THE METHODS AND APPLICATIONS OF ARTIFICIAL INTELLIGENCE USED IN THE TECHNOLOGIES OF PRECISION AGRICULTURE

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Abstract. *The methods and applications of artificial intelligence more and more are linking with technologies of precision agriculture. The classical and modern approaches to artificial intelligence used for problem solving in the technologies of precision agriculture. Searching methods include uninformed and informed search methods which is better way to achieve optimality. Expert systems are typical classical approaches to artificial intelligence and they can be applied for problem solutions. Decision making in precision agriculture include different data collection and data analysis. Hierarchical relationship exists between, data, facts, information and knowledge. Knowledge can be defined as the processing of information to enable intelligent decision making. Both logic and fuzzy logic are discussed. An important aspect of the field of artificial intelligence is the ability of computers to learn from experience and change their behavior in different ways. Some of the modern approaches to artificial intelligence are: artificial neural networks, genetic algorithms, evolutionary computing and agent architectures. One of exciting development in the field of an artificial intelligence appeared through the developments of robotics, which largely related with precision agriculture. The relationships between the methods and applications of artificial intelligence and components of precision agriculture are discussed.*

Keywords.

Precision agriculture, artificial intelligence, agents, knowledge, robotics.

Introduction

Agriculture and artificial intelligence are two separate and different domains. Agriculture processes the soil and cares about food production and elementary supply. Artificial intelligence (AI), in contrast, is deeply interwoven with computerized systems, complex interactions, modeling and reasoning approaches. Artificial intelligence and Computer Science are relative young fields, compared to other sciences such as mathematics, physics, chemistry and biology. There are strong

links between the development of computers and emergence of artificial intelligence. Classical artificial intelligence techniques focused on getting a machine to copy human intelligence, but concept of modern artificial intelligence is to consider how a biological brain operates in terms of its basic functioning, how it learns, how it evolves and how it adapts over time. In beginning of article transition from traditional agriculture to precision agriculture (PA) is discussed.

Transition from traditional agriculture to precision agriculture

Traditional agriculture operations are based on the farmers' experience and intuition. For example, based on previous years, figures were calculated the average dose of fertilizer. As a result, individual sites were over – manured, while in others had insufficient volumes. Harvest grain by combine, field total grain weight was divided by the area of the field, resulting in the average yield. Thereby, the farmer did not know in which part of the field yield was higher, but where the yield was lower. Next example: when working with the harvester or tractor, in some field locations formed overlaps or were untreated sites.

The crops are subject to uncertainties and risks arising from climatic conditions and soil properties (Fig.1). It has been recognized that crops and soils within a field are both spatially and temporally variable.

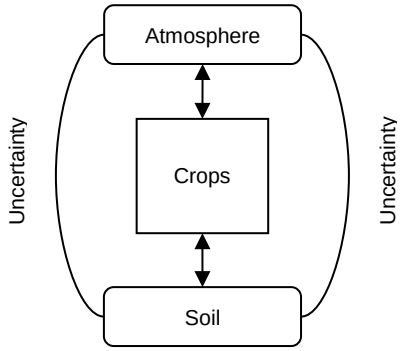

Fig 1. Uncertainty in the agriculture.

Over time, information and communication technologies (ICT) began to be used in the agricultural production. They helped to solve a variety of problems and formed the basis in the precision agriculture. Important moment was introduction of Global Position System (GPS). A GPS identify each field site receiving signals from satellites navigation system. It allowed yield to attract a particular field location. Second important moment was introduction of Geographic Information System (GIS). A GIS for precision agriculture contains base maps such as land ownership, crop cover, soil type, topography, NPK, and other nutrient levels, soil moisture, pH, etc. These maps graphically illustrate the change in production on the field and allow the farmers to take the right decisions. Developments in geo-spatial information and ICT have made it possible to manage such variability much more precisely than before. Essential factor was using proximal and remote sensors. The variable rate technologies (VRT) are either map-based or sensor-based. A more complete definition of PA would be "Applying the right treatment in the right place at the right time" (Stafford, 2006).

An uncertainty in agriculture led to the need for systematic data collection. It provided decision-making in a given time. The main data sources are: GPS receiver, digital maps, sensors and devices of meteorological station, soil and crops (Fig. 2).

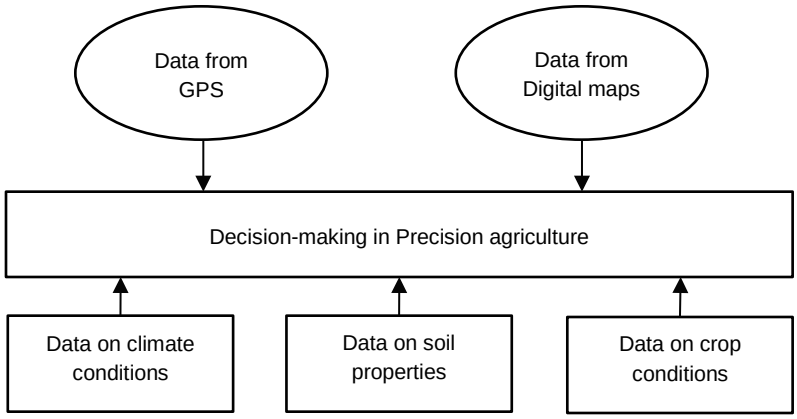

Fig 2. Data sources for decision-making in precision agriculture.

