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Multi-level automation of farm management information systems

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ABSTRACT

As innovative information and communication technology (ICT) tools were gradually introduced over the past decades into the agricultural sector, the use of farm management information systems (FMIS) was widely expanded and nowadays are regarded as important tools for managing the agricultural business. Nevertheless, the necessary workload for collecting, aggregating and importing data related to farming activities into a FMIS, is a task which is often time-consuming and farmers are reluctant to perform. The current paper describes the implementation of three automation levels, which enhance a FMIS by providing solutions related to the collection of fragmented-missing data and time-consuming data entry. The three levels involve: (i) the development of a modular FMIS based on future internet technologies, (ii) the use of standard values for assessing the cost of performed agricultural tasks and (iii) automating the process of importing task-related data into a FMIS using tractor's CAN-Bus ISO 11783 and SAE J1939 communication information. To assess the financial analysis of the developed FMIS, related data were collected, recorded and analysed for an entire growing season, from two distinct crops, i.e. winter wheat and maize. Furthermore, to assess the automated task formulation in the FMIS, machine data were acquired while ploughing with a mouldboard plough. The application proved capable of performing a profitability analysis based on the recorded cost transactions but also based on the information given by the user related to the performed tasks. With the automatically created task, the FMIS gave the possibility to the user to present and process the necessary information with minimum effort.

1. Introduction

The level of complexity for farming enterprises has been gradually increasing over the last decades. From simple production units, which supplied the population with affordable and sufficient food quantities, they have turned into agricultural businesses with multifunctional service sectors. In today's competitive environment, a farm can survive financially and be sustainable only when it is well managed (Husemann and Novković, 2014). However, farm management is a challenging and time-consuming task (Doyle et al., 2000) with existing associated problems such as lack of time for in-field monitoring of tasks, and difficulty to manage finances and subsidies. Furthermore, the increase of the area per farmer during the last decades can explain the decision support that farmers need nowadays. These problems are complicated to handle due to the lack of suitable dedicated hardware and software. To be able to monitor and manage online data collection in the field, farmers require additional information and proper technologies, which recently have even entered the Big Data sector (Wolfert et al., 2017). The combination of proper time-related information with careful decision-making is the key factor for a successful agricultural business (Singh et al., 2008).

The technological progress in computer hardware and software has enabled an effective computer-based support process, which facilitates farmer's decision-making via the manipulation of increased quantity and quality of available information (Lewis, 1998) and, therefore, contributing to the challenge of a complex farm management. Furthermore, the increase of the Information and Communication Technology (ICT) tools during the last decade in precision farming is noticeable (Kaivosoja et al., 2014). In order to be capable of drawing benefits from available databases, farmers have to collect, process, provide and use data in an efficient way.

Farm Management Information Systems (FMIS) store and process farm data for everyday farm management (Fountas et al., 2015a). There are a number of different types of system structures and software architectures offered (Ampatzidis et al., 2016; Nikkilä et al., 2010; Sørensen et al., 2011; Tsiropoulos et al., 2013). At the same time,

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various commercial solutions are available (365FarmNet, AgriWebb, Agworld, FarmLogs and FarmWorks, just to name a few) with the number of FMIS providers to be rapidly increasing.

New trends such as cloud computing and Future Internet (FI) technologies have also been implemented in the development of a FMIS (Kaloxylos et al., 2014, 2012; Paraforos et al., 2016). The FI provides a library of software components that are called Generic Enablers (GEs). The GEs are public and open-source and allow developers to create mash-up applications by implementing innovative FI functionalities such as Cloud Computing, Internet of Things (IoT) connectivity, and Big Data analytics. All GEs are developed and described in detail as a set of Application Programming Interfaces (APIs) in the FIWARE[1] platform. The list of GEs is being updated regularly, with many independent providers building new innovative tools that could be potentially integrated in the future into the FMIS.

A properly developed FMIS proves its valuable ability toward a successful farm management via the provided allocation of scarce resources and profit maximisation (Verstegen et al., 1995). The FMIS has to be capable of monitoring farm's production and business processes including planning, organising, monitoring and controlling. Special attention should be given to the internal interdependencies of production and services branches. Also, the FMIS must be easy to comprehend. The information system can support farmer's decision-making and lead to profit augmentation only when farmers' demands are fully met (Husemann and Novković, 2014). Software after-sale support service is of high importance as if this does not meet their requirements and does not provide efficient help, farmers tend to seek new software providers and vendors.

