability theory. In this paper, we discuss the weakness to capture ignorance with probability theory, and propose an approach inspired by the Dempster-Shafer theory to capture uncertainty and ignorance. Then, we present a rule to combine dependent data that are represented in different relations. Such a rule is required to perform joins in a consistent way. We illustrate that our rule is able to solve the so-called problem of information loss, which was considered as an open problem so far.

100) **Strategies to manage ignorance situations in multiperson decision making problems,** S. Alonso, E. Herrera-Viedma, F. Chiclana, F. Herrera, C. Porcel, Proc 3rd Int Conf on Modeling Decisions for Artificial Intelligence (MDAI 2006), pp. 34-45, Springer (LNAI 3885), 3-5 April 2006

a) **Abstract:** Multiperson decision making problems involve using the preferences of some experts about a set of alternatives in order to find the best of those alternatives. However, sometimes experts cannot give all the information that they are required. Particularly, when dealing with fuzzy preference relations they can avoid giving some of the preference values of the relation. In the literature these incomplete information situations have been faced giving procedures which are able to compute missing information from the preference relations. However, these approaches usually need at least a piece of information about every alternative in the problem. In this paper, several strategies to manage total ignorance situations, that is, situations where an expert does not provide any information on at least one alternative are presented, and their advantages and disadvantages analised.

101) **Simultaneous decision networks with multiple objectives as support for strategic planning,** I. Blecic, A. Cecchini, G. A. Trunfio, Proc 3rd Int Conf on Modeling Decisions for Artificial Intelligence (MDAI 2006), pp. 81-92, Springer (LNAI 3885), 3-5 April 2006

a) **Abstract**: Strategic planning can be schematised as a decision making process where, given a general outline of the desirable future, the decision makers need to choose a set of actions that should coherently lead a system (corporation, institution, city, region, etc.) toward that future. A more sophisticated case is when rather than only choosing actions, the decision maker also decides the allocation of available resources among different available actions. We show that in most cases the problem can be faced using a particular Decision Network with multiple objectives, in which actions are applied simultaneously and are modelled by variables representing the efforts spent on them. The main advantage of the proposed Simultaneous Decision Network is that it can be easily built by a panel of domain experts, under the assumption of the noisy-OR causal interaction. The problem of finding the best strategy in terms of resource allocation is formulated as a combinatorial optimisation, and solved through a multi-objective meta heuristic approach.

102) LSP method and its use for evaluation of Java IDEs, Jozo J. Dujmović, Hajime Nagashima, International Journal of Approximate Reasoning 41(1):3-22, 2006

a) **Abstract**: In this paper we propose a quantitative model for evaluation and selection of integrated development environments (IDEs) for Java enterprise applications. Our goal is to determine the extent to which major IDEs satisfy typical software developer requirements. Our evaluation model is based on the Logic Scoring of Preference (LSP) method for system evaluation. We present an overview of the LSP method, the structure of IDE evaluation criterion, and a sample evaluation and comparison of three competitive systems: IBM WebSphere Studio Application Developer, Borland JBuilder, and SUN ONE Studio. In this paper we also introduce rectangular diagrams, an efficient new notation of LSP criteria.

103) **A rough set-based case-based reasoner for text categorization,** Y. Li, S.C.K. Shiu, S.K. Pal, J.N.K. Liu, International Journal of Approximate Reasoning 41(2):229-255, 2006

a) **Abstract**: This paper presents a novel rough set-based case-based reasoner for use in text categorization (TC). The reasoner has four main components: feature term extractor, document representor, case selector, and case retriever. It operates by first reducing the number of feature terms in the documents using the rough set technique. Then, the number of documents is reduced using a new document selection approach based on the case-based reasoning (CBR) concepts of coverage and reachability. As a result, both the number of feature terms and documents are reduced with only minimal loss of information. Finally, this smaller set of documents with fewer feature terms is used in TC. The proposed rough set-based case-based reasoner was tested on the Reuters21578 text datasets. The experimental results demonstrate its effectiveness and efficiency as it significantly reduced feature terms and documents, important for improving the efficiency of TC, while preserving and even improving classification accuracy.

104) **On the plausibility transformation method for translating belief function models to probability models,** Barry R. Cobb, Prakash P. Shenoy, International Journal of Approximate Reasoning 41(3):314-330, 2006

a) **Abstract**: In this paper, we propose the plausibility transformation method for translating Dempster–Shafer (D–S) belief function models to probability models, and describe some of its properties. There are many other transformation methods used in the literature for translating belief function models to probability models. We argue that the plausibility transformation method produces probability models that are consistent with D–S semantics of belief function models, and that, in some examples, the pignistic transformation method produces results that appear to be inconsistent with Dempster's rule of combination.

105) **Sequential influence diagrams: A unified asymmetry framework,** Finn V. Jensen, Thomas D. Nielsen, Prakash P. Shenoy, International Journal of Approximate Reasoning 42(1-2):101-118, 2006

a) **Abstract**: We describe a new graphical language for specifying asymmetric decision problems. The language is based on a filtered merge of several existing languages including sequential valuation networks, asymmetric influence diagrams, and unconstrained influence diagrams. Asymmetry is encoded using a

structure resembling a clustered decision tree, whereas the representation of the uncertainty model is based on the (unconstrained) influence diagram framework. We illustrate the proposed language by modeling several highly asymmetric decision problems, and we describe an efficient solution procedure.

106) **A forward–backward Monte Carlo method for solving influence diagrams,** Andrés Cano, Manuel Gómez, Serafín Moral, International Journal of Approximate Reasoning 42(1-2):119-135, 2006

a) **Abstract**: Although influence diagrams are powerful tools for representing and solving complex decision-making problems, their evaluation may require an enormous computational effort and this is a primary issue when processing real-world models. We shall propose an approximate inference algorithm to deal with very large models. For such models, it may be unfeasible to achieve an exact solution. This anytime algorithm returns approximate solutions which are increasingly refined as computation progresses, producing knowledge that offers insight into the decision problem.

107) **Generalizing variance to allow the inclusion of decision attitude in decision making under uncertainty,** Ronald R. Yager, International Journal of Approximate Reasoning 42(3):137-158, 2006

a) **Abstract**: The problem of decision making under uncertainty is considered. It is noted that an alternative is described in terms of an uncertainty profile. We observe that a major difficulty in the decision process is the comparison of these uncertainty profiles. We discuss the need for introducing some features of an uncertainty profile to help simplify this comparison. We note that the quantification of these simplifying features involves some subjective considerations about the decision makers preferences. We introduce the idea of the decision maker's attitudinal character to help in the formulation of these considerations. We then investigate two important features associated with an uncertainty profile. The first, the representative value, is a generalization of expected value commonly used under probabilistic uncertainty. The second, called the measure of deviation, provides a generalization of the concept of variance. We show how these new measures allows us to consider uncertainty profiles other then just the probabilistic one. They also allow us introduce other decision maker attitudes then the one implicitly assumed with the expected value and variance.

