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A web mobile application for agricultural machinery cost analysis

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ABSTRACT

Machinery cost is the major cost item in farm businesses in highly mechanized production systems. Moreover, in the last years, high power machines, advanced technologies, higher cost for spare parts and repairing, and fuel consumption contributed to an even more higher increase of the machinery costs. Many engineering and economic methodological approaches have been implemented to calculate machinery use and cost, but they are almost confined in scientific and technical documentations making it difficult for a farmer to apply these approaches for deciding on buying, leasing, or sharing agricultural machinery.

Information and communications technology (ICT) has an increasingly important role on business processes and provides a powerful foundation to address many daily problems. Today users want to be connected to useful information in real time. To that effect, the aim of this work was to develop an easy-to-use mobile application, called "AMACA" (Agricultural Machine App Cost Analysis) for determining the machinery cost in different field operations and making it available via a web mobile application using a cross-platform approach. The customer-driven Quality Function Deployment [QFD] approach was implemented in order to link the user expectations with the design characteristics of the app. The AMACA app is free, readily available, and does not require any installation on the end user's device. It is a cross-platform application meaning that it operates on any device through a web interface and is supported by various browsers. The user can make subsequent calculations by varying the input parameters (fuel price, interest rate, field capacity, tractor power, etc.) and compare the results in a sensitivity analysis basis. AMACA app can support the decisions on whether to purchase a new equipment/tractor (strategic level), the use of own machinery or to hire a service, and also to select the economical appropriate cultivation system (tactical level).

1. Introduction

Information and communications technology (ICT) has an increasingly important role on business processes and provides a powerful foundation to address many daily problems. Today users want to be connected to useful information in real time. For this reason the use of mobile technology has grown rapidly. In fact, for the year 2014 mobile technology and applications were identified in the top-ten strategic technology trends globally (Gartner, 2014).

Nevertheless, in the agricultural sector there is a slow adoption in the use of mobile technology compared to other business domains (Sørensen and Bochtis, 2010; Xin et al., 2015). This is in contrast with the huge potential for applied mobile technologies in the sector for a various number of decision making processes including tailored weather information, geo-referenced soil maps, natural disasters forecast, extension service advices, distance learning modules, plant diseases diagnosis, agri-products traceability, economic information, and agricultural machinery management (Bochtis et al., 2013, 2012; Busato et al., 2013; Kolhe et al., 2011; Orfanou et al., 2013; Thakur and Forås, 2015; Xin et al., 2015).

It has been demonstrated that machinery and equipment are major cost items in farm businesses in different countries (Bochtis et al., 2014). Moreover, during last years, high power machines, advanced technologies, higher cost for spare parts and repairing process, and fuel consumption contributed to an even more higher increase of these costs. Actually, the cost of machinery remains a significant portion of the cost of production of a farm for many operations and continues to be one of the highest input costs for farmers (Buckmaster, 2003). Anderson (1988) showed that the machinery cost is in the range of 35–50% of the farm cost. Many engineering and economic methodological approaches have been

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implemented to calculate machinery use and cost, but they are almost confined in scientific and technical documentations making it difficult for a farmer to apply these methodologies for deciding on buying, leasing, or sharing agricultural machinery.

Agricultural machinery cost regards two types of cost, namely the annual ownership (or fixed) cost, which occurred regardless of the machine use, and the operating (or variable) cost which is directly connected to the machine use intensity. The former cost derives from depreciation, interest, housing, and insurance cost, while the latter derives from maintenance, repair, fuel and lubricant consumption, and labor cost, and depends on various factors including hours of annual use, type of performed operation, field size and characteristic, operator's skills and experience, timeliness etc. (Schuler and Frank, 1991). There is not a unique process to determine machinery cost and the most accurate method to evaluate them is the complete records of the actual costs incurred; unfortunately this method is not usable for prompt forecast purposes. The potential to know in advance such costs is strategic for the farmer, but agricultural machinery cost determination available by internet applications (e.g. Busato and Berruto, 2014) are lacking of a mobile app.