Precision agriculture includes the various branches. So, at the farms in Latvia are used precision crop farming, precision livestock farming, precision fruit growing, precision bee keeping, precision farming greenhouse, and precision growing berries. In this article is discussed more on precision farming, which includes different technologies: tillage, sowing, fertilization, apply lime, protection of weeds, diseases, and pests, harvesting. Precision farming technologies were introduced at farm "Vilcini-1". The farm was founded in 1992 and farm is one of the largest in the Latvia which used precision crop farming. "Precision agriculture" and "precision farming" are often used interchangeably (Auernhammer et al, 2016).

The methods and applications of classical artificial intelligence used in the technologies of precision agriculture

The field of artificial intelligence really came into existence with the birth of computers in the around the 1940s and 1950s (Kevin, 2012). For the earlier period of its development attention was focused on getting computers to copy humans in some aspects of their deal. This period was referred as classical artificial intelligence. Attempting to understand the human brains processing merely from the outside and then attempting to build a machine to copy that way of functioning a top-down approach.

The knowledge, searching, and machine learning

Information age is composed of computer systems that can process and store vast amounts of information. Information components are data and facts. There is a hierarchical relationship between data, facts, information, and knowledge. The simplest pieces of information are data; from data we can build facts, and from facts we gain information. Knowledge can be defined as the processing of information into enable intelligent decision-making. The challenge of our time is the conversion of information into knowledge, which can be used for intelligent decision making. AI is about computer programs that can solve interesting problems and make intelligent decisions based on knowledge. AI is inherently connected with decision making. What sets AI approaches and problems apart from ordinary computer science problems is that they usually require intelligent decisions to be made to solve the problem. Solving a problem often involves solving sub-problems.

Searching is widely used in intelligent systems. Many algorithms are devoted to searching and sorting through a list. Two quintessential blind or uninformed search algorithms are breadth first search and depth first search (Lucci et al., 2013). The large problems tackled by AI are often not amenable to solution by uninformed search algorithms. Informed search methods utilize heuristics to reduce a problem space, either by limiting the depth or breadth of the search. The goal of heuristic methods is to greatly reduce the number of nodes considered in order to reach a goal state. Through

knowledge, information, rules, insights, analogies and simplification, heuristic search methods aim to reduce the number of objects that must be examined. It is a practical strategy for increasing the effectiveness of complex problem solving.

An important aspect of the field of AI is the ability of computers to learn. It is possible for the computer to generate new rules by itself. Many computers can learn from experience.

Hereinafter main AI applications used in the Precision agriculture are discussed (Fig.3).

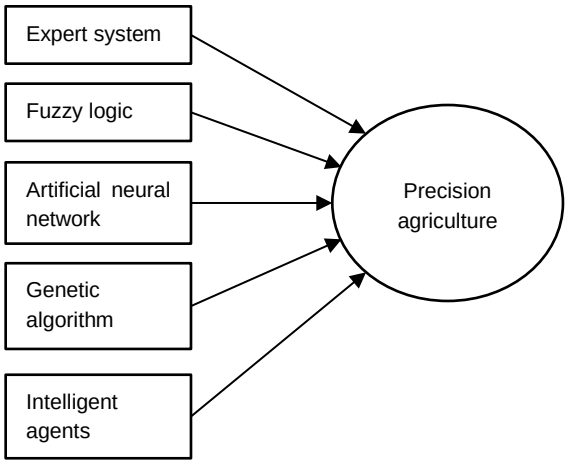

Fig 3. Main applications of AI used in the Precision agriculture.

Expert systems and Fuzzy logic

Expert systems are among the most successful artificial intelligence techniques for production results that are comprehensive and effective. These are computer programs that solve complex problems within some defined domain (O'Regan, 2008). Expert systems are typically built in domains where there is considerable human expertise and where exist many rules for "if – then" structure. The success of the expert system is largely dependent on the quality of the rules provided by the expert. The architecture of an expert system consist a knowledge base, knowledge engineer, inference engine and user interface.

Expert systems arose in artificial intelligence during the 1960s and many expert systems have been developed since then. The first agricultural expert system was PLANT/ds, a system that diagnosed soybean diseases in Illinois, in 1983 (Plant et al., 1991).

The contributions of expert system in the field of agricultural sciences are growing tremendously. With the advancement of technology, the expert systems built can be of great use to the farmers in tackling the problems that arise at various stages of the growth of the crop (Philomine et al, 2015).

Logic is as a knowledge representation paradigm in artificial intelligence. A logical expression can vary anywhere from false to certainty. Uncertainty is an inevitable component in everyone's life. Fuzzy logic and probability theory are two methods for coping with such uncertainty. Fuzzy logic has achieved widespread applications in agriculture.

