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Review

The Use of Computers in Agriculture: A Key to Improved Agricultural Productivity in the 21st Century: A Review

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Abstract

This article reviewed the use of computer in agriculture as key to improved agricultural productivity in the 21st century. Computer applications in agriculture is undoubtedly a key to enhanced agricultural output. Some of the areas in which computers can be applied in agriculture are as follows: farm land assessment, autonomous farm equipment's and tractors, farm software, internet forums, social networks and online data bases, E. agriculture, data mining, bioinformatics, remote sensing and geographic information system, precision agriculture and expert systems. These techniques are capable of coping with the variability and drudgery that is typical of agriculture aiming at increased agricultural intensification and greater yields. These computer techniques have great scope and linkage in robotics control for speedy agricultural activities such as in irrigation. Information technology opens the door on the use of computer technology throughout farming, from selective control of field operations to expert systems for crops, animals and farm process management.

Keywords: Agriculture, computer applications, improved agriculture, 21st century.

INTRODUCTION

As computer technology continues to advance in processing power and speed, compactness and acceptably low cost, new applications in agriculture become feasible. These applications will be as varied as agriculture itself, and will bring with them specific challenges to the technology. Biological variability between items of produce, the complex interactions of physiological processes that underlie crop growth and the uncertainties associated with the prediction of processes that will be influenced by future weather are issues in many agricultural problem areas. Developments in hardware systems and software capability will allow practical implementation of computer techniques in produce grading, crop yield prediction, and crop and animal management (Barley, 2009)

According to Marshall (2008) agricultural Research have benefited from incorporation of technological advances primarily developed for other industries. He further lamented that the industrial age brought mechanization and synthesized fertilizers to agriculture. The technology age offered genetic engineering and automation. The information age brings the potential for integrating the technological and industrial advances into sustainable agriculture production system. The application of the computer in agriculture research originally exploited for the conversion of statistical formula or complex model in digital farm for easy and accurate calculation which are found relatively tedious in manual calculation. In the next generation, the same computers have been used to mechanization, automation and to develop decision support system for taking strategic decision on the agricultural production and protection research. Recently remote sensing and geographic information system has place a major and crucial role in agriculture research especially in the field of yield prediction, suitability of soil for particular crop, and site specific resource allocation of agriculture inputs, etc. Information Systems:

Applications of Computing Technologies in Agriculture

Davis (2016) posits that in today's times, agriculture is not just about crop production or livestock farming and associated activities. The challenges brought forth by ecological factors affecting the environment need to be a major consideration for any kind of farming activity. Farmers need to preempt environmental impact due to climate change and this is where modern technology comes to the rescue. Davis (2016) outlined the following uses of computer in agriculture:

- There are software which help in the prediction of weather conditions and estimation of agricultural production.
- Computers are used for record-keeping of information related to costs involved in production, transport, agricultural processes, and in the estimation and calculation of profit and/or loss.
- The Internet aids communication among farmers and between farmers and agriculture experts. This leads to an exchange of knowledge and serves as guidance for farmers to improve production and earn profits.
- Thanks to the use of software technology, farming practices have evolved into those requiring less effort and leading to greater output. Mechanization has reduced human/animal effort and increased the speed and quality of production

1. Farmland Assessment: *Geographic Information Systems (GIS)* are being used for developing ranking systems that evaluate land and provide a site assessment to aid what is now known as *precision agriculture (*Frost, 2012*)*. These hi-tech, interactive systems provide information based on a variety of factors such as soil conditions, drainage and slope conditions, soil pH and nutrient status, etc. Prior to the use of these systems, farmers were often in the dark about soil output, and unpredictable weather conditions affecting crop quality and profitability. Precision agriculture provides farmers with control by predicting vital information including fertilizer application and problems with drainage, insects, and weeds. Most government websites provide this kind of information free of cost, covering agricultural land masses across the United States. Global Positioning System (GPS) based technologies also help to monitor irrigation, field mapping, soil sampling, tractor guidance and crop scouting. This kind of technology equips farmers with enough information to increase crop yield in a manner that is consistent with the best environmental practices for sustainable agriculture.

