Designing for Farm Management

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ABSTRACT

Agriculture today is facing increased demands to reduce production costs, comply to standards and keep a high quality for the produce and safety. Farm management information systems has now evolved into complex systems to support the farmers as a tool for meeting these demands. The systems have advanced with positioning systems and sensors, among others, to collect data and enhance decision making for the farmer. This paper has investigated how these systems has been developed in the past, how it has helped the farmer, and how design philosophies can help develop the systems further. The methods that were used to investigate were literature reviews from journals about agriculture and electronics and from scientific textbooks about design philosophies. The results were that some of the projects presented had a user-centered approach to the development, but there are little to none information about how user-friendly these systems are. Therefore, it is room for using various design approaches to further develop farm management information systems in the future to ensure a low threshold for investment.

KEYWORDS: farm management information system, agriculture, graphical user interface, user-centered design, TPD4505

1. INTRODUCTION

Agriculture is one of the most important industries for the world's population; as the population is rising, so is the demand for food production. This is now more important than ever, especially with the aspect of environmental impact and sustainability. The warmer temperatures are harmful in southern European countries, as well as in the southern states in the US (Van Passel, Massetti & Mendelsohn, 2017). The farmers are also having to meet increased demands to reduce their production costs, comply with agricultural standards and maintain high product quality and safety (Fountas et al., 2015).

When research in chemical fertilizers, biological innovations, new machines and technology made a big jump in increasing agricultural productivity from the 1970's to the 2000's, today it is the internet that is increasing production further (Kaloxylos et al., 2012). Farming is being more and more digitized, especially with the use of sensors and automation. The latest trend is to enable these systems to operate over the internet. Advances like positioning systems, sensors for yield and machinery performance monitoring are examples of data collecting which can enhance decision making for the farmer (Sørensen et al., 2010).

The collection of farm data has been put together into systems for the farm managers to be advised in different decision-making processes. The technical implementation of a farm management information system (FMIS) has already been worked on for several years (e.g. Kaloxylos et al., 2012; Fountas et al., 2015; Rupnik et al., 2018). The part that has not been worked on as much is the front end of the system i.e. the usability. Although, it is said that new management concepts mean that farmers

have to be ready to adopt new working habits and may also need further training to see a benefit (Sørensen et al., 2011).

The research question investigated in this paper is to find out how FMISs has been developed in the past, and how it has helped the user with their work. If possible, existing systems will be reviewed with regards to its usability, what kinds of design guidelines has been used and how it has helped with decision making. Decision making is one of the priorities for making a FMIS, and the user interface is an important part of that.

2. THEORY

For designing a farm management system, there are several philosophies which can be used. The following philosophies are taken from different areas of design, with a focus on how to make the product user-friendly.

2.1 Design Thinking

Design thinking is a method that designers can use in ideation and development, but it is not necessarily linked to only physical products, but also e.g. services and digital solutions. Design thinking entered the mainstream in the 2000's and is used today in different areas from education, business, and medicine, to making applications for smartphones. The method is about having a human-centered, iterative process to tackle difficult problems.

The process consists of five steps; empathize, define, ideate, prototype, and test. These steps are used in every part of a project, often in parallel or continuously repeated by making iterations - they are not supposed to be executed one after the other to finish a project but be revisited to always find better solutions (Interaction Design Foundation, Undated). When doing this for developing a FMIS, the solution will always be in the farmers best interests.

2.2 Interaction Design

Interaction is about what happens between a user and a medium when the user can influence the medium in what it contains or what can happen to it. When it comes to interaction design, there are many definitions. Interaction design is about the design used between a user and a product, where the product often is an app or a web page (a digital surface) (Nordbø, 2017).

A more general approach is to say that it's designing interactive products to support the way people communicate and interact in their everyday and working lives (Preece, Rogers & Sharp, 2012). Guidelines from interaction design will contribute to easier navigation of a FMIS and thus better usability.

2.3 Human-Computer Interaction

Human-computer interaction (HCI) is a part of interaction design with a narrower focus. It has an origin in the 1940's under functional design and went through different stages; electrical, symbolic, text and graphical. The electrical was about connecting circuits for analog computers early on, and today more about interaction with two-dimensional interfaces (Nordbø, 2017).

2.4 User Interface

A user interface is what the user is interacting with, and there are several types of interfaces. As mentioned, a screen-based 2D graphical user interface (GUI) is the most common today, but up and coming are interfaces for virtual reality, augmented reality and speech, among others. When working on designing a GUI for a farm management tool, there are different things to consider. Some examples are using a computer mouse versus a touch screen, making elements responsive to different sizes of screens and how the system should be navigated on different digital surfaces (Nordbø, 2017).

2.5 User-Centered Design

User-centered design, or UCD, is according to Norman (1988), a philosophy based on the needs and interests of the user, with a goal to make products that are usable and understandable. Good design starts with an understanding of psychology and technology and it requires good communication especially between machine and person (Nordbø, 2017).

