Benefits for Environmental Applications Using TUBSATs Real-Time Video Payload

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ABSTRACT

Focusing on LAPAN-TUBSAT the usability of the TUBSAT (Technische Universität Berlin Satellite) platform for environmental applications is investigated. The test bed is the super-test site DEMMIN (Durable Environmental Multidisciplinary Monitoring Information Network) for calibrating and validating satellite systems.

The TUBSATs are university class microsatellites for remote sensing featuring high resolution real-time video. The imaging payload was designed to verify the high resolution attitude control system which is particularly flexible (interactive attitude control, extraordinary maneuverability) but was not specifically configured to meet commercial requirements of remote sensing. Nevertheless it is possible to derive valuable data in several environmental applications.

Two main application categories can be defined. The first make direct use of the real time video as the satellite acts like a remote sensing drone or a helicopter by means of counter-rotations. Applications include in-situ analysis (advance monitoring) of environmental situations to support large terrestrial and air/space borne activities, illegal deforestation or disaster monitoring (volcanoes, floods, bush fire, oil spill). The second objective is feature detection and analysis using extracted single images from the video data stream and spatial analysis for agricultural and silvicultural evaluations of crop, growth and stress situations (e.g. Pests).

LAPAN-TUBSAT is operated in Indonesia and Germany. The German ground segment includes the TUB satellite control centre, the DLR ground station in Neustrelitz for data reception as well as the company HeJoe for data storage and real-time transmission of the video data stream to the TUB control center and other users.

The test site DEMMIN is one of the largest locations for the examination of the quality of satellite data and the development of new standards and thematic processing algorithms (e.g. atmospheric corrections, geo correction). The test site permits very good conditions for the calibration and validation of remote sensing data due to the available information basis and due to its natural high heterogeneity and the adapted land use intensity.

Using the super-test site DEMMIN we investigate 2 potential applications namely in-situ analysis and crop estimation. The main advantage of the real-time video data is that it needs no processing and is available to the user immediately. Human brains are trained to process motion-pictures and extract information. The data is easy interpretable to obtain a qualitative analysis of the situation and direct measures can be taken. Processed data can be used to make a quantitative inspection of agriculture areas. An analysis of different growing regions of rape fields is presented showing the feasibility of such an analysis based on TUBSAT data.

The first steps of the investigation of satellite real-time video data for scientific and commercial usability in environmental applications proved the value of such data for the community.

1. LAPAN-TUBSAT

The technical possibilities of remote sensing extended extremely in the last years. The ENVISAT with its numerous different sensors, the TerraSAR with its extremely efficient Synthetic Aperture Radar, the RapidEye system with its 5 satellites in one orbit or the planned hyper-spectral satellite EnMAP are only some examples of this development. However, these systems are very complex and expensive contrary to the small satellites. Therefore, small satellites can occupy niches for testing new algorithms or possibilities for using Earth observation.
The TUBSAT can be used as helpful prototype. Substantial reason for this function is in particular its flexible attitude control and extraordinary manoeuvrability with interactive control allowing operations like "helicopter flight", the high satellite's repetition rate and the sensor system allowing an overview modus, a high resolution modus and good differentiability.

The most recent TUBSAT is LAPAN-TUBSAT, a 50kg microsatellite with dimensions of 45x45x27cm³ that has been jointly built by the Indonesian Space Agency LAPAN and the Technische Universität Berlin. The satellite has been launched on January 10, 2007 by an Indian PSLV in a 625 km circular sun-synchronous orbit.

The attitude control system is based on a star sensor, sun sensor, 3 reaction wheels, 3 optical gyros and 3 coils. A detailed description of the target acquisition and the interactive attitude control can be found in [1].

The imaging system consists of two separate video cameras. The first is a high resolution camera with a 3-CCD colour video imager and a 1m focal length telescope resulting in 6m pixel ground resolution. The second camera has a CCD colour video sensor and a telescope with 50mm focal length resulting in 200m pixel ground resolution. The analog video signal is transmitted to the ground in real-time (S-band carrier).

2. TEST SITE DEMMIN

The super-test site DEMMIN (Durable Environmental Multidisciplinary Monitoring Information Network) is located in the northeast of Germany, in the centre of Mecklenburg-Western Pomerania and serves for calibrating and validating satellite systems and data as well as of value added products derived from remote sensing. The site is an intensively used agricultural ecosystem with a total area of about 25.000ha (Figure 1: Location of the DEMMIN test site in the northeast of Germany.. Single fields are very large in size averaging about 80ha. The main crops grown in this area are winter wheat, winter barley, winter rape, maize and sugar beet.

The area of DEMMIN is a typical Pleistocene landscape with hilly, loamy to clayey moraines, sandy plains and peaty floodplains. The altitudinal range is about 80m. In general, precipitation per year is moderate at 500 to 600mm. But torrential rainfall triggers large-scale soil erosion events and is promoted by unfavourable cultivation.