108) **Constructing belief functions from sample data using multinomial confidence regions,** Thierry Denœux, International Journal of Approximate Reasoning 42(3):228-252, 2006

a) **Abstract**: The transferable belief model is a subjectivist model of uncertainty in which an agent's beliefs at a given time are modeled using the formalism of belief functions. Belief functions that enter the model are usually either elicited from experts, or must be constructed from observation data. There are, however, few simple and operational methods available for building belief functions from data. Such a method is proposed in this paper. More precisely, we tackle the problem of quantifying beliefs held by an agent about the realization of a discrete random variable X with unknown probability distribution P_x, having observed a realization of an independent, identically distributed random sample with the same distribution. The solution is obtained using simultaneous confidence intervals for multinomial proportions, several of which have been proposed in the statistical literature. The proposed solution verifies two "reasonable" properties with respect to P_x: it is less committed than with some user-defined probability, and it converges towards P_x in probability as the size of the sample tends to infinity. A general formulation is given, and a useful approximation with a simple analytical expression is presented, in the important special case where the domain of X is ordered.

109) **Extensions of the multicriteria analysis with pairwise comparison under a fuzzy environment,** Ming-Shin Kuo, Gin-Shuh Liang, Wen-Chih Huang, International Journal of Approximate Reasoning 42(3):228-252, 2006

a) **Abstract**: Multicriteria decision-making (MCDM) problems often involve a complex decision process in which multiple requirements and fuzzy conditions have to be taken into consideration simultaneously. The existing approaches for solving this problem in a fuzzy environment are complex. Combining the concepts of grey relation and pairwise comparison, a new fuzzy MCDM method is proposed. First, the fuzzy analytic hierarchy process (AHP) is used to construct fuzzy weights of all criteria. Then, linguistic terms characterized by L–R triangular fuzzy numbers are used to denote the evaluation values of all alternatives versus subjective and objective criteria. Finally, the aggregation fuzzy assessments of different alternatives are ranked to determine the best selection. Furthermore, this paper uses a numerical example of location selection to demonstrate the applicability of the proposed method. The study results show that this method is an effective means for tackling MCDM problems in a fuzzy environment.

110) **On Representation and Aggregation of Social Evaluations in Computational Trust and Reputation Models,** Jordi Sabater-Mir, Mario Paolucci, International Journal of Approximate Reasoning, to appear

a) **Abstract:** Interest for computational trust and reputation models is on the rise. One of the most important aspects of these models is how they deal with information received from other individuals. More generally, the critical choice is how to represent and how to aggregate social evaluations. In this article, we make an analysis of the current approaches of representation and aggregation of social evaluations under the guidelines of a set of basic requirements. Then we present two different proposals of dealing with uncertainty

in the context of the Repage system [1], a computational module for management of reputational information based on a cognitive model of imAGE, REPutation and their interplay already developed by the authors. We finally discuss these two proposals in the context of several examples.

111) **A Gaming Perspective on Command and Control,** Joel Brynielsson. PhD thesis, School of Computer Science and Communication, Royal Institute of Technology, Stockholm, Sweden, June 2006.

a) **Abstract:** In emergency management and in military operations, command and control comprises the collection of functions, systems and staff personnel that one or several executives draw on to arrive at decisions and seeing that these decisions are carried out. The large amount of available information coupled with modern computers and computer networks brings along the potential for making well-informed and quick decisions. Hence, decision-making is a central aspect in command and control, emphasizing an obvious need for development of adequate decision-supporting tools to be used in command and control centers. However, command and control takes place in a versatile environment, including both humans and artifacts, making the design of useful computer tools both challenging and multi-faceted. This thesis deals with preparatory action in command and control settings with a focus on the strategic properties of a situation, i.e., to aid commanders in their operational planning activities with the utmost goal of ensuring that strategic interaction occurs under the most favorable circumstances possible. The thesis highlights and investigates the common features of interaction by approaching them broadly using a gaming perspective, taking into account various forms of strategic interaction in command and control. This governing idea, the command and control gaming perspective, is considered an overall contribution of the thesis. Taking the gaming perspective, it turns out that the area ought to be approached from several research directions. In particular, the persistent gap between theory and applications can be bridged by approaching the command and control gaming perspective using both an applied and a theoretical research direction. On the one hand, the area of game theory in conjunction with research findings stemming from artificial intelligence need to be modified to be of use in applied command and control settings. On the other hand, existing games and simulations need to be adapted further to take theoretical game models into account. Results include the following points: (1) classification of information with proposed measurements for a piece of information's precision, fitness for purpose and expected benefit, (2) identification of decision help and decision analysis as the two main directions for development of computerized tools in support of command and control, (3) development and implementation of a rule based algorithm for map-based decision analysis, (4) construction of an open source generic simulation environment to support command and control microworld research, (5) development of a generic tool for prediction of forthcoming troop movements using an algorithm stemming from particle filtering, (6) a non-linear multi-attribute utility function intended to take prevailing cognitive decision-making models into account, and (7) a framework based on game theory and influence diagrams to be used for command and control situation awareness enhancements. Field evaluations in cooperation with military commanders as well as game-theoretic computer experiments are presented in support of the results.