User-centered design is a way of achieving more effective systems. When a farmer has the right information more easily accessible in an interface, errors can be reduced, and productivity improved, as well as taking away frustration towards the technology. The principles for UCD also implies that situation awareness is key to achieving a user-centered design as they are about keeping the user in control and aware of the state of the system (Endsley & Jones, 2012).

2.6 Situation Awareness

Situation awareness is about finding the right information in a vast amount of data. Today, as a part of the information age, people are having to focus harder on finding this information and then process it with other information to find what you are looking for. Situation awareness is being aware of what is happening around you and is often used about executing a particular job or goal. It's often applied to operational situations like driving a car, treating a patient, air traffic controlling or using the internet. All these operations use systems with user interfaces which allow users to manage the information to gain an understanding of what is happening. Therefore, it is important to design systems that support situation awareness. Situation awareness is very important for making decisions and the performance in complex, dynamic systems (Endsley & Jones, 2012). While farming might not be the most action-packed job, situation awareness is still important.

2.7 Complex Systems

Complexity in systems is important to work with when developing systems that will allow the user to still have a good level of situation awareness and be able to act correctly. One thing that should be done, is to find what level of complexity the user should face (Endsley & Jones, 2012).

There are several factors that make something complex, here are four factors:

- The number of items incorporated in the system
- The degree of interaction or independence of those items in creating functionality
- The system dynamics, indicating how fast the status of items and interactions will change within the system
- The predictability of such changes

Implementing a whole world of farming into a system should qualify it to be complex. UCD of complex systems can quickly become a big task. When systems become very complex, it is necessary to do UCD cooperatively since no one person can provide all possible contributions. This is where a team must be formed, also as collaborative work is an important part of UCD (Boy, 2016).

3. METHODS

To answer the research question about how farm management tools are helping farmers in decision making regarding its design, a literature review has been the used method. Scientific textbooks and a website have been reviewed to find design sciences and guidelines for making a digital surface, like a farm management information system, user-friendly. To find articles relevant for farming software, search phrases like 'farm management system', 'agriculture', 'HCI', 'GUI' and 'user interface' were used in the Oria and Google Scholar search engines. The journal 'Computers and Electronics in Agriculture' held many articles about developing a system for future farming in the EU and has been thoroughly reviewed to find information about how this has been developed in the past and to

see how guidelines from design can help develop the systems further. The downside to only reviewing literature is that all information is from the past and there is no direct information e.g. from a user/farmer through interviews.

4. RESULTS

4.1 Farm management information systems

In the 1970's and 80's, there were already FMISs in use which could keep records, plan operations, support algorithms for these and link data to particular cropping seasons and hold inventory data related to farm stocks and suppliers. These systems have now evolved into sophisticated and complex systems to support production management. It is a tool for meeting the increased demands in agriculture. The agricultural sector has during the last years had fast technological developments. These have introduced changes in the working environment for farmers, where the new era finds success by having access to the right information and elaborate decision making (Fountas et al., 2015).

The latest trend is to make these systems operate over the internet, but there are many difficulties with the number of sensors used in agriculture being linked (Kaloxylos et al., 2012). The lack of interoperability between tractors leads to the development of the international standard ISO 11783 (ISOBUS) for securing a better communication between the different elements. This standardization is emerging in tractors today with the aim to provide enhanced decision support for farm and operations management (Fountas et al., 2014). The main functions these web-based systems offer are field operations management, best practice, finance, inventory, traceability, reporting, site-specific, sales, machinery management, human resource management and quality assurance (Fountas et al., 2015).

There is also another aspect for this to work for the user, which is developing the interface. According to Seneler et al. (2009), special care must be given to the design of the user interfaces since poor design often has been a key reason for low adoption of FMIS in agriculture.

4.2 FMIS projects in Europe

4.2.1 FutureFarm

Back in 2010 started a project for developing future farms in Europe; the EU funded FutureFarm project. At this time, there was a new time coming for farmers and they were under pressure to change production from a focus on quantity to an alternate focus on quality and sustainability (Halberg, 1999). This new paradigm needed a new and improved FMIS. This system is needed to advise the user of formal instructions, recommended guidelines in farming and documentation requirements for different decision-making processes.

They developed a conceptual model to find a way to make a system to meet farmers' changing needs. They had four pilot farms which represented different conditions across Europe. The focus was on the farm manager and the everyday management problems including the farm manager, the fields, the products, and production input. The system got defined in terms of the customers, actors, transformation process, worldview, ownership and environmental constraints (Sørensen et al., 2010). It is also important to highlight that this system was meant for precision farming, which does not include livestock production, only crops.

For the program to be able to do the same as what a farmer does, there had to be many actors to deliver information. The concept of assisting services had to evolve to sustain the need for more automated decision processes in the future. This also meant that farmers had to be ready to adopt new working habits and maybe get further training to use these new technologies. Then, they could also use different services more efficiently and become able to outsource some of the tasks they previously did themselves (Sørensen et al., 2011).

4.2.2 SmartAgriFood

A paper written for the SmartAgriFood project, a part of the Future Internet Public-Private Partnership program in the EU, used a user-centric design model to design a farm management system. The users were involved in all stages of the design and implementation process, including concept specification, design of system functionality and software development. The users, in this case, were 100 people operating in Greece with backgrounds as farmers, agriculturists, agronomists and information and communications technology experts.

