A GPS BASED SYSTEM TO AID IN THE ACQUISITION OF SPATIALLY STRUCTURED FIELD PROPERTIES

A. RIBEIRO, B. DIAZ, M.C. GARCÍA-ALEGRE, D. GUINEA

IAI-CSIC, 28500 Arganda del Rey, Madrid, Spain.
E-mail: angela@iai.csic.es

C. FERNANDEZ-QUINTANILLA, J. BARROSO, D. RUIZ

CCMA-CSIC, Serrano 115 B, 28006 Madrid, Spain.

ABSTRACT

The generation of human-friendly interfaces is an open field aiming at the development of tools that allow non-expert users to take out the maximum profit of the integration of GIS and GPS tools. In this direction, a flexible and open software environment that integrates such technologies with the main objective of supplying a support tool to record field properties in a database is presented. The system is mainly composed of two software packages. The first one allows the user to configure off-line the sampling plan and, with the given information, generate a standard spatial database. The second programme helps the user both to follow the previously designed plan and to fill out the spatial database, using as equipment a GPS, with real-time differential corrections, and a high-performance computer with a special screen to appropriately visualise under extreme illumination conditions. The system has been tested in cereal crop field experiments dealing with the generation of weed control risk maps.

INTRODUCTION

The Precision Agriculture (PA) arises with the purpose of helping to minimise the use of agrochemical products whilst ensuring that weeds, diseases and pests are controlled effectively and that crops are provided with adequate nutrients (Kropff 1997). Hence, the main goal is to ensure that spray application is safer and more efficient. The benefits to be obtained are two folds (Earl 1996): 1) a cost reduction of producing the crop and 2) a reduction in the environmental pollution.

PA needs multi-disciplinary expertise in soils, agronomy, mechanisation, information technology and remote sensing with the purpose of developing robust crop management strategies that explicitly account for field level variability. Furthermore, it is indispensable to develop equipment, sensors and crop monitoring techniques and integrate this technology into management guidelines for viable application within the commercial environment to increase the efficiency of crop production whilst minimising the environmental impact. In fact, Robert analyses (Robert 99) the barriers in USA for adoption of PA by growers and the research that the users demand in this area. As a result the study shows that the main barriers for adoption of PA are the cost and the need for new skills to use such novel tools. Among the research needs, important points are the engineering technology and technology transfer. Specifically, in engineering technology, the data acquisition, processing, quality and interpretation are significant open issues. In technology transfer, the research is focused on the design and development of decision support system.

PA requires a different approach to both sampling and estimation from the traditional policies. In fact, farmers need to know how the soil, crop, weed, etc. vary within the field. But, the information about the field properties usually comes from sample information, since it is not feasible to describe the field properties at each location. Additionally, the variation is complex because many different processes interact at different spatial scales. In consequence, field properties can vary at many different scales of spatial resolution in the landscape, from a few millimetres to several kilometres (Oliver 1999).

Soil sampling by grid or map is the most adopted technique, followed closely by yield monitoring (Robert 99). In most methods, the record of the field properties involve a walking field inspection, for example, this is the most frequent behaviour in those cases when, with selectively spraying purpose, a weed map should be generated. (Colliver 1996) (Christensen 1998) (Clay 1999) and (Krueger 2000). But, as other tasks, the weed spraying based on the spatial variability of the weed is only justified if the cost of weed sampling is proportional to the potential benefits (Foncella 1993).

These observations led to the objectives of the work here presented, which is a part of a research project funded by the Spanish Science and Technology Commission that aims at *the development of a decision-making system to aid at the generation of weed control risk maps.* The project objective is to design and develop a system that completely integrates the necessary stages to generate risk maps for weed control. Emphasis will be placed on both data collection and data post-processing/analyse techniques to generate accurate maps.

