Web Based Research Mapping and Analysis: ICT-AGRI's Meta Knowledge Base Centralizes ICT and Robotics Development in Agriculture and Related Environmental Issues

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ABSTRACT

Ample research is conducted on ICT, automation and robotics in agriculture and related environmental issues. ICT and Robotics innovations are rapidly emerging and have the ability to revolutionize future farming through their major impacts on productivity and profitability. Unfortunately human and financial resources and efforts are fragmented and limited. This led to the creation of the ICT-AGRI ERA-NET that provides a central structured framework. Its main objective is to strengthen and coordinate European research regarding ICT and robotics in agriculture. Besides the creation of the Meta Knowledge Base (MKB), a common European research agenda will be developed and common research calls are launched. The Meta Knowledge Base (http://db-ictagri.eu) is attempting to map all relevant research and development within the selected research area. To accomplish the mapping, two types of information are collected: research profiles and research postings. To organize the postings, a three-dimensional task-technology oriented framework was designed. The results indicated that the three axes: task, technology and scope seemed insufficient to describe the whole research area. Therefore, an improved framework was developed. By extending the task-technology oriented framework with a process-control–information system, a useful framework was designed.

Keywords: Agriculture, Automation, ICT, Robotics, Web, Knowledge Base, Research

INTRODUCTION

Recently, agricultural productivity has been increasing, yet modern agriculture started to pose a threat to the environment and food safety. At the same time the intimate knowledge of farmers and farm workers about animals, crops and fields has diminished [5]. Society and politics reacted by imposing control measures on the use of chemicals. Soil, air, water and energy resources can only be protected when assuring food security and safety. These rules resulted in burdening the farmers with a heap of extra administrative work. Meanwhile new future challenges such as climate change and biodiversity protection are rising [3] while farmers' income is decreasing by 12.2% on average between 2008 and 2009 [4].

General rules and laws are expressed implying regulations for farmers to adhere to. These regulations mainly act on an administrative farm level and are generally implied. However, neither agricultural management nor environmental regulations are particularly intelligent, possibly preventing an optimal application of control measures (e.g. fertilizer and pesticide application), affecting agricultural productivity in a negative manner.

Today's technology can help to counteract against these problems. Precision farming attempts to determine and control every action applied to every spot of farm land and every single farm animal. These controlled farming techniques require advanced sensors to measure the current state of animals and land. Digital data and informatisation measures can facilitate alleviating the administrative burden imposed on farmers. Modern communication techniques allow for an easy data transfer between (inter)national governments, regional authorities, farmers, tractors and robots. By putting all these technologies together, agriculture can take a leap forward in the agriculture management coping with the new challenges farmers are facing, yet taking the environment into consideration. A serious problem however, is the limited ICT adoption in agriculture.

Therefore, extensive research on ICT and Robotics in agriculture and related environmental (ICT-AGRI) issues is conducted. New ICT and Robotics technologies are rapidly emerging and can revolutionize future farming through their major impacts that relate with productivity and profitability. Unfortunately human and financial resources remain fragmented and ICT and precision farming is only slowly becoming an integrated part of farming and farm management [3]. There is little tradition for networking and collaboration within ICT and robotics in agriculture. Awareness of existing knowledge is an absolute prerequisite for faster progress in research and development. The relevant knowledge within the ICT-AGRI research area is quite diffuse. It is also often time-consuming to search for knowledge and difficult to assess the completeness of the relevant knowledge that was found.

The overall aim of this project, integrated in the European Research Area-network ICT-AGRI (figure. 1) is to strengthen and coordinate the European research and to develop a common European research agenda and launch common calls within the areas of ICT and robotics in the agricultural and environmental sector. It is ICT-AGRI Meta Knowledge Base's ambition to become the central internet-based resource for researchers, developers and users within ICT and robotics in agriculture. MKB attempts to stimulate coordination of research and development in this area through user-driven initiatives and activities. Therefore a structured framework for mapping and analysis of all relevant knowledge within the described research area is needed.

Figure 1: Map of the participating countries in ICT-AGRI

METHODOLOGY

First a three dimensional task-technology oriented framework was designed. This structure combined technology (e.g. robotics), with farm tasks (e.g. milking) and subtasks (e.g. milk quality measurement) within four different scopes: fundamental, applied, innovation and standardisation. This framework was tested and evaluated by 3 working groups of 20 experts. The results indicated that the three axes: task, technology and scope seemed not sufficient to describe the whole research area.

Based on the theory of [1] and [6] an improved framework was developed. The farm was approached as a managing system controlling a process or production system and receiving input from an information system. By extending the task-technology oriented framework with the process-control–information system four main areas were created: management, operations, external services and communication. These four parts compose the main level which is called the farm system. Descriptors and keywords further specify each area. Two extra levels were added i.e. technology and application area. IT, communication, sensing, machines and modelling divide the technology level in four sublevels. The application area level was divided into crop operations, crop types, animal operations and animals and environment. Finally an extra classification layer was added that differentiates between on-going research, concluded research and finalized product. This basic concept was implemented in a structured database. The database is accessible through a web-based interface that requires registration for editing, but not for viewing. The website has many functionalities like data provision, search engine for research, person and affiliation information, forums, research call information, links to related websites, etc.

Functionalities

Each item of information is entered as either a posting or a profile. A user is able to make a personal profile or an affiliation profile for the organization, networks or associations of which he/she is a member. Organisations can have profiles for different levels in the organisational structure (e.g. university, faculty, department, research group). A profile includes address and contact information but also expertise, facilities and priorities need to be described. Edit rights can be shared with other users and contact persons can be transferred. Each member of the test group adds objects such as R&D projects, R&D facilities, publications, products and environmental administration schemes. Postings are descriptions of research items of particular interest for ICT and robotics in agriculture. It is important to stress that postings are about research results, ongoing research, automated machines and equipment, robots, software, online services, standards, etc. not purely about describing research projects. Each posting includes a title, an abstract and a text, and links to online content of any kind elsewhere. Each posting is classified using the framework described above using keywords as shown in figure 2.

