Future Research on Application of GPS/GIS/RS for Farmcrops Temporal Arrangement

Deren Li*, Zequn Guan* and Xiufeng He†

*Institute of Remote Sensing and Information Engineering
Wuhan Technical University of Surveying and Mapping, Wuhan, 430070, China
†Department of Automatic Control
Nanjing University of Aeronautics and Astronautics, Nanjing, China

Abstract
Currently, farmcrops temporal arrangement is constrained by the generally inadequate treatment of spatial simulation in terms of socioeconomic and ecological information, resulting in artificially deflected planning. For farming in the future, positional information is of particular importance. In this paper, a description is given of the farmcrops temporal arrangement method, to reduce errors and time in precision farming, based on GPS/GIS/RS and planning techniques currently being used in many institutions together with respective approaches, usability, and trends. The system, being presented here, appears to be particularly suited to data processing and data analysis incorporating image segmentation with location sensing, which will help to combine the advantage of small field sample locations with large-scale, cost-efficient image processing methods.

摘 要
目前，由于依据社会经济和生态信息来正确模拟农作物在特定空间上的生长过程还受到定位信息不足等限制，因而容易导致对农作物的时间安排受人为因素影响而产生偏差。这表明，农业的进一步发展，越来越需要定位信息。本文基于GPS/GIS/RS技术及新近在其它方面已被采用的规划技术，从减少精细农业的失误和缩短耕作时间出发，提出了一种新的农作物时间安排方法以及相关的系统。该系统的目标是在数据处理和数据分析中综合运用定位传感和图像分割技术，以便能将大范围而有价值的图象处理方法与小范围的精细定位采样结合起来。

I. INTRODUCTION

Since China embarked on economic reform and opening up to the outside world, her agriculture has seen relatively rapid development, and it has since produced abundant farm products to meet general social demands. However, from a long-term point of view, China's agriculture is not only confronted with multiple pressures such as growth of population but greater demands on farm products by accelerated industrialization . The prospects brook no over-optimism.

How shall farm products and increase of incomes of peasants be effectively supplied? One of the valid ways is to develop agriculture from a weak-quality industry to a highly effective industry, and it is the key for us to effect the process through the introducing of scientific methods and management , one of whose nature is to handle the precision information of farming.

Precision farming problems are inherently linked to planing problems. To create better Planning Support System(PSS) that will begin to address these complex issues, the changes of farmcrops and the relationships between them and geo-referenced information must be positioned, recognized and understood. One approach to meeting these needs is the integration of remote sensing (RS) image processing, Geographical Information System (GIS), farmcrops inventory, and Global Positioning System (GPS) for an operational farmcrops temporal arrangement.

Lachapelle et al (1994) outlined the precision farming objective of optimizing field potential based on information known about the field. Hermann et al (1995) pointed out that the major application of positioning with GPS/DGPS is to be seen in the area of local information and documentation. Chen et al (1992) developed a portable information manage-

1082-4006/97/0301~2-1$3.00

ment system which integrated the remote sensing (RS), GIS and GPS with basic interface screen overview.

Although the integration of RS, GIS and GPS has been extensively studied in the past, little has been done in developing some adaptive algorithms for incorporating image segmentation with location sensing, and farmcrops temporal arrangement.

The PSS discussed in this paper is intended to operate in a WINDOWS environment.. The PSS graphically integrates digital images and map information with observed positions. In general, the PSS automatically plots a position onto a digital image or map. The real value of the PSS will be realized when data analysis tools permit user to "see" further into the growing digital database of spatial information that is possible using traditional cartographic renditions of the data.

New analytical tools that extend our vision into location sensing and extract the useful information needed to practise farmcrops temporal arrangement are described in this paper.

II. BASIC FUNCTIONALITIES

An application system is proposed for the farmcrops temporal arrangement project. The system under consideration consists of five major functional blocks shown in Figure 1. A standard Microsoft WINDOWS graphical user interface is implemented for PSS system equipped with mouse or other interface tools. A brief discussion will be provided for each function in the following paragraph.

