DUCAS Pre-Trials

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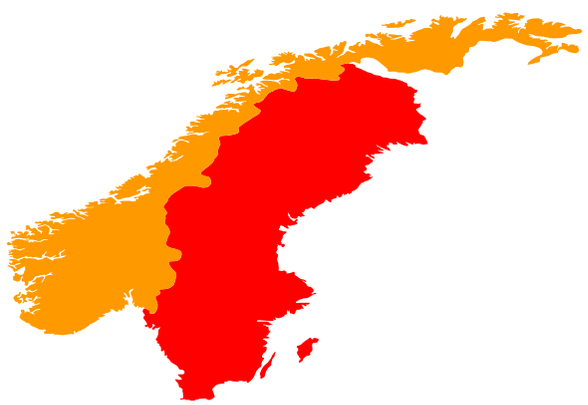

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Sammanfattning

DUCAS, *Detection in Urban scenario with Combined Airborne Sensor*, är ett EDA-projekt finansierat av de sju deltaganade länderna. DUCAS-konsortiet planerar att genomföra ett store fältförsök i Zeebrugge, Belgien, under sommaren 2011. Eftersom fältförsöket kommer att vara omfattande, med sensorer, data och databehandling distribuerat över flera länder, är en för-försöksövning planerad, huvudsakligen i form av datadistribution och distribuerad databehandling. Syftet med för-försöket är att öva och verifiera datadelnings och databehandlingsförmågor, för att på så vis identifiera eventuella kritiska problem i god tid innan det större fältförsöket.

Denna rapport beskriver status för för-försöken i september 2010.

Nyckelord:

Fältförsök, fjärranalys, spaning, hyperspektral, elektro-optiska sensorer.

Summary

DUCAS, *Detection in Urban scenario with Combined Airborne Sensor*, is an EDA project funded by the seven participating countries. The DUCAS consortium is planning a major field trial in Zeebrugge, Belgium, during summer 2011. Since the DUCAS main trial will be extensive, with sensors, data, and processing distributed over several nations, a pre-trial exercise is planned, mainly in the form of data sharing and distributed processing. The purpose of the pre-trial is to exercise and verify data sharing and processing capabilities, specifically to identify any critical problems well in advance of the main trial.

This status report describes the status of the pre-trials in early September 2010.

Keywords: Field trial, remote sensing, hyperspectral, electro-optical sensors.

Contents

1 The DUCAS Project

DUCAS, *Detection in Urban scenario with Combined Airborne Sensor*, is an EDA project funded by the seven participating countries (Sweden, Norway, Germany, the Netherlands, Belgium, France, and Italy). It started in January 2010 and will go on for four years. The three main goals of the project is

- To determine the performance for detection, recognition, and identification of difficult targets in urban environment with combined hyperspectral and high-resolution active and passive sensors, compared to conventional technology,
- To assess the improvement of situation awareness and surveillance capability in complex urban areas.
- To propose conceptual system designs.

The project is described (in Swedish) in [1].

The purpose of this report is to describe the purpose and the current status of the pre-trials. Section 1 describes the DUCAS trials, Section 2 describes the pre-trials, and Section 3 briefly describes the data sharing and the coming data processing.

1.1 DUCAS main trial

The DUCAS consortium is planning a major field trial in Zeebrugge, Belgium, during summer 2011. The trial will receive extensive support from the Belgian army, air force and navy, including ground forces executing scenarios (military exercises and placement of targets), access to an airbase, and access to a naval base. Zeebrugge city and naval base will constitute the trial site, and Koksijde air force base will be the base for the sensor platforms (aircraft) and on-site processing. Sensor platforms from several countries will fly over the trial site, collecting data for tactical intelligence, operations support, and surveillance. The planning of the trial is currently in the scenario definition phase, and the dialogue with the Belgian defence forces regarding specific equipment and personnel during the trial will start in October.