112) **Constructing and Evaluating Sensor-Based Statistical Models of Human Interruptibility,** James Anthony Fogarty, PhD thesis, Human Computer Interaction Institute School of Computer Science Carnegie Mellon University Pittsburgh, Pennsylvania 15213, CMU-HCII-06-100, January 2006

a) **Abstract:** While people can typically make a rapid assessment of another person's interruptibility, current systems generally have no way to consider whether an interruption is appropriate. Systems therefore tend to interrupt at inappropriate times or unduly demand attention. Sensor-based statistical models of human interruptibility are one approach to addressing this problem. In a series of studies, we examine the feasibility and robustness of sensor-based statistical models of human interruptibility, creating models that perform better than human observers. We then present a tool to enable non-expert development of applications that use sensor-based statistical models of human situations. Our first study collects audio and video recordings in the normal work environments of several office workers. We measure their interruptibility by collecting interruptibility self-reports via experience sampling. We then use a Wizard of Oz method to examine the recordings and simulate many potential sensors. Building statistical models from these simulated sensors, we are able to evaluate potential sensors without actually building them. In our second study, human observers view the recordings and estimate the interruptibility of the office workers. Statistical models based on our simulated sensors perform better than these human observers. Our third study examines the robustness of this result by implementing and deploying real sensors with a more diverse set of office workers. While different sensors are more predictive for different types of office workers, even a general model performs better than the human observers. Because these first three studies are dominated by social engagement, our fourth study explicitly examines task engagement. We show that low-level programming environment events can be used to model when a programmer will choose to defer an interruption. We then develop Subtle, a tool to enable further research into how human computer interaction can best benefit from sensor-based statistical models of human situations. With an extensible sensing library, fully-automated iterative feature generation, and support for model deployment, Subtle enables non-expert development of applications that use sensor-based statistical models of human situations. Subtle allows human computer interaction researchers to focus on compelling applications and datasets, rather than the difficulties of collecting appropriate sensor data and learning statistical models. Finally, we present a summary of contributions and plans for future work.

113) **On transformations of belief functions to probabilities,** Milan Daniel, Int J Intelligent Systems 21(3):261-282, 2006

a) **Abstract**: Alternative approaches to the widely known pignistic transformation of belief functions are presented and analyzed. Pignistic, cautious, proportional, and disjunctive probabilistic transformations are examined from the point of view of their interpretation, of decision making and (from the point of view) of their commutation with rules (operators) for belief function combination. A relation to the plausibility probabilistic transformation is added.

114) **Robust Bayesianism: Relation to Evidence Theory,** Stefan Arnborg, Journal of Advances in Information Fusion, Vol. 1, No. 1, July 2006

a) **Abstract:** We are interested in understanding the relationship between Bayesian inference and evidence theory. The concept of a set of probability distributions is central both in robust Bayesian analysis and in some versions of Dempster-Shafer's evidence theory. We interpret imprecise probabilities as imprecise posteriors obtainable from imprecise likelihoods and priors, both of which are convex sets that can be considered as evidence and represented with, e.g., DS-structures. Likelihoods and prior are in Bayesian analysis combined with Laplace's parallel composition. The natural and simple robust combination operator makes all pairwise combinations of elements from the two sets representing the prior and likelihood. The DS-structures can represent one particular family of imprecise distributions, Choquet capacities. Our proposed combination operator is unique, and it has interesting normative and factual properties. We compare its behavior with other proposed fusion rules, and earlier efforts to reconcile Bayesian analysis and evidence theory. The behavior of the robust rule is consistent with the behavior of Mahler/Fixsen's modified Dempster's (MDS) rule, but not with Dempster's rule. The Bayesian framework is liberal in allowing all significant uncertainty concepts to be modeled and taken care of and is therefore a viable, but probably not the only, unifying structure that can be economically taught and in which alternative solutions can be modeled, compared and explained.

115) **Intelligent Human–Machine Interaction Based on Dynamic Bayesian Networks Probabilistic Intention Recognition,** Karim A. Tahboub, In Journal of Intelligent and Robotic Systems (2006) 45: 31–52 # Springer 2006 DOI: 10.1007/s10846-005-9018-0

a) **Abstract**. In this article, a novel human–machine interaction based on the machine intention recognition of the human is presented. This work is motivated by the desire that intelligent machines as robots imitate human–human interaction, that is to minimize the need for classical direct human–machine interface and communication. A philosophical and technical background for intention recognition is discussed. Here, the intention–action–state scenario is modified and modeled by Dynamic Bayesian Networks to facilitate for probabilistic intention inference. The recognized intention, then, drives the interactive behavior of the machine such that it complies with the human intention in light of the real state of the world. An illustrative example of a human commanding a mobile robot remotely is given and discussed in details. Key words: compliant interaction, dynamic Bayesian networks, human–machine interaction, human–robot interaction, intention recognition. Categories: intention recognition, intelligent systems, man–machine interaction, teleoperation.

116) **Autonomous vision networking: miniature wireless sensor networks with imaging technology,** Gioia Messinger, Giora Goldberg, Proc. SPIE Int. Soc. Opt. Eng. 6394, 63940W, 2006

a) **Abstract:** The recent emergence of integrated PicoRadio technology, the rise of low power, low cost, System-On-Chip (SOC) CMOS imagers, coupled with the fast evolution of networking protocols and digital signal processing (DSP), created a unique opportunity to achieve the goal of deploying large-scale, low cost, intelligent, ultra-low power distributed wireless sensor networks for the visualization of the environment. Of all sensors, vision is the most desired, but its applications in distributed sensor networks have been elusive so far. Not any more. The practicality and viability of ultra-low power vision networking has been proven and its applications are countless, from security, and chemical analysis to industrial monitoring, asset tracking and visual recognition, vision networking represents a truly disruptive technology applicable to many industries. The presentation discusses some of the critical components and technologies necessary to make these networks and products affordable and ubiquitous - specifically PicoRadios, CMOS imagers, imaging DSP, networking and overall wireless sensor network (WSN) system concepts. The paradigm shift, from large, centralized and expensive sensor platforms, to small, low cost, distributed, sensor networks, is possible due to the emergence and convergence of a few innovative technologies. Avaak has developed a vision network that is aided by other sensors such as motion, acoustic and magnetic, and plans to deploy it for use in military and commercial applications. In comparison to other sensors, imagers produce large data files that require pre-processing and a certain level of compression before these are transmitted to a network server, in order to minimize the load on the network. Some of the most innovative chemical detectors currently in development are based on sensors that change color or pattern in the presence of the desired analytes. These changes are easily recorded and analyzed by a CMOS imager and an on-board DSP processor. Image processing at the sensor node level may also be required for applications in security, asset management and process control. Due to the data bandwidth requirements posed on the network by video sensors, new networking protocols or video extensions to existing standards (e.g. Zigbee) are required. To this end, Avaak

has designed and implemented an ultra-low power networking protocol designed to carry large volumes of data through the network. The low power wireless sensor nodes that will be discussed include a chemical sensor integrated with a CMOS digital camera, a controller, a DSP processor and a radio communication transceiver, which enables relaying of an alarm or image message, to a central station. In addition to the communications, identification is very desirable; hence location awareness will be later incorporated to the system in the form of Time-Of-Arrival triangulation, via wide band signaling. While the wireless imaging kernel already exists specific applications for surveillance and chemical detection are under development by Avaak, as part of a co-founded program from ONR and DARPA. Avaak is also designing vision networks for commercial applications – some of which are undergoing initial field tests.

