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THE USE OF AIRBORNE VIDEOGRAPHY AND OTHER INFORMATION SOURCES IN PRECISION FARMING

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ABSTRACT

The following paper will describe the development of a video system and its use in precision farming. Development started with a very simple analog monospectral system, which later was changed into a multivideo system with digital data recording and logged real-time GPS positioning. The second part of the paper is showing how this kind of remote sensing information can be incorporated into a precision farming concept. Beside the explanation of the necessity of several flights during the season it will be discussed the benefit of combining the images over various years by using a GIS. The combination of several information sources like yield maps, soil maps, soil sampling and remote sensing images with supervised classification procedures are presented. Finally a practical approach to variable rate application of agricultural inputs is proposed.

1. INTRODUCTION

An emerging group of technologies now allow farmers to change input application rates as farm equipment moves across the field. Site-specific farming (Precision Farming) embodies the practice of applying crop inputs in each part of a field according to its unique set of conditions, using computer controlled variable rate application equipment, GPS satellite navigation, GIS field mapping and data analysis of various sources. By using these techniques farmers improve profitability by managing the field variability. Beside the better economics environmental benefits are expected from this new crop management strategy.

But before managing variability becomes feasible, first of all it has to be detected and the reasons have to be analyzed. Thereby the principle of "limiting factors" has to be taken into account saying that the level of crop production can not be greater than that allowed by the most limiting of the essential plant growth factors. Particularly in Germany nutrients and water are the most significant factors that caused plant growth variability (Funk and Maidl, 1997).

Beside nutrient data, soil survey maps, topographic maps, yield mapping and other data sources; remote sensing data has proved to be a very powerful information source. It helps to incorporate all information into a comprehensive precision farming system to produce more accurate and cost effective application maps.

2. AIRBORNE VIDEOGRAPHY

Various authors have shown that airborne videography is an ideal remote sensing tool for agricultural resource management application (Escobar et al., 1983; Manzer, 1983; Everitt et al., 1985; Cook et al., 1997; Everitt et al., 1997).

In comparison to classic airborne photography video techniques offer a number of significant advantages in agricultural remote sensing applications. The foremost advantage is the immediate availability of imagery, which is particularly useful in highly time-sensitive applications such as monitoring crop stress or disaster assessment. But also the ability of the operator to see a live image in a

control monitor during acquisition ensures that the system has been properly set up and successful coverage of a target site can be confirmed during the flight.

Another important benefit of using video is the electronic format of video data, which makes it amenable to quick image processing by computer.

Finally, the price of a video tape is lower than the cost of a film and its processing. This becomes particularly evident by using the infrared bands of the light.

On the other hand, video has its limitations, particularly in regard of resolution. But in large-scale agriculture this point, in our opinion, is no more a real limitation since the introduction of S-VHS and digital video systems.

In the last few years dramatic improvements have been made on video camera systems and recording equipments, particularly in resolution and quality by the introduction of digital cameras and digital VCR's.

3. SYSTEM DEVELOPMENT

Encouraged by the results of literature analysis, which showed that even a single-band-video is useful to assess the amount of phytomass production (Everitt, 1989), the decision was taken to begin with single-band equipment.

The basic system is comprised of a B&W 2/3-inch CCD visible/near infrared light sensitive video camera, which is mounted on a frame that permits image acquisition through a whole in the bottom of the used aircraft (Cessna). The camera was equipped with a wide-angle lense and a NIR (>0,8 µm) filter. The video signal was recorded on a portable digital videocassette recorder with more than 500 horizontal line resolution (Sony), which integrates a small monitor for recording control. A 12V battery provided the power source for the entire system.

For navigation the following three components were included: A pentop PC, a GPS receiver (Garmin) and a GIS software (Field Notes) with the capability of online display of the actual GPS position. This combination allowed an optimal preparation of the flight route and an exact on line monitoring and checking whether unknown targets were over flown. Additionally this navigation system allowed tracking of the flight route by storing the GPS position and GPS time into a database. After converting GPS time into a specific time format a comparison of GPS time and recorder's time counter data allowed us manually to localize the targets on the videotape for capturing via PC.

After the flight mission video images were selected and identified by the counter position and digitized by frame grubber with variable resolution and 8 bits per pixel using a computer with 256 MB Ram and 20 GB Hard disc drive.

For further image processing software like Photo Plus, IDRISI and Ermapper were used. Firstly the captured images were georeferenced and geometrically corrected to the field boundaries by using a GIS. Then images were subjected to histogram analysis and a supervised classification. The resulting kind of "thematic maps" were used as a basic for field monitoring, soil sampling and prescription maps by farmers and consultants.

4. IMAGE AQUISITION DURING DIFFERENT GROWTH STAGES

The experience in the use of images acquired in 2002 and 2001 on a 3.000-hectare farm within the state of Sachsen-Anhalt confirmed the results of the previous years. (Dohmen, 1997).

In spring the use of the processed thematic NIR-reflection maps in combination with GPS simplified very much the detection of areas with bad emergence of the summer crops or zones of less development in the winter crops like wheat, barley and oilseed rape. As the processed remote sensing data was imported into the farm's GIS, reactions like targeted soil sampling and subsequent site specific fertilizer or herbicide application could be easily defined after ground truthing the problem areas or zones of above-average development.