1.2 DUCAS pre-trials

Since the DUCAS main trial will be extensive, with sensors, data, and processing distributed over several nations, a pre-trial exercise is planned. The purpose of the pre-trial is to exercise and verify data sharing and processing capabilities, specifically to identify any critical problems well in advance of the main trial. Experience from previous projects (Spectral Imaging, Hipod) tells that unforeseen legal, bureaucratic, logistic and technical problems *will* arise when sharing data, especially between different nations. Most of the project consortium members have been working together before, presumably making everything run smoother.

The pre-trial data collection will be performed within the ongoing sensor system development and data collection activities within national projects.

A subset of the project participants will be involved in the pre-trial. Data will be collected by Sweden, Norway, and Germany. The collected data will be shared with all countries within the consortium, who will apply their own processing tools. In this way, we will confirm compatibility of data formats, procedures, processing tools and results.

2 Sensors, Platforms, and Trials

So far, Norway, Sweden and Germany have agreed to contribute to the pre-trials. However, since the German contribution will be at the grace of DLR who owns and operates the sensor, but is not a consortium partner, the trial plans are not included in this document.

Moreover, since the main trial is expected to include hyperspectral thermal imagery from a rented sensor, we have requested two competing sensor manufacturers/operators, Itres and Telops, to provide us with sensor data for evaluation.

2.1 Sweden

Sweden will exploit data from an already performed field trial described in [13].

2.1.1 Sensor

The used imager, an ImSpec sensor, is a visual and near-infrared (391-961 nm) hyperspectral imager from SpecIm [3,4], with 1024 pixels in each scan line and a maximum of 240 spectral bands. Due to limitations in the read-out electronics' data rate, the number of spectral bands might need to be reduced to meet requirements on the number of scan lines to be acquired per second. In this trial, 60 spectral bands were recorded, which is more than enough for our applications. The dynamic range is up to twelve bits, but in this case the used dynamic range was only around eight bits due to cloudy weather and low-light conditions. The sensor's integration time was set to 7 ms and the scan line frequency was set to 100 Hz. The IFOV is approximately 0.51 mrad and the FOV 29.9 degrees (1024 pixels).

2.1.2 Platform

The imager is mounted nadir-looking in a small fixed-wing aircraft as shown in Figure 1. The aircraft is equipped with gyro and GPS. At a flight speed of 166 km/h and an altitude of 1000 meters, the distance between the pixels is about 0.51 and 0.46 meters in the flight direction and in the cross-flight direction respectively. At 400 meters, the distances are 0.2 and 0.46 meters, respectively.

Figure 1: Sensor installation.

2.1.3 Trial scenario

Data was collected at the Swedish Army Ground Combat School's premises at Kvarn outside Linköping, Sweden. Data was collected over two areas, about 1800 meters long

and 580 meters wide at a flight altitude of 1000 meters (and 230 meters wide at 400 meters altitude). In one area, four military and two civilian vehicles were placed and moved between two positions between the data acquisitions. In the other area, around 20 boards of sizes from 7×7 m to 0.2×0.2 m large were placed and moved between two positions between the acquisitions. The vehicles and some of the boards are shown in Figure 2. The data set is available for download at the FOI website [7]. The data can be used freely for non-commercial use provided that the source is acknowledged. One data strip is shown in Figure 3.

Figure 2: Ground setup of Swedish pre-trial.

Figure 3: One data strip from the Swedish data set.

2.2 Norway

2.2.1 Sensor

The Norwegian sensor is the HySpex [5] sensor from Norsk ElektroOptikk [6]. It is a hyperspectral push-broom sensor operating in the VNIR and SWIR domain using separate camera modules. It has a very high spatial resolution in VNIR: 1600 spatial pixels across track with a pixel IFOV of 0.18 mrad across track and 0.36 mrad along track. Together with the NVIR module, either a SWIR module or a high-resolution panchromatic sensor can be installed in the aircraft. The SWIR module has a more modest resolution of 320 pixels, and the panchromatic sensor has 8000 pixels. Since other countries are bringing similar SWIR sensors, it is likely that the Norwegian setup will use the VNIR module and the panchromatic sensor. For the main trial, a thermal imager might be added as well.