117) **Detection of human interaction from a distance using salient body behaviour modelling,** Hayley Hung, Shaogang Gong, Proc. SPIE Int. Soc. Opt. Eng. 6402, 640203, 2006

a) **Abstract:** Understanding far and close proximity human-human interaction observed from a distance is a necessary step towards automated suspicious or antisocial behaviour detection. Most previous work on human-human interaction has made the implicit assumption that interactions occur only at immediate spatial and temporal proximity between the subjects concerned. We propose a more realistic application of human-human interaction detection from surveillance data where the subjects of interest tend to be represented by few pixels relative to the rest of the scene. The subjects are represented by relatively few pixels since surveillance cameras are usually placed to maximise area coverage therefore there is a significant distance between the camera and the physical scene. This in itself is not so much of a disadvantage when we consider that interactions among subjects can occur between quite large distances in space. Our technique uses a spatial and temporal saliency measure to extract and select features using modifications to Kadir and Brady's scale saliency and Hung and Gong's temporal saliency algorithms respectively. From this, a hierarchical multi-scale model of a single person, his/her body pose and groups of people is formed. A person is represented by an elliptic blob where prominent oval-shaped parts are formed into a configuration. Interactions are identified by finding temporally correlated salient changes (we call events) in the probability distributions of our multi-scale configuration model. In this paper we will show how pose or configuration based models of the human body can provide a rich framework for modelling human-human interactive body behaviour even when body parts are occluded. In particular, the framework is suitable for extracting salient features from the human body where each part is represented by a few pixels in each image frame. The work is highly relevant to the development of automated systems for suspicious and antisocial behaviour detection and prevention.

118) **A mathematical approach for mission planning and rehearsal,** Erol Gelenbe, Yu Wang, Proc. SPIE Int. Soc. Opt. Eng. 6249, 62490Q, 2006

a) **Abstract:** The world that we live in is filled with large scale agent systems, from diverse fields such as biology, ecology or finance. Inspired by the desire to better understand and make the best out of these systems, we propose an approach which builds stochastic mathematical models, in particular G-networks models, that allow the efficient representation of systems of agents and offer the possibility to analyze their behavior using mathematics. This work complements our previous results on the discrete event simulation of adversarial tactical scenarios. We aim to provide insights into systems in terms of their performance and behavior, to identify the parameters which strongly influence them, and to evaluate how well individual goals can be achieved. With our approach, one can compare the effects of alternatives and chose the best one available. We model routine activities as well as situations such as: changing plans (e.g. destination or target), splitting forces to carry out alternative plans, or even changing on adversary group. Behaviors such as competition and collaboration are included. We demonstrate our approach with some urban military planning scenarios and analyze the results. This work can be used to model the system at different abstraction levels, in terms of the number of agents and the size of the geographical location. In doing so, we greatly reduce computational complexity and save time and resources. We conclude the paper with potential extensions of the model, for example the arrival of reinforcements, the impact of released chemicals and so on

119) **An information-based approach to decentralized multiplatform sensor management,** Christopher M. Kreucher, Keith D. Kastella, John W. Wegrzyn, Brent L. Rickenbach, Proc. SPIE Int. Soc. Opt. Eng. 6249, 62490H, 2006

a) **Abstract:** This paper describes a decentralized low communication approach to multi-platform sensor management. The method is based on a physicomimetic relaxation to a joint information theoretic optimization, which inherits the benefits of information theoretic scheduling while maintaining tractability. The method uses only limited message passing, only neighboring nodes communicate, and each node makes its own sensor management decisions. We show by simulation that the method allows a network of sensor nodes to automatically self organize and perform a global task. In the model problem, a group of unmanned aerial vehicles (UAVs) hover above a ground surveillance region. An initially unknown number of moving ground targets inhabit the region. Each UAV is capable of making noisy measurements of the patch of ground directly below, which provide evidence as to the presence or absence of targets in that sub-region. The goal of the network is to determine the number of targets and their individual states (positions and velocities) in the entire surveillance region through repeated interrogation by the individual nodes. As the individual nodes can only see a small portion of the ground, they must move in a manner that is both responsive to measurements and coordinated with other nodes.

120) **Hybrid evolutionary algorithms for network-centric command and control,** Deepak Khosla, Tom Nichols, Proceedings of SPIE -- Volume 6249, Defense Transformation and Network-Centric Systems, Raja Suresh, Editor, 624902, May. 2, 2006

a) **Abstract:** Network-centric force optimization is the problem of threat engagement and dynamic Weapon-Target Allocation (WTA) across the force. The goal is to allocate and schedule defensive weapon resources over a given period of time so as to achieve certain battle management objectives subject to resource and temporal constraints. The problem addresses in this paper is one of dynamic WTA and involves optimization across both resources (weapons) and time. We henceforth refer to this problem as the Weapon Allocation and Scheduling problem (WAS). This paper addresses and solves the WAS problem for two separate battle management objectives: (1) Threat Kill Maximization (TKM), and (2) Asset Survival Maximization (ASM). Henceforth, the WAS problems for the above objectives are referred to as the WAS-TKM and WAS-ASM, respectively. Both WAS problems are NP-complete problem and belong to a class of multiple-resource-constrained optimal scheduling problems. While the above objectives appear to be intuitively similar from a battle management perspective, the two optimal scheduling problems are quite different in their complexity. We present a hybrid genetic algorithm (GA) that is a combination of a traditional genetic algorithm and a simulated annealing-type algorithm for solving these problems. The hybrid GA approach proposed here uses a simulated annealing-type heuristics to compute the fitness of a GA-selected population. This step also optimizes the temporal dimension (scheduling) under resource and temporal constraints and is significantly different for the WAS-TKM and WAS-ASM problems. The proposed method provides schedules that are near optimal in short cycle times and have minimal perturbation from one cycle to the next.

121) **commonSense: a preprocessing system to identify errors in large transcribed corpora,** Ryan Propper, Keyvan Mohajer, Vaughan Pratt, Proceedings of SPIE -- Volume 6242, Multisensor, Multisource Information Fusion: Architectures, Algorithms, and Applications 2006, Belur V. Dasarathy, Editor, 62420B, Apr. 18, 2006

a) **Abstract:** A system was designed to locate and correct errors in large transcribed corpora. The program, called CommonSense, relies on a set of rules that identify mistakes related to homonyms, words with distinct definitions but identical pronunciations. The system was run on the 1996 and 1997 Broadcast News Speech Corpora, and correctly identified more than 400 errors in these data. Future work may extend CommonSense to automatically correct errors in hypothesis files created as the output of speech recognition systems.

