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A user-centric approach for information modelling in arable farming

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ABSTRACT

Agriculture and farmers face a great challenge in effectively manage information both internally and externally in order to improve the economic and operational efficiency of operations, reduce environmental impact and comply with various documentation requirements. As a part of meeting this challenge, the flow of information between decisions processes defined as realizing a decision must be analyzed and modelled as a prerequisite for the subsequent design, construction and implementation of information systems.

This paper defines the actors, their role and communication specifics associated with the various decision and control processes in farmers' information management. Core-task analysis and core task demands from earlier research are utilised as premises for the modelling of information flow from the farmers' point of view. A user-friendly generic FMIS design reference model is the primary objective for the study in which planning, execution and evaluation measures have been incorporated.

A user-centric approach to model the information flows for targeted field operations is presented. The information models are centred around the farmer as the principal decision maker and involves external entities as well as mobile unit entities as the main information producers. This is a detailed approach to information modelling that will enable the generation of a Farm Management Information System in crop production.

1. Introduction

The analysis of decision processes, as well as information modeling for field operations is not a new approach. Decision-making is an important aspect in farm management and has been studied by numerous studies (e.g. Anderson et al., 1980; Van Elderen and Kroeze, 1994). The reasoning of why there is a need to analyze decision-making has been addressed by Gladwin (1989), who argued that the benefit is to know and understand why a specific group of people acts as they do. This will enable researchers to provide the farmers with supporting knowledge and tools as a way to enhance decision-making at specific stages of the process. In agriculture though, farmers, in general, both generate and execute any plan made, and their decision process associated with the planning remains very much implicit and internal (Sørensen, 2000) and often make decisions based on their intuition and not using formalized planning tools. That is contradictory to the industry, where there is a long tradition for explicit planning comprising formalised documents passed down to the shop floor by the management section for implementation (Chary, 2006). The efforts aimed at developing agricultural planning support must be targeted at externalising and formalising the farmers planning effort.

Kay and Edwards (1999) discussed the unique attributes that make farm business complex in comparison to the industry, such as the biological processes, the fixed supply of land, the small size, weather forecast and the perfect competition (Runge, 2006). They argued that the systematic analysis of decision-making process would not necessarily lead to perfect decisions, but would help a farm manager act in a logical and organized manner when confronted with choices. The US North-Central Regional Research team in Farm Information Systems (2000) categorized the farmers into two groups: "information hogs" seeking and using large amount of information and "seat of the pants" where personal intellect and intuition are the main drivers in decision-making. They observed that seat of the pants farmers most likely utilize information in ways not fully understood by researchers or advisors. It is perhaps useful to recognize intuition as a complex result of a given farmer's unique experience and familiarity with his/her farm. Much of the information exists as tacit knowledge of the farmer, but in order to specify all the elements it is necessary to explicitly specify the detailed information flows for individual planning tasks.

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With the advent of Precision Agriculture (PA) technologies farmers acquire a vast amount of data and they face even bigger problems on how to effectively utilize them to make better decisions (Auernhammer, 2001). PA aims to change the focus of agricultural production from quantity to quality and sustainability (Jensen et al., 2000). By generic definition, PA refers to agricultural techniques that increase the number of (correct) decisions per unit area of land per unit of time, with associated net benefits (McBratney et al., 2005). When practising PA, a farmer manages crop production inputs (seed, fertiliser, lime, pesticides, etc.) on a site-specific basis to increase profits and crop quality, but also to reduce waste and maintain environmental quality. In order to make precise decisions in different phases of the farming process, the farmer therefore needs to analyse information from different vast and dispersed located information sources. Management of the information and decision-making is the core issue for the farmer in successful PA, not the data acquisition process.

Fountas et al. (2006) have decomposed the decision-making process for farmers using PA into twenty-one decision analysis factors. These factors were assembled into a data flow diagram describing the main information processes and flows. The diagrams analyzed the information flows for field operations taking a general approach to represent the transformation from gathered data into information and then decisions. Nash et al. (2009) modeled all range of data flows covering the broad spectrum of PA practices into one very large diagram showing the interrelations, while also including the modeled data-streams for specific PA practices, such as management zones, yield mapping or exploitation of remote sensing data.