2.2.2 Platform

The Norwegian sensors are mounted in a Cessna 172 4-seat single-engine aircraft. The cameras are mounted in a nadir viewing position without a stabilized platform. For navigation, the system employs a high-performance inertial sensor supplemented by a GPS and with post-processing using software developed at FFI. The resulting georeference accuracy is typically on the order of a few meters on the ground. Georeference data is stored at 18 points per scan line.

2.2.3 Trial scenario

Data will be collected over the centre of Oslo. Several image strips will be recorded a few minutes apart, and normal city activity will ensure there are plenty of changes between the strips.

Radiance measurements will be available for a couple of controlled targets on the ground. Otherwise the urban background provides a lot of clutter and changes, although with no independent ground truth.

3 Data Exchange and Processing

3.1 Data preparation and delivery

3.1.1 Selection

Data selection will be performed by the data collectors and a subset of the data be passed on to the consortium partners.

3.1.2 Delivery

Data will be delivered on hard disks, CD/DVD media, or be made available online for download. Data will be delivered to each project participant who notifies its interest in the data.

3.1.3 Formats

- Push-broom data (e.g., hyperspectral imagery) and high dynamic range (HDR) data (e.g., 16-bit thermal imagery). Data should be in ENVI format, i.e., each image strip is represented by a data file and an ASCII header file as defined by ENVI User's Guide, Appendix V: ENVI File Formats (pp. 879-882).
- Single- or multispectral low-dynamic range data (e.g., "ordinary" RGB images). Data should be in RAW, TIFF, PNG or JFIF (JPEG) format. Destructive image compression (JFIF/JPEG) should be used with care and preferably only for imagery used for visualization (in contrast to signal processing).
- Georeference data format is still to be decided.
    - The coordinate system used shall be WGS84 lat/long, alternatively a conversion method should be provided.
    - For orthorectified images, the pixel footprint size together with the WGS84 coordinate of one corner should be provided (for example in the ENVI ASCII header).
    - For other images, a coordinate image in ENVI format should be delivered. Band 1 then represents the N-S coordinate and band 2 the W-E coordinate (32 or 64 bit floating point number, with degrees as the unit). An optional third band can contain the height (in meters above sea level).
    - Auxillary information, e.g., GPS and gyro data should be provided in a documented format (in order to enable later recomoutation of the georeference data, e.g., when a new DEM is available).
- Target/object mask format is still to be decided. Possible alternatives are:
    - Single band images with no or lossless compression (BMP or PNG format).
    - ENVI mask files exported in to ASCII.
- For the main trial, image sequences (video) will be delivered as well. To be decided.

3.2 Processing

Partners participating in the work package on processing (WP3) will apply their available tools on the delivered data. Examples are:

- Registration. Data is typically not georeferenced with high enough precision to enable pixel-wise fusion or change detection. Thus, image-based registration methods will be tried out in order to enhance the precision.
- Fusion. With more than one sensor observing an area, analysis can be performed simultaneously in multiple domains.
- Change detection. Provided that registration is performed with high enough precision, change detection between two time instances can be done. However, due to environmental changes, most notably change in incoming light, radiometric compensation is needed as well.
- Anomaly detection. In the previous projects (Spectral Imaging, Hipod), anomaly detection was successfully demonstrated in rural environment. Since DUCAS focuses on urban environment, anomaly detection might be less useful.
- Target detection. Target detection might be tested on the pre-trial data. Since the pre-trials are somewhat simplistic, without ground truth, laboratory measurements or signature intelligence, no strong results are expected. However, concepts can still be demonstrated.

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