2. Autonomous Farm Equipment and Tractors: Automated farm equipment, needless to say, scores over human controlled equipment in terms of consistency and reliability. Engine and machine functions such as transmission and hydraulic power output are controlled using microchips built into the equipment. *Guidance technology* is already being widely used in self-propelled equipment to aid crop seeding and fertilizer application. Automated feeding systems, computerized milk collection and milking machines have been around since the late 20th century, resulting in better economic yield for the dairy industry as well as livestock production. Automated tractors are probably not far away (Maracchi *et al.,* 2018).

3. Farm Software: With regard to livestock farming, ready-made computer applications are available to track animals, storing and evaluating information such as age, health records, milk production, offspring productivity, and reproductive cycle status. This is often called *herd recording*. Similarly, most farm accounting software and other computer applications in agriculture provide services for record keeping, simulation of prediction-based models using that data, and revenue and productivity estimation. Most farm software vendors provide you with an option to customize their applications to the specific needs of your farm or ranch Maracchi *et al.,* 2018).

4. Internet Forums, Social Networking and Online Knowledge Bases: Hashimoto (2020) is of the believe that any business in the world that you can think of, has benefited from the advent and global reach of the Internet and related communication technologies (mobile computing, e-commerce, etc.). Agriculture is no different. Imagine using the power of the Internet to connect with farmers, agriculturists and agricultural scientists and other experts spread across the globe. There are several forums and social networking sites on the Internet where farmers can connect with other farmers and farming experts and exchange know-how. In addition, there are several learning repositories that provide information on a wide variety of agricultural topics. These avenues serve to reduce the rural digital divide, influence public policies, foster partnerships and connect all stakeholders across the agricultural value chain (Maracchi *et al.,* 2018). For instance, a farmer can easily seek out and connect with an agricultural entrepreneur and begin the exchange of ideas or business proposals. Information such as price review for grain and livestock, pest information, real-time weather information (precipitation, temperature, humidity, solar radiation, wind speed, soil moisture and soil temperature) in any part of the world is literally available at one's fingertips.

5. E-agriculture: An emerging field of agricultural practices, e-agriculture focuses on coming up with innovative ways and best practices to use the existing information and communication technologies (ICTs) for sustainable agricultural development and food safety standards, particularly in rural areas. E-agriculture encompasses other related technological fields such as agricultural informatics, agricultural development and business. It aims to deploy all available technologies (computers, mobile computing, satellite systems, and smart cards) for the empowerment of farmers and strengthening of partnerships across the food value chain (Frost, 2012).
Maracchi *et al.,* (2018) supported that the uses of computers in agriculture do have some real constraints such as, the lack of hardware and software infrastructure, training and skills, and research priorities. However, once these are overcome, the use of computers goes past automation and software application. In fact, it could be instrumental in bridging the digital divide and bringing prosperity to agriculturists not only in the United States, but also in other developing and emerging economies around the world.

6. Data Mining: Data mining is the process of discovering potentially useful, interesting, and previously unknown patterns from a large collection of data. The process is similar to discovering ores buried deep underground and mining them to extract the metal. The term "knowledge discovery" is sometimes used to describe this process of converting data to information and then to knowledge. The data mining process is interactive and iterative, and it requires an understanding of the decision maker's intentions and objectives, the nature and scope of the application, as well as the limitations of data mining methods. A variety of software systems are available today that will handle the technical details so that people can focus on making the decisions. All most all statistical techniques including bioinformatics we are using are just data mining either it may be in the field of agriculture, medicine or engineering (Beulah et al., 2019).

7. Bioinformatics: Bioinformatics integrates the advances in the areas of Computer Science, Information Science and Information Technology to solve complex problems in Life and plant Sciences. Biology depended on chemistry to make major strides, and this led to the development of biochemistry. Similarly, the need to explain biological phenomena at the atomic level led to biophysics. The enormous amount of data gathered by biologists—and the need to interpret it— requires tools that are in the realm of computer science (Maracchi *et al.,* 2018). The present role of bioinformatics is to aid agriculture researchers in gathering and processing genomic data to study protein function.