122) **Higher-level fusion for military operations based on abductive inference: proof of principle,** Aleksandar V. Pantaleev, John Josephson, Proceedings of SPIE -- Volume 6242, Multisensor, Multisource Information Fusion: Architectures, Algorithms, and Applications 2006, Belur V. Dasarathy, Editor, 624207,Apr. 18, 2006

a) **Abstract:** The ability of contemporary military commanders to estimate and understand complicated situations already suffers from information overload, and the situation can only grow worse. We describe a prototype application that uses abductive inferencing to fuse information from multiple sensors to evaluate the evidence for higher-level hypotheses that are close to the levels of abstraction needed for decision making (approximately JDL levels 2 and 3). Abductive inference (abduction, inference to the best explanation) is a pattern of reasoning that occurs naturally in diverse settings such as medical diagnosis, criminal investigations, scientific theory formation, and military intelligence analysis. Because abduction is part of common-sense reasoning, implementations of it can produce reasoning traces that are very human understandable. Automated abductive inferencing can be deployed to augment human reasoning, taking advantage of computation to process large amounts of information, and to bypass limits to human attention and short-term memory. We illustrate the workings of the prototype system by describing an example of its use for small-unit military operations in an urban setting. Knowledge was encoded as it might be captured prior to engagement from a standard military decision making process (MDMP) and analysis of commander's priority intelligence requirements (PIR). The system is able to reasonably estimate the evidence for higher-level hypotheses based on information from multiple sensors. Its inference processes can be examined closely to verify correctness. Decision makers can override conclusions at any level and changes will propagate appropriately.

123) **Combining elements of information fusion and knowledge-based systems to support situation analysis**, Jean Roy, Proceedings of SPIE -- Volume 6242, Multisensor, Multisource Information Fusion: Architectures, Algorithms, and Applications 2006, Belur V. Dasarathy, Editor, 624202, Apr. 18, 2006

a) **Abstract:** Situation awareness has emerged as an important concept in military and public security environments. Situation analysis is defined as a process, the examination of a situation, its elements, and their relations, to provide and maintain a product, i.e., a state of situation awareness for the decision maker(s). It is well established that information fusion, defined as the process of utilizing one or more information sources over time to assemble a representation of aspects of interest in an environment, is a key enabler to meeting the demanding requirements of situation analysis. However, although information fusion is important, developing and adopting a knowledge-centric view of situation analysis should provide a more holistic perspective of this process. This is based on the notion that awareness ultimately has to do with having

knowledge of something. Moreover, not all of the situation elements and relationships of interest are directly observable. Those aspects of interest that cannot be observed must be inferred, i.e., derived as a conclusion from facts or premises, or by reasoning from evidence. This paper discusses aspects of knowledge, and how it can be acquired from experts, formally represented and stored in knowledge bases to be exploited by computer programs, and validated. Knowledge engineering is reviewed, with emphasis given to cognitive and ontological engineering. Facets of reasoning are discussed, along with inferencing methods that can be used in computer applications. Finally, combining elements of information fusion and knowledge-based systems, an overall approach and framework for the building of situation analysis support systems is presented.

124) **Data modeling for predictive behavior hypothesis formation and testing,** Holger M. Jaenisch, James W. Handley, Marvin H. Barnett, Richard Esslinger, David A. Grover, Jeffrey P. Faucheux, Kenneth Lamkin, Proceedings of SPIE -- Volume 6241, Data Mining, Intrusion Detection, Information Assurance, and Data Networks Security 2006, Belur V. Dasarathy, Editor, 62410P, Apr. 18, 2006

a) **Abstract:** This paper presents a novel hypothesis analysis tool building on QUEST and DANCER. Unique is the ability to convert cause/effect relationships into analytical equation transfer functions for exploitation. In this the third phase of our work, we derive Data Models for each unique word and its ontological associated unique words. We form a classical control theory transfer function using the associated words as the input vector and the assigned unique word as the output vector. Each transfer function model can be tested against new evidence to yield new output. Additionally, conjectured output can be passed through the inverse model to predict the requisite case observations required to yield the conjectured output. Hypotheses are tested using circumstantial evidence, notional similarity, evidential strength, and plausibility to determine if they are supported or rejected. Examples of solving for evidence links are provided from tool execution.

125) **A physical-space approach for the probability hypothesis density and cardinalized probability hypothesis density filters**, Ozgur Erdinc, Peter Willett, Yaakov Bar-Shalom, Proceedings of SPIE -- Volume 6236, Signal and Data Processing of Small Targets 2006, Oliver E. Drummond, Editor, 623619, May. 19, 2006

a) **Abstract:** The probability hypothesis density (PHD) filter, an automatically track-managed multi-target tracker, is attracting increasing but cautious attention. Its derivation is elegant and mathematical, and thus of course many engineers fear it; perhaps that is currently limiting the number of researchers working on the subject. In this paper, we explore a physical-space approach - a bin model - which leads us to arrive the same filter equations as the PHD. Unlike the original derivation of the PHD filter, the concepts used are the familiar ones of conditional probability. The original PHD suffers from a "target-death" problem in which even a single missed detection can lead to the apparent disappearance of a target. To obviate this, PHD originator Mahler has recently developed a new "cardinalized" version of PHD (CPHD). We are able to extend our physical-space derivation to the CPHD case as well. We stress that the original derivations are mathematically correct, and need no embellishment from us; our contribution here is to offer an alternative derivation, one that we find appealing.

126) **Higher category theory as a paradigm for network applications**, James R. Bonick, Proceedings of SPIE -- Volume 6235, Signal Processing, Sensor Fusion, and Target Recognition XV, Ivan Kadar, Editor, 623515, May. 17, 2006

a) **Abstract:** The importance of network science to the present and future military is unquestioned. Networks of some type pervade every aspect of military operations-a situation that is shared by civilian society. However, several aspects of militarily oriented network science must be considered unique or given significantly greater emphasis than their civilian counterparts. Military, especially battlespace, networks must be mobile and robust. They must utilize diverse sensors moving in and out of the network. They must be able to survive various modes of attack and the destruction of large segments of their structure. Nodes often must pass on classifications made locally while other nodes must serve as combined sensor/classifiers or information coordinators. They must be capable of forming fluidly and in an ad hoc manner. In this paper, it will be shown how category theory, higher category theory, and topos theory provide just the model required by military network science. Category theory is a well-developed mathematical field that views mathematical structures abstractly, often revealing previously unnoticed correspondences. It has been used in database and software modeling, and in sensor and data fusion. It provides an advantage over other modeling formalisms both in its generality and in its extensive theory. Higher category theory extends the insights of category theory into higher dimensions, enhancing robustness. Topos theory was developed, in part, through the application of category theory to logic, but it also has geometric aspects. The motivation behind including topos theory in network science is the idea that a mathematical theory fundamental to geometry and logic should be applicable to the study of systems of spatially distributed information and analysis flow. The structures presented in this paper will have profound and far-reaching applications to military networks.