The required information modelling can be fulfilled through concentrated efforts aimed at extracting domain knowledge and deriving information flows at various planning and process levels. This effort demands considerable research and development, which is the case in terms of incorporating user preferences and requirements. The tendency to use a more user-centric approach in developing new technologies has gained considerable appeal (e.g. Akao and Mazur, 2003; Norros, 2004). The core-task analysis (CTA) is a user-centric methodology, which was initially developed in Governmental Technical Research Centre of Finland (VTT: Valtion Teknillinen Tutkimuskeskus) (Norros, 2004). It is a functional modelling technique that informs system modellers of the aims, intrinsic constraints and user practices in the work under study A user-centric approach assumes that the users' ideas and requirements reactions concerning the specific characteristics of the designed technology are integrated in the subsequent design. When end-users and other actors in the value chain are involved into the design and development process from its early stage, the system becomes more realistic to realise and build in real world, and it readily meets most of the user requirements. Since the adoption of Decision Support Systems (DSS) and Farm Management Information Systems (FMIS) within PA has been disappointingly low (Rosskopf and Wagner, 2003; McBratney et al., 2005; Parker, 2005), this kind of user-centric development method is expected to improve the acceptance of the new technology in the markets and among end-users. This leads to smaller risk associated with introducing new FMIS in the farm business domain (Norros et al., 2009), which was communicated in a research project, InfoXT[1] – user-centric mobile information management in automated plant production – running from 2006 to 2008 in Scandinavia (Pesonen et al., 2008). Here, the applicability of using a user-centric approach to develop an information system for mobile work units was indicated.

The aim of this paper is to define the actors, their role and communication specifics associated with the various decision and control processes in farmers' information management. The core-task analysis involving farmer interviews and derived Core-Task demands is the basic framework for the pursued approach. A user-friendly generic FMIS design reference model is the primary target for the study where both planning, execution and evaluation measures are incorporated. The generic design is intended to support and guide the actual implementation of a specific FMIS in terms of capability, invoking of information and communication technologies, etc. The design reference model is developed in the early phases of system design and the detailed decomposition and component construction can be derived from this model.

This study was part of an on-going EU research project FutureFarm.[2] FutureFarm has defined aims at meeting the challenges of the farm of tomorrow by integrating Farm Management Information Systems (FMIS) to support real-time management decisions and compliance to standards.

2. Farm management and field operations

The agricultural production processes within arable farming involve transformation processes that are realised by biological processes (e.g. crop biomass growth) taking place in the course of the growing season. The processes are regarded as an autonomous system, which is basically independent of decisions made by the farmer. In contrast to this, the intervention realised by labour and machinery during the plant growing process is dependent on decisions made by the farmer and termed an *operation*. An formal definition of an operation is given by Van Elderen (1977), who states that an operation is "*a technical coherent combination of treatments by which at a certain time a characteristic change of condition of an object (a field, a building, an equipment, a crop) is observed, realised or prevented*". This definition extends operations beyond those for crop production to supporting enterprise functions like maintenance, repairs, etc. An operation is generally seen as the link between some resources (e.g. labour and machinery), some materials processed, and some material produced (e.g. harvested crops, repaired machine, etc.).

The decomposition of information processes attributed to the planning and execution of field operations is based on the management functions ranging from strategical to operational planning, execution control and evaluation, and a number of underlying processes and sub-processes. All planning levels have to be included in a generic FMIS as it is necessary to know what kind of information the system has to be able to handle. Farmers cannot have separate systems for each management level. All levels utilise/need data/information produced in the other levels. The integration of all planning levels is pivotal to the usefulness of the FMIS. Fig. 1 outlines the basic management processes which are identified within the agricultural plant production cycle for both manned and unmanned machinery items.

Plan generation and execution must be linked in a system monitoring effects of actions, unexpected events and any new information that can attribute to a validation, a refinement, or a reconsideration of the plan. Plans must be presented conditionally, so that supplementary knowledge from observations, farm databases, sensors, etc., can be incorporated in order to revise plans.

It should be noted, that although that the concept of "farm databases" is an important issue in the modelling of a FMIS, it is not within the scope of the paper. The pursued concept, in principle, does not make any difference between information in a "database"

1 www.mtt.fi.infoxt.

2 www.futurefarm.eu.