Web-based Farm Management Information System for Agricultural Robots

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ABSTRACT

The needs to increase the efficiency in agricultural production, and the latest technological developments in ICT, have led to the creation of the first autonomous agricultural robots for open fields. Additionally, the rapidly growing technology of mobile internet communication and its capabilities have given the possibility for remotely internet connection of the autonomous vehicles. The aim of this study was to design and develop a web-based farm management information system (FMIS), capable of controlling agricultural robots and for analyzing their data in real time remotely with the use of a web browser. The FMIS was built in C#, and the first tests were held to two low cost fully autonomous vehicles designed to perform specific tasks within field operations. This research was funded from the ICT-Agri project “RoboFarm: Integrated robotic and software platform as a support system for farm level business decisions”.

Keywords: FMIS, agricultural robot, autonomous vehicle, web-based, Robofarm

1. INTRODUCTION

The research for agricultural autonomous vehicles has started at early 60’s (Wilson, 2000). Advances in mechanical design capabilities, sensing technologies, electronics, and algorithms for planning and control have led to a possibility of realizing field operations based on autonomous robotic platforms (Bak et al., 2004). Nowadays, the use of ICT and autonomous vehicle technologies is rapidly evolving. Farmers are increasing the use of advanced technologies for completing agricultural tasks and for managing their farms. The International Federation of Robotics Statistical Department reports that there were a significant increase in the number of robots (especially for animal production) developed around farms (IFR Statistical Department, 2010), while

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the sales of agricultural robots were US $879 million in 2011 (IFR Statistical Department, 2012). Recently, the States of Nevada, California and Florida approved the use of autonomous vehicles on their roads. States of Hawaii and Georgia are also working on legalizing autonomous vehicles in public streets (Kohanbash et al., 2012). Hortibot (Jørgensen et al., 2006), Hako (Blackmore et al., 2004), BoniRob (Ruckelshausen et al., 2009), Armadillo (Jensen et al., 2012) are some of the most known autonomous robots for agriculture.

Sørensen et al. (2010), defined the Farm Management Information System (FMIS) as a planned system for collecting, processing, storing and disseminating of data in the form of information needed to carry out the operations and functions of the farm. Fountas et al. (2012) used the soft systems methodology and proposed a rich picture of a FMIS for agricultural robots. Additionally, Fountas et al. (2010) established a methodology for decomposing the agricultural operations into robotic behaviors and Blackmore et al. (2008) set the specification requirements for agricultural robots, which should behave sensibly in a semi-natural environment, over long periods of time, unattended, whilst carrying out a useful task.

Mobile internet is a fast growing technology, and the adoption of mobile internet as new Information and Communication Technology (ICT) in everyday life is huge. The HSPA+ standard which is used at 4th generation mobile systems (4G) has a downstream speed of 84Mbit/s and in the near future the 11th revision of the HSPA+ will have a downstream of 672Mbit/s (3rd Generation Partnership Project – 3GPP, 2013). Also the LTE-Advanced update expected to offer downstream speeds up to 1 Gbit/s (Wannstrom, 2012). The 4G generation mobile systems provide speeds that can compare with the speeds of cable and DSL connections, and makes possible the access to fast internet connection everywhere.

The first attempts for operating and controlling vehicles from distance have started in the early 1900's, but systems of vehicle teleoperation started to be used widely in the 1970's (Fong et al., 2001). The first tries for controlling robots via the World Wide Web, have started at in the middle of 1990's when the WWW started to expand all over the world. Nowadays, there are small commercial robots that can be controlled from web – based applications. An example is the Rovio mobile webcam (WowWe, 2008)

2. MATERIALS AND METHODS

For the development of the Web-based Farm Management Information System for Agricultural Robots we used 2 low cost fully autonomous vehicles (Figure 1), four-wheel drive and four-wheel steering, designed to perform specific tasks within the limits of a field. The first one was the "Zeus" agricultural robot from the Laboratory of Agricultural Engineering of University of Thessaly, and the second one was the "RoboTurk" agricultural robot from the Department of Agricultural Machinery of the

Ege University. Both rbots are equipped with spectral cameras and laser scanners and they can carry external sensors, such as EM 38.