127) **Belief network-based situation assessment for air operations centers,** Catherine Call, Paul Gonsalves, Proceedings of SPIE -- Volume 6235, Signal Processing, Sensor Fusion, and Target Recognition XV, Ivan Kadar, Editor, 623513, May. 17, 2006

a) **Abstract:** In dynamic environments (e.g. an Air Operations Center (AOC)), effective real-time monitoring of mission execution is highly dependent on situation awareness (SA). But whereas an individual's perception of mission progress is biased by his or her immediate tasks and environment, the combined perspectives of key individuals provides an effects-based assessment of the mission overall. Belief networks (BNs) are an ideal tool for modeling and meeting the requirements of SA: at the individual level BNs emulate a skilled human's information fusion and reasoning process in a multi-task environment in the presence of uncertainty. At the mission level, BNs are intelligently combined to yield a common operating picture. While belief networks offer significant advantages for SA in this manner, the work of defining and combining the models is difficult due to factors such as multiple-counting and conflicting reports. To address these issues, we develop a system consisting of three distinct functional elements: an off-line mechanism for rapid construction of a BN library of SA models tailored to different air combat operation situations and derived from knowledge elicitation with subject matter experts; an off-line mechanism to adapt and combine BN models that supports the ability to adjust the SA models over time and in response to novel situations not initially available or anticipated during model construction; and an on-line combination of SA models to support an enhanced SA and the ability to monitor execution status in real time and informed by and responsive to the individuals and situations involved.

128) **Effective behavioral modeling and prediction even when few exemplars are available,** Terrance Goan, Neelakantan Kartha, Ryan Kaneshiro, Inc Proceedings of SPIE -- Volume 6235, Signal Processing, Sensor Fusion, and Target Recognition XV, Ivan Kadar, Editor, 623511, May. 17, 2006

a) **Abstract:** While great progress has been made in the lowest levels of data fusion, practical advances in behavior modeling and prediction remain elusive. The most critical limitation of existing approaches is their inability to support the required knowledge modeling and continuing refinement under realistic constraints (e.g., few historic exemplars, the lack of knowledge engineering support, and the need for rapid system deployment). This paper reports on our ongoing efforts to develop Propheteer, a system which will address these shortcomings through two primary techniques. First, with Propheteer we abandon the typical consensus-driven modeling approaches that involve infrequent group decision making sessions in favor of an approach that solicits asynchronous knowledge contributions (in the form of alternative future scenarios and indicators) without burdening the user with endless certainty or probability estimates. Second, we enable knowledge contributions by personnel beyond the typical core decision making group, thereby casting light on blind spots, mitigating human biases, and helping maintain the currency of the developed behavior models. We conclude with a discussion of the many lessons learned in the development of our prototype Propheteer system.

129) **Bayes-invariant transformations of uncertainty representations,** Ronald Mahler, Proceedings of SPIE -- Volume 6235, Signal Processing, Sensor Fusion, and Target Recognition XV, Ivan Kadar, Editor, 62350O, May. 17, 2006

a) **Abstract:** Much effort has been expended on devising "conversions" of one uncertainty representation scheme to another- fuzzy to probabilistic, Dempster-Shafer to probabilistic, to fuzzy, etc. Such efforts have been hindered by the fact that uncertainty representation formalisms vary considerably in the degree of complexity of information which they encode. For example, 2M - 1 numbers are required to specify a Dempster-Shafer basic mass assignment (b.m.a.) on a space with M elements; whereas only M - 1 numbers are required to specify a probability distribution on the same space. Consequently, any conversion of b.m.a.'s to probability distributions will result in a huge loss of information. In addition, conversion from one uncertainty representation formalism to another should be consistent with the data fusion methodologies intrinsic to these formalisms. For b.m.a.'s to be consistently converted to fuzzy membership functions, for example, Dempster's combination should be transformed into fuzzy conjunction in some sense. In this paper we show that a path out of such quandaries is to realize that in many applications all information must ultimately be reduced to state estimates and covariances. Adopting a Bayesian approach, we identify Bayes-invariant conversions between various uncertainty representation formalisms.

130) **A theory of PHD filters of higher order in target number,** Ronald Mahler, Proceedings of SPIE -- Volume 6235, Signal Processing, Sensor Fusion, and Target Recognition XV, Ivan Kadar, Editor, 62350K, May. 17, 2006

a) **Abstract:** The multitarget recursive Bayes nonlinear filter is the theoretically optimal approach to multisensor-multitarget detection, tracking, and identification. For applications in which this filter is appropriate, it is likely to be tractable for only a small number of targets. In earlier papers we derived closed-form equations for an approximation of this filter based on propagation of a first-order multitarget moment called the probability hypothesis density (PHD). In a recent paper, Erdinc, Willett, and Bar-Shalom argued for the need for a PHD-type filter which remains first-order in the states of individual targets, but which is higher-order in target number. In this paper we show that this and much more is possible. We derive a closed-form cardinalized PHD (CPHD), filter, which propagates not only the PHD but also the entire probability distribution on target number.

131) **A market-based optimization approach to sensor and resource management,** Dan Schrage, Christopher Farnham, Paul G. Gonsalves, Proceedings of SPIE -- Volume 6229,

Intelligent Computing: Theory and Applications IV, Kevin L. Priddy, Emre Ertin, Editors, 62290I, May. 9, 2006

a) **Abstract:** Dynamic resource allocation for sensor management is a problem that demands solutions beyond traditional approaches to optimization. Market-based optimization applies solutions from economic theory, particularly game theory, to the resource allocation problem by creating an artificial market for sensor information and computational resources. Intelligent agents are the buyers and sellers in this market, and they represent all the elements of the sensor network, from sensors to sensor platforms to computational resources. These agents interact based on a negotiation mechanism that determines their bidding strategies. This negotiation mechanism and the agents' bidding strategies are based on game theory, and they are designed so that the aggregate result of the multi-agent negotiation process is a market in competitive equilibrium, which guarantees an optimal allocation of resources throughout the sensor network. This paper makes two contributions to the field of market-based optimization: First, we develop a market protocol to handle heterogeneous goods in a dynamic setting. Second, we develop arbitrage agents to improve the efficiency in the market in light of its dynamic nature.