The domain of agricultural science has varied branches such as soil and seed management, water and irrigation, disease and pest control, weed management, fertilizers etc. The problems that are faced in each of these areas are complex as it involves many factors that constitutes and influence them such as geographical location, climatic conditions, weather changes and other organisms that infect them. All these makes the problem encountered, to be very difficult to formulate it in a particular model and devise method to solve it in a traditional way. Fuzzy logic had been successfully applied in the field of agricultural sciences: in disease management, in pest management, in weed management, in analyze soil (Philomine et al., 2015).

The methods and applications of modern artificial intelligence used in the technologies of precision agriculture

In recent years the modern approach to AI has focused more on bottom-up techniques – that is, to take some of the basic building blocks of intelligence – put them together and get them to learn and develop over a period of time and see where we are (Kevin, 2012).

Artificial Neural Networks and Genetic algorithms

The term “neural network” (artificial or biological) refers to an interconnected group of processing elements called nodes or neurons. These neurons cooperate and work together to produce an output function. Neural networks may be artificial or biological. A biological network is part of human brain, whereas an artificial neural network is designed to mimic some properties of a biological neural network.

Artificial Neural Networks (ANN) aims to simulate various properties of Biological Neural Networks. They are computers whose architecture is modeled on the brain. They consist of many hundreds of simple processing units which are wired together in a complex communication network. Each unit or node is a simplified model of a real neuron which fires if receives a sufficiently strong input signal from the other nodes to which it is connected. The strength of these connections may be varied in order for the network to perform different tasks corresponding to different patterns of node firing activity. The objective is to solve a particular problem, and ANN has been successfully applied to speech recognition problems, image analyses, and so on. Many of the existing ANN are based on statistical estimation and control theory. ANN has also been applied to the cognitive modelling field. Neural networks have been widely applied over the last three decades to solve problems in several areas: control, search, optimization, pattern association, classification, forecasting. The use of ANN to generate decision rules for site-specific nitrogen fertilization was discussed (Wagner, 2012).

By modelling in a computer some of the general processes involved in the biological form of evolution, it is possible to achieve a technique which improves the solution to an AI problem. The best-known approach to evolutionary computing is the method of genetic algorithms (GA). In GA, a problem is encoded as a string. Genetic operators guided by a fitness function iteratively modify a population of these strings until some string (hopefully) solves the given problem. With genetic algorithms, a string is used to encode a program that solves the problem. Applied to problems involving optimization and product design and to monitor industrial systems where many alternatives or variables must be evaluated to generate an optimal solution. Multi-objective optimization analysis model for county range soil nutrients sampling point layout based on improved genetic algorithm was created (Tian-el et al., 2012).

Agents and Robotics

Agents are an entirely different approach to developing problem-solving paradigms. Decision making also comes in many flavors, depending on whether the agent has complete or partial knowledge of its world, whether it is acting alone or in collaboration/competition with other agents, etc. Taking actions can have different forms, depending on whether the agent has wheels, arms, or is entirely virtual reality. The term multi-agent system refers to a variety of software systems that are comprised of multiple semi-autonomous components (Wooldridge, 2009). These agents have their independent knowledge and it must be tapped and combined in the best way to solve problems that none of the agents can solve alone. All software agents are programs, but not all programs are agents. Improving precision agriculture methods with multi-agent systems in Latvian agricultural field was discussed (Pentjuss et al., 2011).

The computer system requires an accurate up-to data picture of state of the external world. If it senses inaccurate information then any decisions it makes will themselves be inaccurate. One good example of a computer/agent system is the case of a mobile robot. Some of the most exciting developments in the field of AI have appeared through the development of robotics. It could be argued that an intelligent robot is merely the embodiment of an artificially intelligent entity – giving a body to AI. It is a big advantage of AI in comparison with human intelligence that the potential range

of sensory input is extremely broad, whereas human senses are limited (Kevin, 2012).

Significant progress has been made since the early 2000's in automated guidance, variable-rate application, section control, machine coordination, and logistics support. However, there is still along way to go toward robotic farming (Han et al, 2016)

Conclusion

The methods and applications of artificial intelligence more and more are linking with technologies of precision agriculture. In result the tractors, combines and agricultural machines with every year become more and more "smarter"; they autonomous can make the different tasks.

The classical and modern approaches to artificial intelligence used for problem solutions in the technologies of precision agriculture. Expert systems are typical classical approaches to artificial intelligence and they can be applied for problem solutions. Knowledge can be defined as the processing of information to enable intelligent decision-making. Fuzzy logic had been successfully applied in the field of agricultural sciences. Some of the modern approaches to artificial intelligence are artificial neural networks, genetic algorithms, and agent architectures. The combination of fuzzy logic with genetic algorithms and neural networks has more promising future to solve problems that deals with uncertainty. One of the exciting developments in the field of the artificial intelligence appeared through the development of robotics.

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