Figure 1. Zeus (left) and Roboturk (right) agricultural robots.

The FMIS was built in C#, which is a programming language that is designed for constructing applications that run on the .NET Framework. C# is an object-oriented language, but also includes support for component-oriented programming. The data is stored in 1 MS – SQL 2012 database. MS - SQL Server 2012 databases have a lot of new features as: dynamic management views and functions, spatial features, metadata discovery, sequence objects etc. Also, they are having a lot of enhancements in performance and security. The FMIS and its database were installed at a Windows Server 2012, .NET Framework 4.5, IIS8 server with Intel® Core™ i7-2600 CPU, 16GB DDR3 RAM and 3TB of storage space. The FMIS uses HTML5 markup language and CSS3 styling and the responsive web design (RWB) of the FMIS theme, which is automatically adjusts to different screen sizes, allows being easily viewable and workable at any desktop PC, laptop, tablet or mobile phone.

3. RESULTS

The developed Web-based Farm Management Information System (Figure 2) has incorporated the common modules that a FMIS should include (Robbemond and Kruize, 2011) as: best practice, finance, inventory, traceability, reporting etc. Additionally, it has incorporated two additional modules to address the needs for the autonomous vehicles, namely:

- Control and Inspection Module (CIM), which is used for controlling and inspecting the working parameters of the agricultural robots.
- Sensors Data Module (SDM), for gaining and analyzing the sensors data from the installed sensors (e.g. multispectral camera). The data is visible in real time to the user of the FMIS through the graphical user interface (GUI) of the FMIS.

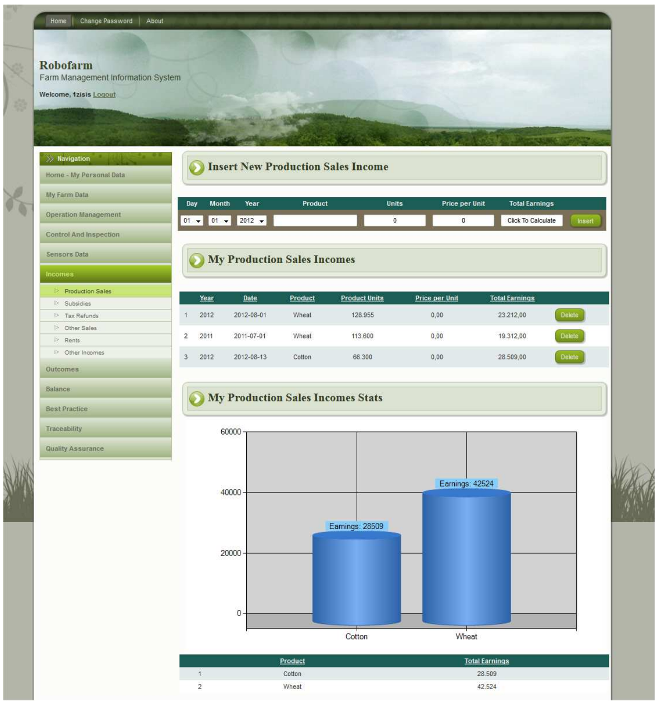


Figure 2. Web-Based Farm Management Information System.

In these two modules, which are dedicated to agricultural robots, the FMIS user can:

- View, collect, store and analyze data from the installed sensors and from the working parameters of the robots.
- Control the autonomous vehicle movement in the field, or in the road.
- View alerts and make fault diagnosis.
- Set the working parameters and variables of the vehicle and its sensors.
- Read, and store event logs.
- Record maps of all vehicle movements.
- Create spatial maps from the sensors data.
- View video from the robot's webcams.