The summer flights proved to be essential for the identification of water-short areas within single fields. Particularly in the state of Sachsen-Anhalt water and soil moisture are one of the mayor limiting factors in intensive crop production. As the NIR-spectral band of the aerial videography system responds to the active photosynthetic size of the canopies, NIR-reflection maps of cereal crops are highly correlated to yield maps, if water and soil moisture are critical.

The autumn flights (October) gave the farmer quick information about the establishment of his winter crops and the thematic maps beside other information sources were used to decide about site-specific soil sampling.

5. GENERATING YIELD-RELATED MAPS FOR MANAGEMENT ZONES

Site-specific farming (Precision Farming) involves beside collecting also managing information to make practical, economical an environmentally sound crop production decisions. In the following example (comp. Fig 1) we took 3 information from different years into consideration: Digital near infrared airborne remote sensing data (processed false colour image of maturing process of maize Sept. 1999, left image), a harvester yield map of the subsequent year (wheat yield, July 2000, middle image) and a soil type map („Reichsbodenschätzung", around 1936, right image).

In order to extract management areas from the different information sources we used multivariate statistics. Supervised classification procedures are known to be essential tools to extract quantitative information from remotely sensed data. To perform it one first determines the classes they which to obtain from the images. In our case we wished to determine four main classes: high yield potential, medium and low yield potential areas and zones, which are still indifferent (not yet or not classifiable). For each class, a sample of pixels that correspond to it, is selected to allow a reasonable estimate for the range of pixels in each class. These ranges, called training sites, are saved in a vector file, which is then used to create a signature or spectral response pattern for each class and to classify the full image by determining the most likely class for each individual pixel in the image (compare right image).

Farmers can use this maps for guided application within their fields. For example: As long as driving in the red areas they will apply 80 kg of nitrogen, in the green areas they will reduce the rate to 50 kg and in the low yielding blue areas they will apply only 30 kg of nitrogen while driving their machines. The change of the dose rate can be done manually by changing pressure of the sprayer or the speed of the tractor. Special GPS receivers could guide farmers within their own fields showing the position of the vehicle within this map.

In Germany a GARMIN GPSMAP 176 is already guiding the first machines using these kind of management areas as a basis for application maps.

6. SUMMARY AND CONCLUSIONS

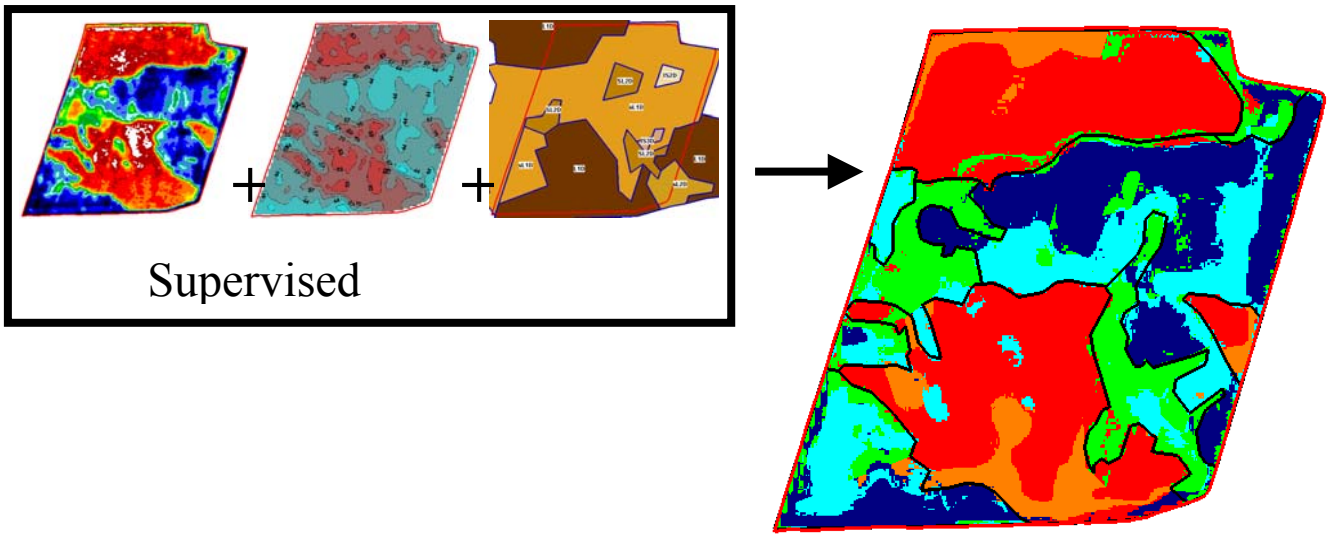
Airborne video systems offer some characteristics, which can be useful for agricultural management. Although video does not have the detailed resolution like photographs, it can provide farm managers with near-real-time remote sensing data. According to our six years experience for many applications a black-and-white single camera system is sufficient, which has been already demonstrated in the early beginnings of videography (Manzer et al., 1982;).

Beside phytopathologic symptoms and water stress effects videography can also help to characterize soil types (Dohmen and Reh, 1997) and optimize soil sampling and subsequent site-specific fertilizer application.

For data processing it is concluded that supervised classification of multitemporal data is one of the most powerful procedures to determine yield potential areas for the subsequent defining of management zones.

Low cost GPS receivers are capable to guide farmers for variable application without big changes in farm equipment.

Fig 1: Management Area Map



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