1. Data processing. All the data process of the observation and images until one gets the final farmcrops planning can be arranged in the following steps:

1). To input the multi-temporal images data from the user.

2). To determine if there are significant changes, either increases or decreases, occurring in the images.

3). To classify the images.

4). To document the features which could characterize the change areas of farmcrops, such as size, time, speed, domain and so on.

2. GPS. A GPS unit concerns:

1). To feed field measurement information into

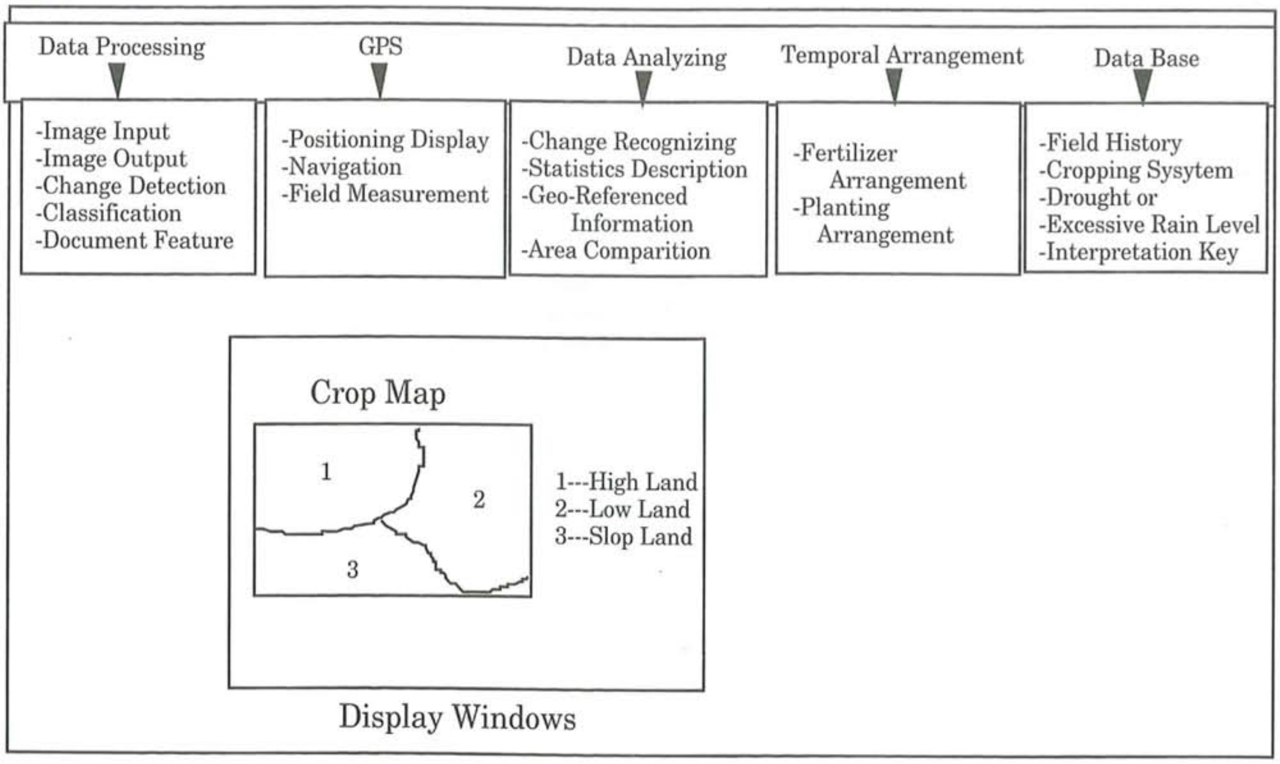

Figure 1. Basic Interface Screen Overview and Display Windows

the system.

2). To feed position information into the system.

3). To feed navigation information into the system.

3. Data analyzing. The analysis subsystem will be in charge of following several items:

1). To determine possible correlation between the features and interpretation of significance to farmcrops temporal arrangement

2). To describe the situation for a service area around each of pointed locations based on statistics

3). To compare the areal extent of the farmcrops defined in each set of satellite data

4. Temporal arrangement. The study which is proposed has two important appliances:

1). To find the appropriate procedure for monitoring and detecting farmcrops change

2). Planning techniques are used to arrange the rotation of crops and the adequate time of fertilization.