In order for a farmer to receive valuable information from a state-of-the-art FMIS, all details related to the performed agricultural operations should be carefully recorded and imported into a FMIS. A common problem is that these agricultural tasks are not recorded properly; additionally, a farmer often neglects to gather all necessary data and import them into a FMIS (Paraforos et al., 2016). A solution that appears promising is to utilise agricultural machinery communication data. The connection of ISO 11783 (ISOBUS) with a FMIS has been described in detail in Part 10 of the standard (ISO, 2014). Data are obtained from the machines' sub-systems (e.g. different sensors and electronic control units), which are initially installed for the correct operation as well as for the real-time inter-machine communication (Fountas et al., 2015b; Kortenbruck et al., 2017).

This is taken into account in recent trends aimed to improve the functionality of the FMIS. A methodology for gathering agricultural process data from ISOBUS was introduced by Steinberger et al. (2009). These data were transmitted to a server for further analysing and task formulation. The onboard data management and integration of mobile devices were presented and evaluated by Blank et al. (2013) focusing on data sharing in wheat and forage harvesting. Oksanen et al. (2015) also performed remote access of ISOBUS data. A number of commercial solutions in the field of machinery fleet management are already present: CLAAS Telematics, John Deere JDLink, AGCO AgCommand, etc. but usually these solutions support machines from the same brand or partner companies.

The aim of this study is to describe the FMIS architecture that can incorporate different automation levels, in order to minimise farmers' effort and time to perform data entry into the FMIS. A significant advance would be the establishment of a solution towards fragmented or missing data sets. Standard values could be used to calculate the cost of a farming task even when no specific data are provided by the user. These values could be given by the farmers based on their experience or could be acquired from existing databases which can also provide this information for specific regional conditions. A second improvement would be to automate the process of importing task-related data into a FMIS since necessary information that farmers import into a FMIS could be obtained by recording tractor's CAN-Bus ISO 11783 and SAE J1939 communication information.

The contribution of the present work, focusing mainly on small and medium-size farms, whose machinery fleet is not so advanced, is based on the combination of the following three automation levels: (1) Use of new ICT tools for developing a modular FMIS; (2) Use of standard values, related to predefined farming activities, for performing financial analysis for the entire growing season; and (3) Automated machine data acquisition for importing task-related information into an FMIS.

2. Materials and methods

2.1. The FMIS

A cloud-based FMIS, which is commercially available by Agrostis Agricultural Information Systems (Thessaloniki, Greece), named *ifarma*[2], was chosen to be automated according to the three described automation levels. Ifarma is an integrated farm management, which is being offered as a subscription-based application and can be used by farmers, who wish to utilise mobile devices and modern technologies. The main purpose of ifarma is to plan, monitor and keep a record of all farming activities during the cultivating season. Detail tracking of quantities and cost of all inputs and resources, such as workers, machines, seeds, fertilisers, plant protectants is also available.

The ifarma backend is a cloud-based application which operates the main FMIS service. This service communicates with the main database of the FMIS where all farmer's data are stored. For managing all imported data, the database management system MySQL is utilised. The Entity-Relationship model of the ifarma database is presented in Fig. 1. All information linked with the farm is integrated into a data model of ifarma. This includes fields and land parcels, crops, and agricultural activities as well as all the inputs and resources required for these activities. A hierarchical model with the farm itself on top is used to organise the datasets. The data are divided by crops, which are cultivated on one or more fields. A specific set of tasks is prescribed to each crop. Each task activity includes inputs or resources. Inputs are represented in forms of resources divided by categories such as labour, machinery, materials, equipment, etc. Farm-specific resources are represented as individual data entities such as workers, machines, fertilisers, plant protection products, etc. Both inputs and resources have their own unit cost and unit efficiency values per task, which are used to calculate the final quantity and amount of this input/resource for each task.

2.2. Instrumentation and data acquisition

To acquire machine-related data, a metal construction was developed in order to mount all the necessary instrumentation (Fig. 2) and was placed inside the cabin of a 6210R 156.6 kW tractor (John Deere, Moline, Illinois, United States) (Paraforos et al., 2017). A GL2000 CAN-Bus data logger (Vector Informatik GmbH, Stuttgart, Germany) was connected to the CAN-Bus diagnostic interface, to record J1939 and ISO 11783 communication data. The logged data were stored in a 2 GB SDHC card, which was possible to be increased up to 32 GB storage capacity. To wirelessly transmit the acquired data to the cloud-based server of the FMIS, the logger was connected with a 3G M2M (Machine to Machine) gateway (Sierra Wireless, Richmond, BC, Canada) with an installed SIM card. Every time the data had been successfully received by the application running on the server, the memory card was cleared to avoid storage capacity problems. The acquired data were georeferenced by the logger using the positioning data from a Navilock NL-603P differential global navigation satellite system (DGNSS) receiver (Tragant Handels- und Beteiligungs GmbH, Berlin, Germany).

[1] www.fiware.org.

[2] ifarma.agrostis.gr.