OBJECTIVES

Design and plan of the fieldwork are the first stages for a data sampling session. Usually, the results of this initial task are recorded on a paper document that user utilises later on in successive data collection tasks. Then, the collecting phase can be addressed in two different ways: 1) in a traditional manner, collecting soil samples and writing interesting information in a notebook, or 2) using some of the available commercial system to record field data with or without georeference. This last procedure is the one performed by commercial systems as are, KEMIRA LORIS, SATCON DGPS-SYSTEM, GEO-GPS, AgGPS, GeoExplorer 3, etc.[1]

All these tools display some of the following main disadvantages, in a greater o lesser extend:

1) The user needs new skills, since he has to use a lot of different applications in order to, e.g., record geocoded raw data, conveniently structure these data in a (GIS) format, analyse the field data, etc.. All this implies a learning period.

2) The global equipment required to record data in field greatly varies in price from the one needed for recording and post-processing and analyse of the collected data. Consequently, the total equipment cost is very high when all stages are needed.

3) Data are not directly collected with the structure that would be needed later on for the data analysis process (some GIS).

4) It is not possible to change or to extent the type of the data that could be recorded in the field, since the field computers execute closed applications that have not been developed in standard languages.

The objective of the work here presented is to overcome the former disadvantages through the development of a human-friendly interface that directly integrates a Geographical Information

[1] More information about these systems can be found in http://www.satcon.com, http://www.geo-net.de and http://www.trimble.com.

System (GIS) and a Global Positioning System (GPS) receiver, this last accepts real-time differential corrections. In other words, a flexible and open software environment to record field properties, to be executed in a conventional computer. The system has three main modules or subsystems. Only the two novel ones are here presented. The third one is a more conventional application that permit to introduce in the database all the properties extracted at the laboratory, for example, the soil nitrate residuals.

THE CONFIGURATION SAMPLING PLAN SUBSYSTEM (COPLAS)

COPLAS (<u>CO</u>nfiguration <u>PLA</u>n <u>S</u>ubsystem) has been designed as a human-friendly interface that allows non-expert users to easily define a sampling plan; that is, field information to be collected and strategies to appropriately accomplish this task. COPLAS offers all the elements to define the kind of variable and the plan to get them in a specific position. This will allow the user later on to acquire field information of a wide range of the variable types (e.g. a number to identify a soil sample as well as picture about an interesting crop part). Different sequences of the system run are displayed in Figure 1. In (a) the user can select a new or old sampling project. In (d) it is shown the form that will be filled out to define or modify the sampling. Former forms allow acquiring general information about the field. But not all the variables displayed in the form must be fulfilled, e.g. the information devoted to physical properties and vegetable characteristics.