5. Database. Field history, cropping system, level of drought or excessive rain, interpretation key and so on are maintained, managed and created for the farmcrops temporal arrangement.

III. PLOTTING A POSITION ONTO A SEGMENTATION IMAGE

Image segmentation is an important step in the analysis of digital images. Usually, it is employed after image enhancement and before object recognition. In this section, the problem of how to transform a primary image into a segmentation image, and homogeneous region image is described. At the same time, we will apply an adaptive Voronoi tessellation to the image.

At first, the primary image is segmented by the judgment of intraparallelism which involves the attributes stemming from the gray level, such as intensity, hue, saturation etc. To each pixel of the segment that maybe contains multiple objects, if the attributes are parallel, then give it a corresponding label, otherwise give it a question mark label which is a control label used to indicate where the segments must be continuously subdivided. As a result, an image composed of these labels is obtained. It is called the segmentation image.

The pixel intensities of neighboring pixels from the same object can be assumed to be incompletely correlated. For many objects more than one segment may be obtained. Thus these segments must be conbined into homogeneous regions on the basis of the knowledge of objects that determine collections of segments, which form "natural" components of the scenes.

Figure 2 illustrates the elements of segmentation image and homogeneous region image, and their transformation. The attribute and uniformity of segments, which are mainly based on statistical properties and sensor dependent; while the attribute and homogeneity of homogeneous regions mainly refer to the knowledge of objects and themes, which in-

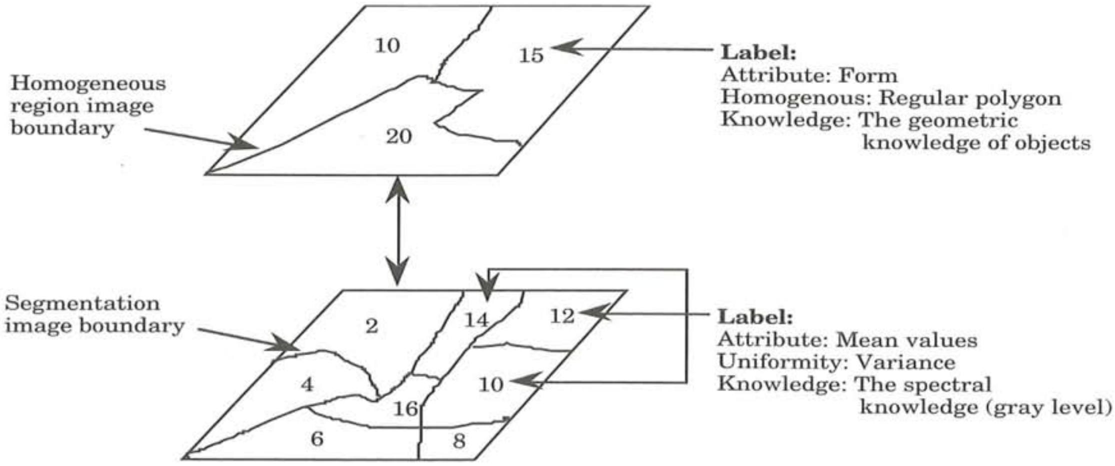

Figure 2. The elements of segmentation image and homogeneous region, and their transformation.

clude the geometric characteristics. For example, segments 10, 12, 14 in Fig.2 indicate three rice lands with different water depths. Because all of them have the same attribute, regular polygon, they should be merged into a single homogeneous region by using form attribute.

Pyramidal techniques have been shown to be efficient methods for image segmentation. On this already irregular structure, an irregular pyramid will be build. The advantage of this approach is that the Voronoi tessellation and the Delaunay graph offer a reduced description of the image and the neighbour relation between regions, which is already adapted to the image content(Etienne 1996).