8. Remote Sensing and Geographic Information System: Remote sensing refers to the process of gathering information about an object, at a distance, without touching the object itself. The most common remote sensing method that comes to most people's minds is the photographic image of an object taken with a camera. Remote Sensing techniques have a unique capability of recording data in visible as well as invisible (i.e. ultraviolet, reflected infrared, thermal infrared and microwave etc.) part of electromagnetic spectrum. Therefore certain phenomenon, which cannot be seen by human eye, can be observed through remote sensing techniques i.e. the trees, which are affected by disease, or insect attack can be detected by remote sensing techniques much before human eyes see them. Geographical Information System is a computer-based information system that can acquire spatial data from a variety of sources, change the data into useful formats, store the data, and retrieve and manipulate the data for analysis (Marachi *et al.,* 2018). Today, GIS is a multi-billion dollar industry and has become part of a basic information infrastructure for private enterprises, government agencies, and academic institutions. The majority of the operational GIS are used for thematic mapping, handling spatial queries, and decision-making support. The application of remote sensing data taken momentum in the field of agriculture and crop studies in India especially crop production forecasting covering both crop inventory and crop yield forecast models, drought assessment, soil mapping and soil degradation, command area monitoring, flood damage assessment, land suitability mapping, insect pest infestation forecasting and widespread availability of satellite signals that allow private use of GPS made it possible for farmers to spatially locate data from precision farming applications. GIS technology is being increasingly employed by agriculture researchers to create resource database and to arrive at appropriate solutions/strategies for sustainable development of agricultural resources. Maracchi *et al.,* (2018) supported that the application of remote sensing and GIS techniques in the management of agricultural resources are increasing rapidly due to improvement in space borne remote sensing satellites in terms of spatial, spectral, temporal and radiometric resolutions. Other analytical functions of GIS include buffer zones, neighborhood characterization, and connectivity measurement. A particular feature of GIS is the ability to calculate more realistic distance measures among objects based on actual geometry, travel time, and cost, rather than straight-line distance. The trend in developing GIS analytical functions is to better integrate GIS with other software in statistical analysis, operations research, and artificial intelligence (AI) tools

9. Precision agriculture: Beulah *et al.,* (2019) found out that Precision Agriculture is conceptualized by a system approach to re-organize the total system of agriculture towards a low-input, high-efficiency, sustainable agriculture. This new approach mainly benefits from the emergence and convergence of several technologies, including the Global Positioning System (GPS), geographic information system (GIS), miniaturized computer components, automatic control, in-field and remote sensing, mobile computing, advanced information processing, and telecommunications. Agricultural research is now capable of gathering more comprehensive data on production variability in both space and time. The desire to respond to such variability on a fine-scale has become the goal of Precision Agriculture.

10. Expert Systems: An expert system is a specific kind of information system in which computer software serves the same function expected of an expert. The computer, programmed to mimic the thought processes of experts, provides the decision-maker with suggestions as to the best choice of action for a particular problem situation. The hope is that we can design computers (information systems) that extend our ability to think, learn, and act as an expert. Expert systems allow users to influence the knowledge of experts without requiring their presence (Maracchi *et al.,* 2018). Expert systems are useful in any field especially in agriculture where experts are rare, expensive, or inaccessible. The knowledge base is the core component of any expert system since it contains the knowledge acquired from an expert in the field and from published literature. Typically, a knowledge engineer is responsible for working with an expert to build the knowledge base for the system. The knowledge engineer must perform a detailed analysis of the inference process and develop the prototype knowledge base. The tasks involved in developing any knowledge base include knowledge acquisition, knowledge representation, knowledge programming, and knowledge refinement.

11. Decision Support Systems: Computer systems that provide users with support to analyze complex information and help to make decisions are called decision support systems (DSSs). Decision support systems are information systems with a specific function to help people with the problem solving – to some extent and decision- making process. DSS consists of a collection of people, procedures, software, and databases with a purpose. The computer is the primary technology in such systems. Decision support systems are an advancement of management information systems, generally help human beings solve complex problems, and provide data that can lead to non-predetermined solutions that are beyond the limitations of expert systems. Decision support systems may work actively or in a passive mode. Passive systems are mostly used by decision makers or supervisors or physicians for reference purposes, while active systems give advice in certain situations, such as alerting technical personnel when a parameter being monitored exceeds its designated threshold value (Marshall, 2008).