The aim of this work was to develop an easy-to-use mobile application (app), named: Agricultural Machine App Cost Analysis (AMACA) for determining the machinery cost in different field operations and makes it available via a web mobile application using a cross-platform approach. Mobile apps in agriculture can be clustered in two broad categories (Brugger, 2011): m-learning (transfer of know-how on specific farming techniques and trends) and m-farming (decision support systems and services based on localized-specific data); for its characteristics AMACA can be considered an m-farming app.

2. Materials and methods

2.1. The design process

The design process for the AMACA development was focused on extracting the specific requirements for farm operations cost prediction including the steps of extracting the individual users' requirements, identifying the necessary system components, and identifying the need for supplemental development. The methodology of quality function deployment (QFD) has been implemented in this process. QFD is one of the most common customer-driven tools of total quality management process linking the user expectations with the design characteristics of the product (Carnevalli and Miguel, 2008; Chan and Wu, 2002). Although QFD has been considered as a having a high potential for the design of new systems, especially in the case of ICT (Schiefer, 1999), there is a limited number of design process that have implemented such a methodology in the agricultural domain (Sørensen et al., 2010).

The general steps of the QFD include the following: users identification; users requirements extraction; users requirements prioritization; design parameters identification; determination of relationships between users requirements and design parameters; and correlation between design parameters. These steps are described in detail in the following sections.

2.1.1. Users requirements

The identification of the users requirements includes four phases: the information gathering where the target groups of the users are identified and the questionnaires are defined; the interaction with the users where personal interviews take place; the evaluation phase where the user needs are addressed; and the requirements identification phase where the various requirements are prioritized according to the users preferences. The methodological approach involved a participatory approach and analysis, extracting current farm management challenges facing agricultural machinery users and owners.

Four target user groups were identified, including:

a. **Farmers**. As users the farmers have different roles. A farmer can use the application on a strategic level, e.g. to assess the cost for purchasing a new machinery (i.e. tractor, equipment, or self-propelled machine), or in case of owing a machine she/he can evaluate the cost for providing services to other farmers (i.e. to act as contractors), or for verifying the benefit of using a contractor service.
b. **Contractors**. Similarly to farmers, contractors can assess a number of decisions on strategic level (e.g. purchase more machines), on tactical level (e.g. to find the break-even point in the use of machinery), and on operational level (e.g. to price the rates of servicing).
c. **Consultants**. Consultants might work for advisory services or private companies to support farmers in decision making for machinery purchase or contracting a service, and also to support farmers to evaluate the whole production cost for a crop.
d. **Machinery dealers**. Machinery dealers can use the application for providing farmers with an optimal solution for purchasing machinery based on their individual needs.

A number of user requirements for agricultural fleet management systems have been identified and listed in Sørensen and Bochtis (2010). The majority of these user requirements have been adopted and/or modified. The voiced user requirements for the development of the AMACA app are listed in Table 1.

A five-point scale measure was implemented for raking the requirements which were defined according to the following mapping: 1 → not at all important; 2 → not very important; 3 → fairly important; 4 → very important; and 5 → extremely important.

For the extraction of the average relative importance ratings of the identified requirements the simple isobaric method was implemented.

Table 1
Voiced user requirements for n agricultural management system.

General category	ID	Specific requirement
Data acquisition	R1.1	Improved general knowledge of the production process
	R1.2	Effective documentation system
	R1.3	Detailed work time specification
	R1.4	Detailed cost elements specification
	R1.5	Information search availability (quick access to information)
	R1.6	Easy and quick access to information
	R1.7	Data exchange interfaces
	R1.8	Available data bases
	R1.9	Reduction of user inputted errors
Decision making	R2.1	Resource optimization (e.g., labor, fuel)
	R2.2	Generation of tasks orders
	R2.3	Environmental benefits (e.g., soil compaction, resource usage)
	R2.4	Preventive maintenance
	R2.5	Benchmarking
Software/hardware/ technology components	R3.1	Dedicated user-interface
	R3.2	Application roughness
	R3.3	Communication with internal databases
	R3.4	Communication with external databases
	R3.5	Availability in various devices