Initially, a panel of researchers was asked to test the website and its functionalities. Now, researchers on ICT and robotics in agriculture from 36 different countries are involved on a European or even global scale. The provision of information by researchers, developers and other users is performed on a voluntary basis. National editors or intermediaries are responsible for stimulating the use of the website and database and for maintaining the quality, validity and integrity of the data.

Finally, the database will contain information concerning a range of objects such as R&D projects, R&D facilities (including human, hardware and software resources), publications, products and environmental administration schemes. The knowledge base is populated by the researchers, developers and users, while the tasks for ICT-AGRI are to create and maintain the framework. The knowledge will be available by linking to digital material stored elsewhere.

The knowledge base only holds structured metadata and each input is classified by the framework allowing different analyses. Consequently, the amount of research on each topic can be calculated and analyzed to identify duplications, gaps and needs for future research. The collected information will be classified by an overall classification system allowing different analyses. Analysis of the gathered and classified research items will form the basis for the development of a strategic research agenda.

RESULTS AND DISCUSSION

At this moment the ICT-AGRI Knowledge base is online and reachable from the ICT-AGRI website (www.ict-agri.eu). The database is open to all researchers and developers. The information gathering is a continuous process, making the MKB a dynamic website. To give the database a boost at start-up, ICT-AGRI members collected relevant information. This information was entered into the database before transferring it to the relevant owners by email. They were asked to accept the transfer and become owner of the information, giving them the possibility to adapt it to their wishes. The idea behind the invitations is that once a user is acquainted with the system, the motivation to enter information into the system will be greater. Removal of the first contact barrier with a more appealing personal request will eventually lead to more information in the database. Since users are allowed to enter additional keywords to characterize their research, the keyword list has been growing since the website launch. The current classification system is shown in figure 2. Profiles from 36 different countries have been recorded already, and their number is still growing. This diversity ensures a unique platform for building and maintaining international collaboration and networks. Today, over 500 postings and more than 600 profiles have been recorded in the MKB, hopefully boosting its use and dispersion on a global scale.

CONCLUSION

The Meta Knowledge Base aims at becoming the internet reference for researchers and developers within ICT and robotics in agriculture, providing a structured framework for mapping and analysis of relevant knowledge within the described research area. This easily accessible resource can become a tool to stimulate coordination of research and development in this area through user-driven initiatives and activities. Our study tries to pool fragmented human and financial resources in order to improve both the efficiency and the effectiveness of Europe’s research efforts. The MKB helps coordinating European research in ICT and robotics and in developing a common research agenda based on shared priorities.

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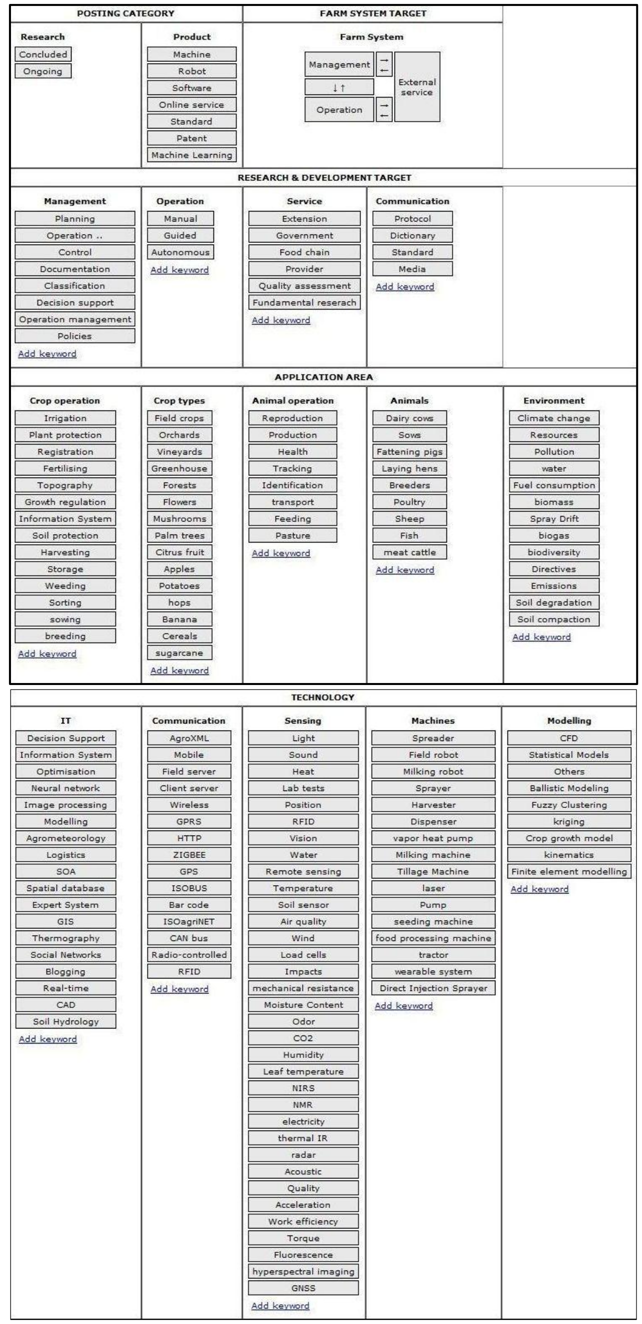

Figure 2: MKB’s keyword classification list

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