All the working parameters and all the sensors data are being stored in the FMIS database, and they are accessible to the user at any time.

The results of the tests were very satisfactory. Figure 3 shows the control web page for controlling the autonomous vehicles. User can set up the steering angle and the speed of the vehicles by using the two slidebars or by setting the desired set points for each wheel separately. The status of each wheel is shown at the status tables at the left of the page, and the current values of speed and angle for each wheel is written at the textboxes at the right of the page. By clicking at the checkboxes at the top of the screen, user can view video from the robot's webcams, view vehicle movement in Google map and view the coordinates of the vehicle position.

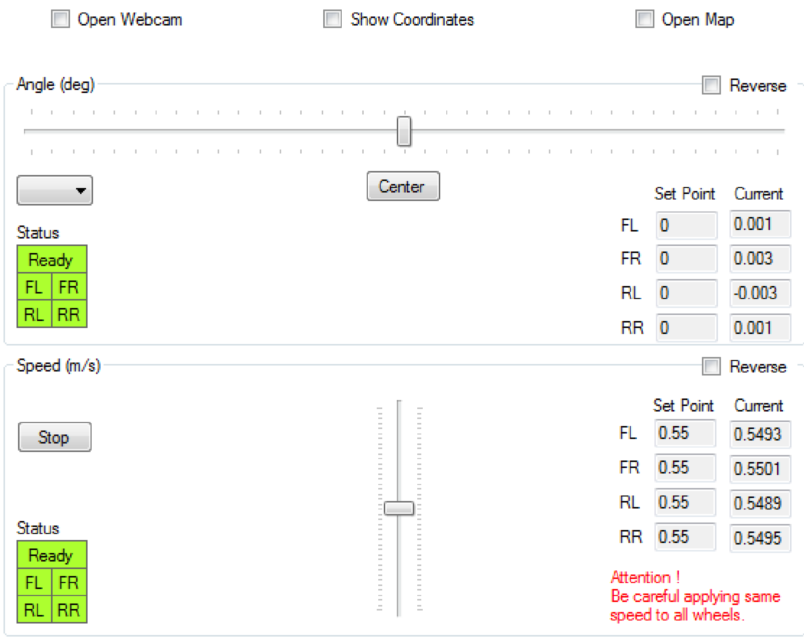


Figure 3. Controls for controlling the autonomous vehicle.

Figure 4 shows the “view sensors data” web page and more specifically shows the data gained from a field test with “Zeus” robot, having the EM 38 sensor for measuring the apparent conductivity installed on it. FMIS user has a lot of options a this page as: selection of the sensor, selection of the start and the end time of the shown data etc.