132) **I-FGM: information retrieval in highly dynamic search spaces,** Eugene Santos, Jr., Eunice E. Santos, Hien Nguyen, Long Pan, John Korah, Qunhua Zhao, Morgan Pittkin, Proceedings of SPIE -- Volume 6229, Intelligent Computing: Theory and Applications IV, Kevin L. Priddy, Emre Ertin, Editors, 622901, May. 4, 2006,

a) **Abstract:** Intelligent foraging, gathering and matching (I-FGM) has been shown to be an effective tool for intelligence analysts who have to deal with large and dynamic search spaces. I-FGM introduced a unique resource allocation strategy based on a partial information processing paradigm which, along with a modular system architecture, makes it a truly novel and comprehensive solution to information retrieval in such search spaces. This paper provides further validation of its performance by studying its behavior while working with highly dynamic databases. Results from earlier experiments were analyzed and important changes have been made in the system parameters to deal with dynamism in the search space. These changes also help in our goal of providing relevant search results quickly and with minimum wastage of computational resources. Experiments have been conducted on I-FGM in a realistic and dynamic simulation environment, and its results are compared with two other control systems. I-FGM clearly outperforms the control systems.

133) **PEGASUS: an information mining system for TV news videos,** Jingen Liu, Yun Zhai, Mubarak Shah, Proceedings of SPIE -- Volume 6229, Intelligent Computing: Theory and Applications IV, Kevin L. Priddy, Emre Ertin, Editors, 622903, May. 9, 2006

a) **Abstract:** In this paper, we present the PEGASUS system. PEGASUS is an integrated news video search system with three major components: (1) user interface, where users can formulate search queries and browse the returned results; (2) server, which takes the queries from user interface, performs the searches and ranks the search results before returns them to the users; (3) data storage, which is composed of feature indexing system and video database. The PEGASUS system has the capability to allow users to perform fast multi-modality video search using video features, including features from both audio and visual portions of the videos. To search a target topic, the user first submits an initial query using the prior knowledge on the topic. Then, through a series of relevance feedback processes, a set of relevant video shots are returned by the system to the user. The user is able to further view the results using the video-on-demand (VoD) functionality of the system. The system has been constructed using over 45,000 news video shots, and it is available online of public access.

134) **Simulation-based planning for peacekeeping operations: selection of robust plans**, Cvetelina Cekova, B. Chandrasekaran, John Josephson, Aleksandar Pantaleev, Proceedings of SPIE -- Volume 6228, Modeling and Simulation for Military Applications, Kevin Schum, Alex F. Sisti, Editors, 622818, May. 22, 2006

a) **Abstract:** This research is part of a proposed shift in emphasis in decision support from optimality to robustness. Computer simulation is emerging as a useful tool in planning courses of action (COAs). Simulations require domain models, but there is an inevitable gap between models and reality - some aspects of reality are not represented at all, and what is represented may contain errors. As models are aggregated from multiple sources, the decision maker is further insulated from even an awareness of model weaknesses. To realize the full power of computer simluations to support decision making, decision support systems should support the planner in exporing the robustness of COAs in the face of potential weaknesses in simulation models. This paper demonstrates a method of exploring the robustness of a COA with respect to specific model assumptions about whose accuracy the decision maker might have concerns. The domain is that of peacekeeping in a country where three differenct demographic groups co-exist in tension. An external peacekeeping force strives to achieve stability, an improved economy, and a higher degree of democracy in the country. A proposed COA for such a force is simluated multiple times while varying the assumptions. A visual data analysis tool is used to explore COA robustness. The aim is to help the decision maker choose a COA that is likely to be successful even in the face of potential errors in the assumptions in the models.

135) **Modelling military information operations with multi-agent complex adaptive system techniques**, C. J. Willers, Proceedings of SPIE -- Volume 6228, Modeling and Simulation for Military Applications, Kevin Schum, Alex F. Sisti, Editors, 622812, May. 22, 2006

a) **Abstract:** The behaviour of a complex adaptive system (CAS) cannot be predicted from the behaviour of its constituent components. Individual components of the system interacts with each other such that the behaviour at the aggregate level is not predictable from knowledge about the components. Software agents based on the 'Belief-Desire-Intention' (BDI) paradigm are used to model the various roles and actors in a military complex adaptive system. Each agent can sense some aspects of its environment, interprets its sensory perceptions, and reacts in a manner consistent with its intended task or goal. The design of the system entails setting down the internal rules for each agent, as well as the rules of interaction between the agents. During the simulation run, the agents are allowed to interact according to their programmed rule sets, and the emergent behaviour of the system as a whole is observed. The application of complex adaptive system theory is used to model the interaction between elements of a military command and control system and information operations/warfare core areas. The purpose with the investigation is to investigate the optimal integration of activities between the various information operations core areas.

136) **Adaptation of a multi-resolution adversarial model for asymmetric warfare**, Brad Rosenberg, Paul G. Gonsalves, Proceedings of SPIE -- Volume 6228, Modeling and Simulation for Military Applications, Kevin Schum, Alex F. Sisti, Editors, 62280S, May. 22, 2006

a) **Abstract:** Recent military operations have demonstrated the use by adversaries of non-traditional or asymmetric military tactics to offset US military might. Rogue nations with links to trans-national terrorists have created a highly unpredictable and potential dangerous environment for US military operations. Several characteristics of these threats include extremism in beliefs, global in nature, non-state oriented, and highly networked and adaptive, thus making these adversaries less vulnerable to conventional military approaches. Additionally, US forces must also contend with more traditional state-based threats that are further evolving their military fighting strategies and capabilities. What are needed are solutions to assist our forces in the prosecution of operations against these diverse threat types and their atypical strategies and tactics. To address this issue, we present a system that allows for the adaptation of a multi-resolution adversarial model. The developed model can then be used to support both training and simulation based acquisition requirements to effectively respond to such an adversary. The described system produces a combined adversarial model by merging behavior modeling at the individual level with aspects at the group and organizational level via network analysis. Adaptation of this adversarial model is performed by means of an evolutionary algorithm to build a suitable model for the chosen adversary.