According to them, their GUI was a user-friendly web application, allowing the user to interact without getting involved with the underlying complexity of the system. They had visual elements which indicated the state of the farmer's sensors, with green = ok, gray = not used, and red = problem. The farmers also got the opportunity to monitor the perceived data and make decisions based on the solutions proposed by the system. They found that 80% of the respondents found the system useful and could use it to complete some of their daily tasks. 88% also believed that the system could reduce the cost of their work since it may contain adequate information for the farmer and was easy to use (Kaloxylos et al., 2013).

4.2.3 RoboFarm

The RoboFarm project, funded by ICT-Agri in Europe, did interviews and questionnaires with farmers asking about their farming machinery and optimization. Some of the results were that the younger farmers were much more willing to use new technology on their tractors than the older. The general feedback they got from the farmers were also useful for further work on their farm management system (Fountas et al., 2014).

4.2.4 AgroDSS

AgroDSS is a decision support system for agriculture and farming used today. It was developed within the AgroIT project which has partly been founded by the EU program CIP-ICT PSP. The system made a connection between agricultural systems and state-of-the-art decision support methodology. It could help users make predictions for simulated scenarios and better understand interactions within their work (Rupnik et al., 2018). They calculated the financial outcome of using AgroDSS for three farms to have a positive influence. With the system, the farms increased their crop quality which made higher gained price of crop and used less money on spraying by not having to spray as much as before (Rupnik et al., 2018).

4.3 Future development of FMIS

For the future, FMISs should provide the user with information about resources across the farm and the potential impacts of decisions on those resources. Web-based solutions are already introduced and help collaboration between the different actors in agriculture (Fountas et al., 2015). For integrating data, the ISOBUS standard should improve transparency for the user, and help provide user-friendly interfaces. Also, a greater emphasis on software design governed by usability and human-computer interaction will help further development. Studies have shown that cooperation between software developers and academia through a user-centric development process show effectiveness in making a FMIS (Pesonen, Koskinen & Rydberg, 2008). The social aspect also has a great relevance to the business aspect of farming with marketing, sales and supply chain functions. When combining everything into a system is when the FMIS get the sophistication it needs to truly support the user's decision-making process (Fountas et al., 2015).

5. DISCUSSION

Rupnik et al. (2018) concluded that decision support systems for various aspects of agriculture and farming have been extensively studied, which also can be seen in the previous part of this paper. The projects in Europe have spent much time finding good solutions for their users. One thing to note is that the

presented projects in this paper have FMISs for plant-based production i.e. not for livestock production. This seems to be because of precision farming which uses many sensors and is easier to generate data from. From this, it is apparent that there is a gap in what kind of farmers these systems are for, where the ones with a livestock production get neglected.

The projects have mainly been about finding a solution from a technical view, but with the user often being in the center of the development. There has been conducted interviews, electronic questionnaires and workshops (Sørensen et al., 2011; Kaloxylos et al., 2013; Fountas et al., 2014;) over a number of years to develop some of these systems. While the work has mainly been about what data the user needs and how to implement it in a technical way, it is difficult to find reviews of commercialized systems after they have been in use. One article from 1999 addresses this in detail though. They had farmers use their system for on-farm crop simulations between 1991 and 1993. They tested the users using general guidelines for usability testing and had observational interviews. The users' experiences were that wizards were a nice help to get through the system, normal Windows shortcuts did not work - which made things difficult, and some icons were confusing (Acock et al., 1999). This is useful feedback to remember when developing a user interface, but deliberately, as this user interface is over two decades old.

It is quite difficult to find any other, and newer, user reviews of FMISs, and it is, therefore, hard to find out what is working for the user and not - from an interaction design standpoint. It is not addressed how the user is actually using the system. Something that could be retrieved is that some users found some of these systems useful and got a better financial outcome after using them, but it doesn't say if the user found the system easy to use.

6. CONCLUSION

The research question investigated in this article was to find out how FMISs has been developed and if it has helped farmers in their work. Above examples has been given to different aspects of FMIS; it still seems to be some hesitation to start using a computer-based system for farm management for farmers. As mentioned, studies show that elder farmers are almost not interested at all in new technology (Fountas et al., 2014) and that they have to adopt new working habits to see a benefit in using this technology (Sørensen et al., 2011). Since it is hard to read up on how user-friendly these systems are, it seems to open up for the different design sciences to take a place in further FMIS development. It is already known that poor interface design has been a reason for not using the systems (Seneler et al., 2009).

As previously mentioned, some systems have made use of user-centered design during development, which leads to valuable feedback and iterations. The teams behind the systems are not clearly presented in the papers so it is difficult to say how interdisciplinary they have worked, thus how much they have implemented design philosophies. There is a need for future research in this area about using design methods for FMIS development and what the outcome for the farmers has ended up being. When using different guidelines from design during development, the end product should be user-friendly and support decision making for complex systems. The psychology aspect is still in the roots of good design, and when integrating it the user will make fewer errors, improve their productivity and have less frustration towards the systems.

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