Voronoi diagrams built from a distribution of discrete seeds are also of interest in the content of geometrical partitions. Given a distance function, each Voronoi polygon is associated with a seed and is defined as the set of points which are closer to this seed than from any of the other seeds (see Figure 3).

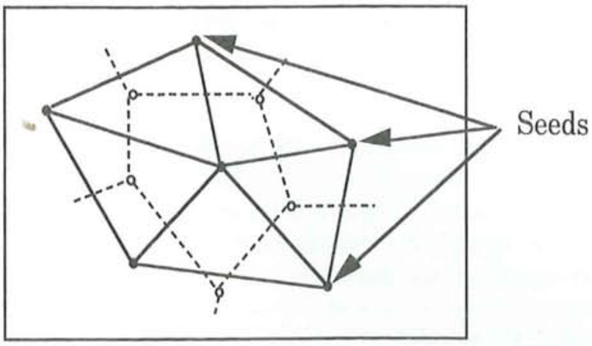

Figure 3. A Voronoi diagram and the associated Delaunay tessellation. The seeds are contained in the interiors of the polygons.

Each seed is connected with field sample locations using GPS/DGPS so that a consistent reference system could be used. The number of sample points is approximately that of the seeds.

Geo-referenced information means information available at a respective seed position. Thus, if positioning is available at the seed, image segments may be accessed. A number of intermediate stages are conceivable, starting with a display for the user only and leading to totally automated processes.

Image segmentation proceeds in two steps. The first step is the splitting: polygons are added in the support of the seeds and image until convergence. This step involves a dynamic management of the Voronoi diagrams. The second step is the merge step: some polygons and seeds are deleted. If a polygon P is nonhomogeneous, a seed should be added in the middle of each Voronoi edge $e = P \cap Q$ where the polygon Q is neigbbour of P, otherwise, we do nothing.

IV. PLANNING TECHNIQUES FOR FARMCROPS TEMPORAL ARRANGEMENT

Economic representation of data with all their interrelationships is one of the most central problem in information sciences. In thinking, and in the subconscious information processing, there is a general tendency to compress information by forming reduced representations of the most relevant facts, without loss of knowledge about their interrelationships. The purpose of intelligent information processing seems in general to be creation of simplified images of the observable world at various levels of abstraction, in relation to a particular subset of received data.

Temporal arrangement of crops is a vivid example of this kind of problem hence the name "temporal arrangement problem". The term "temporal" strongly evokes the idea of a one-dimensional planning space but the temporal arrangement problem may also refer to temporal-spatial planning in a four-dimensional workspace. However the section of this paper will focus on the one-dimensional case.

Consider the map shown in Figure 4. It consists of three landforms: high-land, slope-land and low-land, where one is a neighbour of the others which are planted or are not.

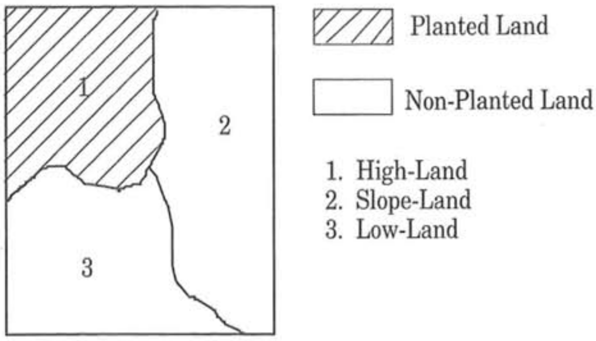

Figure 4. A map of cropping system

The study area is chosen in lower reaches alluvial plain of Yellow river. This study area selection is made on the basis of the geographic coverage of the socioeconomic data that corresponds to the mainly farming area in China. In addition, area bounding the Yellow river and suffering from severe drought or excessive rain is the major factors considered in choosing the study area. The relationships between landform and drought or excessive rain are demonstrated in Table 1. The farmcrops in this area may be classified five types:

(1) Spring-sown crops April-August.
(2) Spring-Summer-sown crops May-Septem ber.
(3) Summer-sown crops June-October.
(4) Summer-Autumn crops July-November.
(5) Autumn-sown crops October- June.