137) **Foresight for commanders: a methodology to assist planning for effects-based operations**, Paul K. Davis, James P. Kahan, Proceedings of SPIE -- Volume 6227, Enabling Technologies for Simulation Science X, Dawn A. Trevisani, Editor, 62270I, May. 22, 2006

a) **Abstract:** Looking at the battlespace as a system of systems is a cornerstone of Effects-Based Operations and a key element in the planning of such operations, and in developing the Commander's Predictive Environment. Instead of a physical battleground to be approached with weapons of force, the battlespace is an interrelated super-system of political, military, economic, social, information and infrastructure systems to be approached with diplomatic, informational, military and economic actions. A concept that has proved useful in policy arenas other than defense, such as research and development for information technology, addressing cybercrime, and providing appropriate and cost-effective health care, is foresight. In this paper, we provide an overview of how the foresight approach addresses the inherent uncertainties in planning courses of action, present a set of steps in the conduct of foresight, and then illustrate the application of foresight to a commander's decision problem. We conclude that foresight approach that we describe is consistent with current doctrinal intelligence preparation of the battlespace and operational planning, but represents an advance in that it explicitly addresses the uncertainties in the environment and planning in a way that identifies strategies that are robust over different possible ground truths. It should supplement other planning methods.

138) A **qualitative multiresolution model for counterterrorism**, Paul K. Davis, Proceedings of SPIE -- Volume 6227, Enabling Technologies for Simulation Science X, Dawn A. Trevisani, Editor, 62270F, May. 22, 2006

a) **Abstract**: This paper describes a prototype model for exploring counterterrorism issues related to the recruiting effectiveness of organizations such as al Qaeda. The prototype demonstrates how a model can be built using qualitative input variables appropriate to representation of social-science knowledge, and how a multiresolution design can allow a user to think and operate at several levels - such as first conducting low-resolution exploratory analysis and then zooming into several layers of detail. The prototype also motivates and introduces a variety of nonlinear mathematical methods for representing how certain influences combine. This has value for, e.g., representing collapse phenomena underlying some theories of victory, and for explanations of historical results. The methodology is believed to be suitable for more extensive system modeling of terrorism and counterterrorism.

139) **Theory and methods for supporting high-level decision making**, Paul K. Davis, James P. Kahan, Proceedings of SPIE -- Volume 6227, Enabling Technologies for Simulation Science X, Dawn A. Trevisani, Editor, 622701, May. 22, 2006

a) **Abstract:** High-level decision makers face complex strategic issues and decision support for such individuals needs to be topdown, and to use representations natural to their level and particular styles. Decision support should focus on objectives; uncertainties, which are often both large and deep; risks; and how to do well despite the uncertainties and risks. This implies that decision support should help identify flexible, adaptive, and robust strategies (FAR strategies), not strategies tuned to particular assumptions. Decision support should also have built-in zoom capability, since decision makers sometimes need to know the underlying basis for assessments in order to review and alter assumptions, and to communicate a concern about details that encourages careful work. These requirements apply to both strategic planning (e.g., force planning in DoD or the Services) and operations planning (e.g., a commander's war planning). This paper discusses how to meet the requirements and implications for further research and enabling technology.

140) **What is trackable?,** George Cybenko,Valentino Crespi, Goufei Jiang, Proceedings of SPIE -- Volume 6201, Sensors, and Command, Control, Communications, and Intelligence (C3I) Technologies for Homeland Security and Homeland Defense V, Edward M. Carapezza, Editor, 620107, May. 10, 2006

a) **Abstract:** We have developed a general framework, called a Process Query System (PQS), that serves as a foundation for formulating tracking problems, implementing software solutions to tracking problems and understanding theoretical issues related to tracking in specific scenarios. The PQS framework posits that an environment consists of multiple dynamical processes. Processes have states, state transitions (deterministic, nondeterministic or probabilistic) and observables related to state occupancy. Examples of such dynamical processes are nondeterministic automata, Hidden Markov Models and classical state space models. We define a tracking problem as the inverse problem of determining the processes and process states that explain a stream of observations. This paper describes a quantitative concept of trackability by considering the rate of growth of state sequences of a process model given a temporal sequence of observations. Recent formal results concerning this notion of trackability are summarized without proof. Complete proofs of the various results are contained in a technical report by the authors and cited in the bibliography.

141) **Identifying and tracking dynamic processes in social networks**, Wayne Chung, Robert Savell, Jan-Peter Schütt, George Cybenko, Proceedings of SPIE -- Volume 6201, Sensors, and Command, Control, Communications, and Intelligence (C3I) Technologies for Homeland Security and Homeland Defense V, Edward M. Carapezza, Editor, 620105, May. 10, 2006

a) **Abstract:** The detection and tracking of embedded malicious subnets in an active social network can be computationally daunting due to the quantity of transactional data generated in the natural interaction of large numbers of actors comprising a network. In addition, detection of illicit behavior may be further complicated by evasive strategies designed to camouflage the activities of the covert subnet. In this work, we move beyond traditional static methods of social network analysis to develop a set of dynamic process models which encode various modes of behavior in active social networks. These models will serve as the basis for a new application of the Process Query System (PQS) to the identification and tracking of covert dynamic processes in social networks. We present a preliminary result from application of our technique in a real-world data stream— the Enron email corpus.

142) **A Survey of Web Information Extraction Systems**, Chia-Hui Chang, Mohammed Kayed, Moheb Ramzy Girgis, Khaled F. Shaalan, IEEE Transactions on Knowledge and Data Engineering, 10(18):1411-1428, October 2006.

a) **Abstract**: The Internet presents a huge amount of useful information which is usually formatted for its users, which makes it difficult to extract relevant data from various sources. Therefore, the availability of robust, flexible Information Extraction (IE) systems that transform the Web pages into program-friendly structures such as a relational database will become a great necessity. Although many approaches for data extraction from Web pages have been developed, there has been limited effort to compare such tools. Unfortunately, in only a few cases can the results generated by distinct tools be directly compared since the addressed extraction tasks are different. This paper surveys the major Web data extraction approaches and compares them in three dimensions: the task domain, the automation degree, and the techniques used. The criteria of the first dimension explain why an IE system fails to handle some Web sites of particular structures. The criteria of the second dimension classify IE systems based on the techniques used. The criteria of the third dimension measure the degree of automation for IE systems. We believe these criteria provide qualitatively measures to evaluate various IE approaches.

143) **Countering Terrorism through Information and Privacy Protection Technologies**, Robert Popp, John Poindexter, IEEE Security & Privacy November/December 2006 (Vol. 4, No. 6) pp. 18-27

a) **Abstract:**Security and privacy aren't dichotomous or conflicting concerns--the solution lies in developing and integrating advanced information technologies for counterterrorism

along with privacy-protection technologies to safeguard civil liberties. Coordinated policies can help bind the two to their intended use.