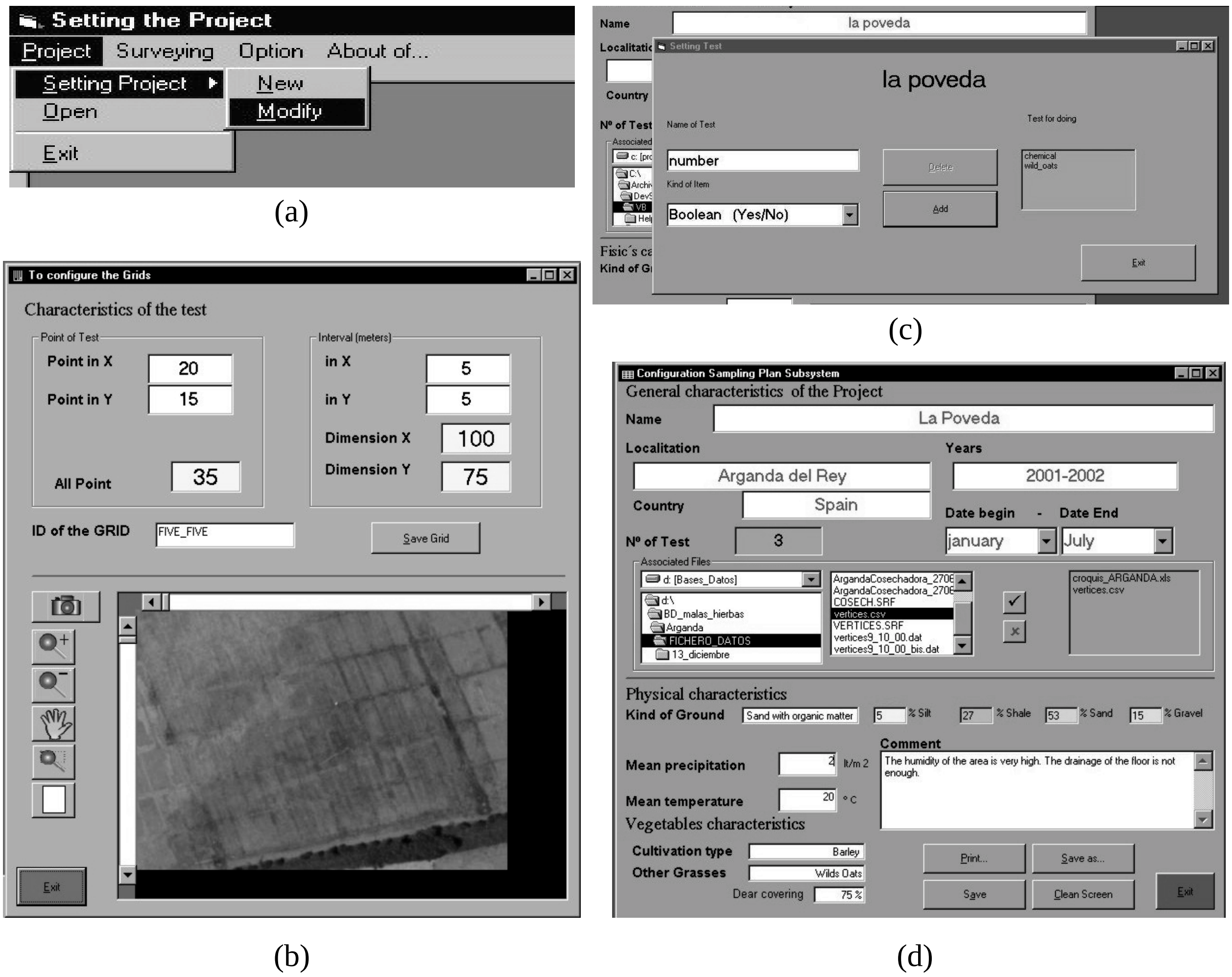

FIGURE 1. Several screens of the COPLAS application

The field (c) in the picture shows the form used to introduce the variable type. It is important to remark that at each sampling point the user can define as much variables as he wants; including image files to introduce digital pictures, and text plain files to record any comment. In (b) it is displayed the way in which the program obtain the information of the sampling plan. Through this form sampling, any strategy can be defined via simple tools. Additionally, COPLAS supplies a device that allows the user to introduce high accurate digital maps or only schematic drawings.

COPLAS generates as output a standard spatial database that contains initial information, partially required to correctly accomplish next stage. The database has Access format and the contained information is spatially structured by using GeoMedia[2] components.

EXTERNAL EQUIMENT

Many of the performances, in the developed system to record field properties, are obtained due to the new hardware technology available. The equipment that has been used is composed of two main subsystems, Figure 2: A) The Personal Computer is a Fujitsu Stylistic 2300^{SM} pen tablet, a high-performance pen based computer that is designed to support, in this case, Windows NT. It is specially designed to work on outdoor environment, with Colour Transflective (CTF) SVGA LCD display, which a size of 8.4". This screen allows colour visualisation in extreme lighting conditions. In addition, the pen computer is equipped with a very complete connectors system (PS/2, RS-232C, USB, etc.), that, in future, will allow the connection of different sensors without additional cost. The pen computer weight is around 1.8 Kg. with battery pack. B). The Global Positioning System (GPS) is a 3100LR12 from OmniSTAR a Fugo Group Company; a 12-channel GPS receiver and a L-Band differential receiver, both housed within a single unit. Position accuracy is typically less than one metre and the receiver is suitable for both ground and air applications. The DGPS receiver is supplied with combined GPS and OmniSTAR antenna for signal reception. The connection to computer is via a standard RS-232C port

FIGURE 2: Weed sampling carried out in July of 2000 with the described external equipment.

THE FIELD DATA COLLECTION SUBSYSTEM (FIEL)

As COPLAS, the FIEL (FIELd data collection subsystem) subsystem has been implemented to offer an application of easy utilisation for non-expert users. This programme allows filling out the formerly configured database and helps the user to go completely through the field using a GPS, following a previously designed plan and controlling the data that are acquired at each point of the defined sampling grid.