To make a farmcrops temporal arrangement, we give the constraints as follows:

(a) Balance spring-sown crops with autumn-sown crops.
(b) The farmcrops temporal arrangement of high-land is prior to slope-land, in turn slope-land is prior to low-land.
(c) Adjust farmcrops temporal arrangement cor responding to the level of drought or excessive rain.

The planning techniques used for farmcrops temporal arrangement by this system have two cases:

(1) When the middle-long-term weather forecasting is not considered, the farmcrops temporal arrangement is a combination of Plot 1 + Plot 2 + Plot 3 temporal arrangement. In terms of constraints (a), (b),(c) above, we may get the arrangements shown in Figure 5.
(2) According to middle-long-term weather forecasting, the farmcrops temporal arrangement appears to be a more complicated situation to represent the relationships between the plots. An algorithm for farmcrops temporal arrangement considering middle-long-term weather forecasting is presented. According to constraints (a), (b), (c) above, we may get the arrangement shown in Figure 6.

V. CONCLUSIONS

The use of PSS is expected to increase in the future, but the development of both the hardware and the software will have to be based on rational considerations and projects. To enhance the interactivity, efficiency, and computational power in a WINDOWS environment as much as possible, suitable system may be developed as, for instance, the framework presented in Section 2. A novel data processing and data analysis algorithm that attempts to build Voronoi diagrams from a distribution of discrete seeds, which are connected with field sample location using GPS/DGPS, is proposed. The incorporation of image segmentation and location sensing helped to combine the advantages of small field sample locations with large-scale, cost-efficient image processing methods is pointed out. At the same time, a farmcrops temporal arrangement method in terms of the integration of GPS/GIS/RS and planning techniques is proposed. It will be useful to reduce errors and time in precision farming.

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Table 1. The relationships between landform, level of drought or excessive rain and rotation of crops

Landform	Level of drought or excessive rain	Rotation of crops	Field yield
High-land	Other	Twice / a year	High
	Very serious	Thrice / two years	Middle
Slope-land	Less serious	Twice / a year	High
	Serious	Thrice / two years	Middle
	Very serious	Once / a year	Low
Low-land	Less serious	Thrice / two years	Middle
	Serious		
	Very serious	Once / a year	Low

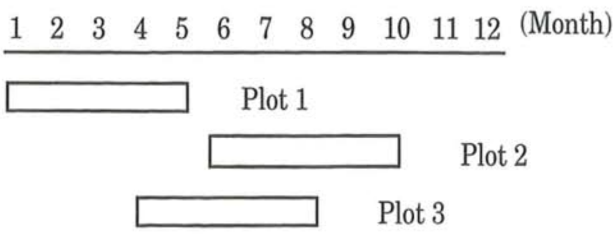

Figure 5. Farmcrops temporal arrangement ignoring weather forecasting

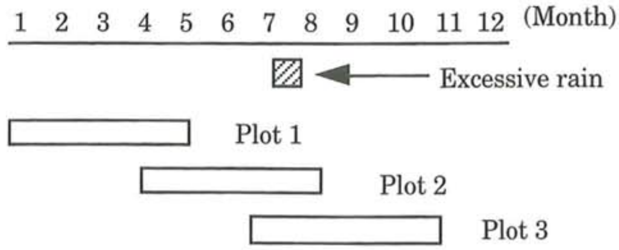

Figure 6. Farmcrops temporal arrangement considering weather forecasting

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CPGIS 于 1997 年 6 月 2 日在北京举行了创会五周年庆祝活动。在京的 60 多位 GIS 专家、领导参加了这一活动。会后，由 CPGIS 会员举办了七场专题讲座。图为 CPGIS 五任会长，从左到右：宫鹏、李斌、丁跃民、柳林、林珲。又见本刊 19 页和 50 页。

On June 2, 1997, CPGIS held its 5th Anniversary Celebration Meeting in Beijing. All the Presidents of CPGIS attended the meeting. From left to right, they are Peng Gong, Bin Li, Yuemin Ding, Lin Liu, and Hui Lin.