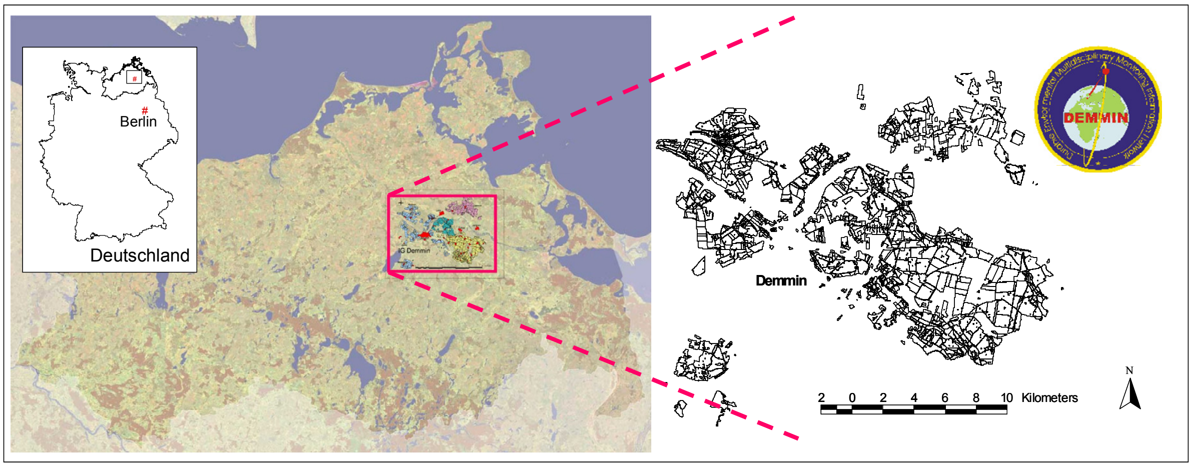

Figure 1: Location of the DEMMIN test site in the northeast of Germany.

3. FEATURE DETECTION AND ANALYSIS ALGORITHM

The camera systems of the TUBSAT satellite do not permit a clear calibration with sufficient accuracy, since the system adapts itself with respect to the respective scene situation. Therefore a quantitative evaluation is not meaningful. However a qualitative evaluation of the data can deliver useful results for precision farming.
For developing and testing a method for interpreting the video stream data of TUBSAT a single scene was extracted video stream data (Figure 2). Beside other land use classes, the image shows different rape fields which were collected by TUBSAT on May 9, 2008. The selected example (marked by the red rectangle) shows a rape field with different growing regions.

Figure 2: Large rape fields in the area of DEMMIN (imaged by TUBSAT, 09 May 2008).

On the basis of this image section the processing of the video data can be demonstrated. In a first step the data are histogram equalized. This is a method of contrast adjustment using the image's histogram. On basis of this data a classification can be carried out (Figure 3, left image). A following contour extraction discriminating the variability of the field is represented in Figure 3 (middle). The classification result is shown in the image merge (Figure 3, right site).

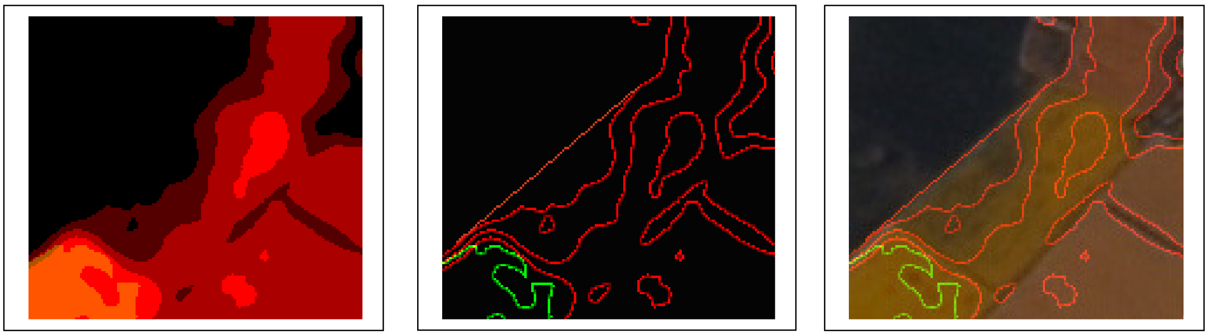

Figure 3: Classified image selection (left), contour detection (middle) and merged image (right).

4. IN-SITU ANALYSIS (ADVANCE MONITORING)

In the case of scientific satellite and/or air borne measuring campaigns the TUBSAT system was successfully used with the in-situ analysis, in order to examine the cloud conditions or other environmental situation (Figure 4). On basis of this information the terrestrial and air borne activities can be coordinated.

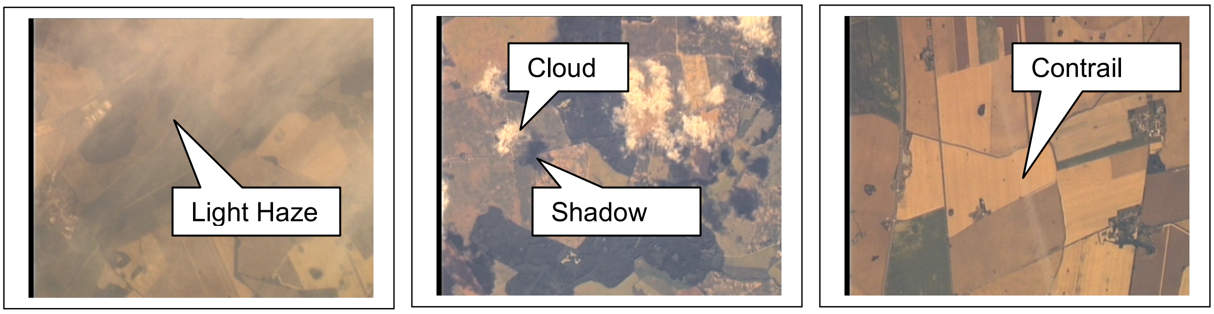

Figure 4: In-situ-image over test site DEMMIN: dust assessment July 30, 2008; cloud and cloud shadow assessment June 30, 2008; contrail assessment July 29, 2008

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