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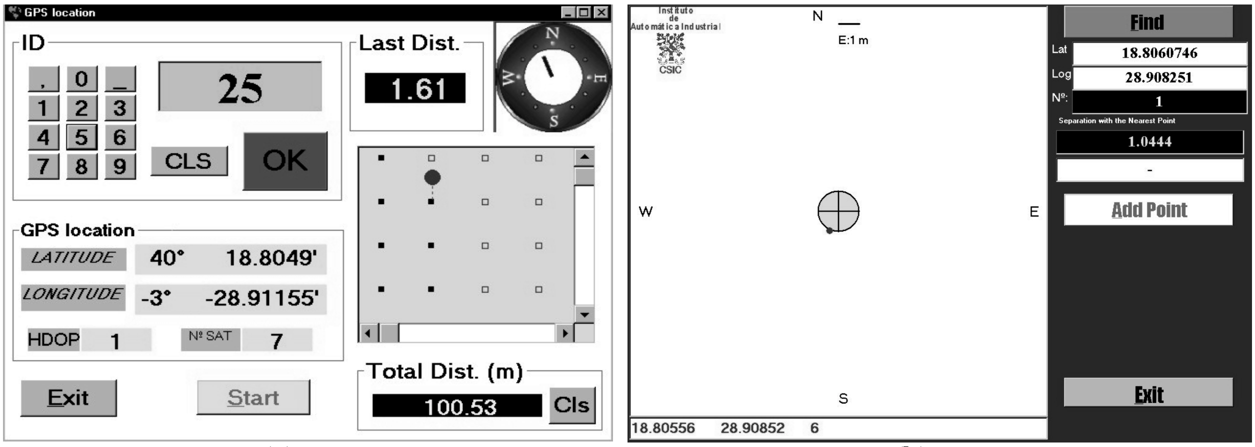
[2] It is a universal GIS client that allows performing spatial analysis (http://www.intergraph.com)

It is important to emphasise that the application uses the DGPS receiver as a mean to aid user in the location task of the grid intersection points, following the previously defined plan, as well as a system to precisely know the co-ordinates of a sampling point.

The subsystem runs in two different modes:

A) The first time that the sampling is conducted FIEL shows a screen like the one illustrated in Figure 3.a. User knows at each moment his position, as well as his distance in meters relative to the last sampled point. Other information that is important for a correct navigation following the designed plan is also displayed here.

B) When the sampling is performed a second time, and under the user's petition, the FIEL program can display a screen as the one presented in Figure 3.b. In this case the program guides the user through the previous sampling grid. The reader can observed in the figure a target, this is drawn to a meter of the objective point or grid point near to the user. The ball represents the user's position relative to the objective point. This screen aids the user to know the direction to be followed to reach the goal point.



(a) (b)

FIGURE 3. Several screens of the FIEL application

CONCLUSION AND FUTURE WORK

The presented software environment is extremely useful at the stage of data acquisition in precision agriculture tasks. Main advantages of the system are:

1) It is possible, in situ and for each point, to introduce information that can be very useful at the analysis stage; information as e.g. a digital picture or comments in plain text about the weed patch.

2) The a priori design of the sampling plan allows assisting the user in the data collection task. Moreover, an expert in data analysis can be the designer of the plan and a non-expert user can carry out the data collection, as at each point pictures and comments can be introduced.

3) The use of a high-performance PC to carry out the sampling and to introduce the data directly in the GIS permit to ignore all concerning data structure, since the GIS is filled out in real-time during the data collection stage.

4) The equipment required for data acquisition and pre-processing/analyses is a conventional PC and a DGPS receiver. For the fieldwork, it is necessary that the PC has a special display and a pen-computer is greatly recommended. Then, it is not necessary to buy additional equipment with the consequent cost reduction.

5) The spatial database is built in Access format, so it is compatible with applications as are Microsoft Exel.

Finally, the presented system has been proven in weed control field experiment. Results are explained in the work: *"Comparison of various sampling methodologies for site specific sterile wild oat (Avena sterilis) management"*, also communicated in this Conference

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