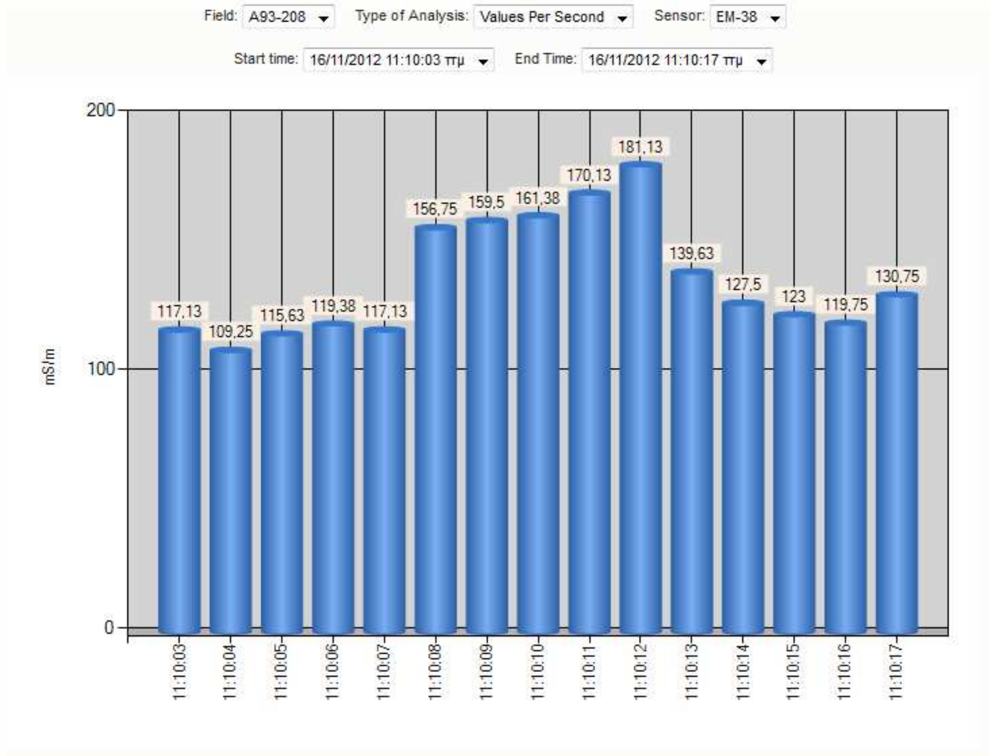
Moreover, the web-based FMIS cooperates with SAFAR software (Software Architecture For Agricultural Robots) via XML files for the creation of the robots optimal route in the fields, the 3D simulation of the route following by the robots, and the statistical analysis of their movements.

Working in the open field’s environment, could create problems in the communication between the robot and the web server via the mobile internet connection. One of the parameters that the user has to set up through the web – based FMIS, is robot’s priorities/options in case that the communication between the robot and the FMIS will be lost. These options are:

- Keep Working. In that case, the agricultural robot will continue its task, but in case that the robot will be 10cm deviated of the proposed by SAFAR route, it will be stopped. All the data of the working parameters and from the sensors are been stored temporally at the robot, until the connection restores.
- Stop Working. In that case the robot will stop working until internet connection restores.

In case that the mobile internet connection speed is too low, then, only the tools for controlling the robot, for the position of the robot, and for the robot alerts are working.

All the other data are stored in the robot temporally until the mobile connection speed becomes faster.



Date	Apparent conductivity (mS/m)	Latitude	Longitude	Altitude (m)	Velocity (km/h)
16/11/2012 11:10:03 πμ	117,13	N393769,083333	E222277,216667	77	2.49
16/11/2012 11:10:04 πμ	109,25	N393769,233333	E222277,133333	77	2.47
16/11/2012 11:10:05 πμ	115,63	N393769,35	E222277,05	77	2.53

Figure 4. View sensors data page.

4. DISCUSSION AND CONCLUSIONS

The latest developments in ICT technology, have led to new possibilities and perspectives. Soon, a new era will come for agricultural tasks in open fields, where most of agricultural operations will be automated, and everything will be controlled and inspected from farmers and farm managers from everywhere via the World Wide Web. A lot of work needs to be done, for the further development of communication compatibility of the various agricultural robots between them, and for the communication compatibility between agricultural robots and the various applications. Communication protocols as ISOBUS, and standardized languages for data exchange as agroXML, can help to achieve this.

A Farm Management Information Systems (FMIS) has been created to include modules for managing the farm and at the same time to control and store data from agricultural robots. Tests with the Greek robot "Zeus" have been completed, while the tests with the

Turkish robot RoboTurk have been implemented in laboratory conditions. In both cases, the results so far are very satisfactory. The development of the web – based FMIS for agricultural robots still continues in order to add even more capabilities and options at the interaction between the robot and the FMIS. One of the most important stages of the future FMIS integration will be the development of a robot fleet management module that will be added to the final version of the FMIS, which will allow the coordination and the management of a large number of different robots at various agricultural tasks.

5. ACKNOWLEDGEMENT

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