12. The Internet: Use of Internet has given the globe a shrinking effect. Every kind of information is only a few clicks away. In today's world of competition – "information" is the key word to success (Davis, 2016). Availability of right information at the right time can make all the difference. Today relevant information outweighs the price of gold. The graphical user interface has simplified one of the most complex issues in the world. The time has come to exploit this medium to the best-suited interests in the other fields of life such as agriculture. As this technology evolved and access expanded to business, industry, research, education, and personal users, the Internet and the World Wide Web (WWW) were born. They have changed the way we work, learn, and stay in touch with others. We can send and receive letters electronically and instantly; articles, books and journals are accesses instantly on your table without wasting time and money; we can purchase almost anything without physically traveling to a store; and we can quickly locate products and services via the Internet that may not be available in our own geographic neighborhoods. We can even build businesses and create networks of coworkers and customers without the need for office space and daily commuting. Computer based information systems have changed the way we do research (Maracchi *et al.,* 2018).. They have enhanced our ability to identify and solve problems and to perform tasks that are beyond our physical ability. Information system technology, bioinformatics, and nanotechnology no doubt will continue to provide new horizon to us in the years to come

13. Information Technology on Farm: The greatest global impact of the computer revolution has been in the development of Information Technology (IT) - the use of based systems to acquire, store, process, and disseminate data and information. IT computer transform has made some inroads into farming, but the major computer application in this area is just beginning. The concept of the IT farm has been described fully by Marshall (2008), as a comprehensive and integrated management information system. Components already exist, in the form of packages for farm business management, bureaux services for market price information, weather and disease forecasts, and some automatic data collection equipment, e.g. in dairy farming . The longer term view is that these components will be supplemented by others, and integrated into a system that can provide information for both strategic and tactical decision-making on the farm. Within the IT farm, some components will operate on quite short timescales and have close control over processes. The protected crops industry provides a current example of IT systems in direct control over a farming process. The greenhouse control computer, gathering information from its sensor array, makes decisions on operational control of heating and ventilation systems to maintain a preset environment plan. In the previous section, the next stage in the development of this implementation of IT was outlined - with real time optimization of system models defining the optimal environmental set points for current weather and market conditions. In field agriculture, the opportunities for direct control are not so well formed as yet. An example of current interest is the concept of selective or spatially variable field operations - tailoring operations to meet the requirements of soils or crops in parts of the field, rather than applying the same uniform operation over the whole field. On the fringe of the IT farm itself, information technology systems will be important to the adviser. They can provide him with rapid access to management information, forecasts and the results of research and development work, so that his decisions are up to date and based on the knowledge of many experts. To this end, expert systems will play an important role. Selective field operations the basic unit of most farming operations is the field - whose size can vary from a fraction of a hectare to many hundreds of hectares. Large fields will often contain a range of soil types; there may be considerable variation in slope and in water table height; long term weed problems may exist in some parts of the field but not in others. Maracchi et al., (2018) explained that with appropriate technology, these variations could be taken into account to ensure that operations are closely tailored to the requirements of each part of the field. Benefits would be both economic and environmental. Maracchi *et al.,* (2018) believed that matching soil conditions and fertilizer supply more closely to the crop's needs will give more cost effective production, often by reducing input costs, and reduced use of agrochemical inputs will be beneficial in meeting environmental demands on agriculture, now increasingly forming part of the legislative framework in developed countries. What makes selective field operations a possibility now? As a concept it depends upon making decisions about field management on a local basis, and controlling farm machinery in order to implement these decisions. This involves similar issues of information processing and control that we have seen in the use of image analysis to control grading. The prime components in the execution of selective operations in the field will be quantifying the key parameters that vary across the field, interpreting their influence on the optimal form of the field operation and implementing this operation at the appropriate positions in the field (Barley, 2009).

CONCLUSION

Agriculture is a diverse industry, and the scope for computer applications in agriculture is equally diverse. The problems associated with accurate description of the form or performance of agricultural systems is a continuing challenge to practical agriculture and hence improved productivity. Implementation of some of the new concepts in computing to boost agricultural output is indispensable if improved agricultural productivity is to be recorded. These continuing advances in computing technology will be needed to ensure many of these applications are realised for cherished agricultural production.

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