ISSN: 0975-766X
CODEN: IJPTFI
Available Online through
Research Article
www.ijptonline.com

A SURVEY ON ROLE OF COMPUTATIONAL APPROACHES IN PRECISION AGRICULTURE

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Received on: 18-02-14 *Accepted on: 27-03-17*

Abstract

In today scenario, Agriculture is the world's largest and important feeding industry of the ever-growing population. Most of the countries perceives, it to be a labor intensive process. Recently, with the advent of the technology, Agricultural mechanization is attempted in the developed countries to reduce the labor intensity and environmental degradation to improve the agricultural benefits. In order to proceed in the process, researches are being carried out towards precision agriculture.

The approach deals with the design and development of decision support system and its variance to handle the precision decisions in the field of agriculture. It is an approach that uses satellite image or information and Information technology to manage the concept based on observations, measurements and response. It targets on wealth of information for farmers in building up the record for traceability and decision making about the farms, farm products and quality of both. In addition, enhanced marketing is also addressed through the precision agriculture. Mostly, the benefits are drawn through the usage of current advanced technologies. Especially, the innovations involving sensors, control systems, robotics, remote sensing, communication networks and information management contributes widely for the precision agriculture. These innovations provides variety of data in large quantity relevant to agricultural usage that are to be collected, stored, shared and analyzed for a precise decision making. This process introduces the complexity of interoperability that need to be addressed specially towards the support of single interface irrespective of the device, type, and its data format. One of the prime solutions for this issue is usage of web service standards and its associated tools. This paper attempts to highlight the various web services and its tools usage in the field of precision agriculture.

Keywords: Precision Agriculture, Web Services, Expert System, Image Processing, GIS, Semantic Web.

1. Introduction

In the recent days, agricultural engineering is booming to improve the strategies to be adopted for increased yield. It is a field of engineering dealing with the design and development of farm machinery, soil management, land development, mechanization and automation of livestock farming along with the efficient planting, harvesting, storing and processing of farm wares.

To improve the current scenario of agriculture to address poverty alleviation, enhance quality of life and food security, a proper mechanism is required. The mechanism should report the socio economic need for enhanced productivity / unit of land, water and time. The development of sensor and information technology in the recent days motivates the use of these technologies to get utilized for the purpose. The opportunity to use these technologies into agriculture field has become wide open to have procedures for farming management activities viz cultivation, seeding, fertilization and harvesting. Hence, an integrated agricultural system incorporating global positioning system, geographical information system, yield monitor, variable rate technology, and remote sensing would be a good choice.

This type of integrated leads to a technology that improves agricultural production and efficiency called precision agriculture (PA). Ultimately, PA provides complete technical support to farmers in the identification and improvement of niche areas of farming. One of the promising technologies that contribute for the same is the ICT. It acts as a tool to support exchange of data through digital tools and technologies. Hence the major issue arises is the interoperability. To standardize the utilization of variety of tools and techniques and to solve the issue of interoperability, a ultimate solution is the use of web services known to be a software system that is designed to support interoperability in machine to machine interaction over a network. Thus, the paper focuses in exploring the PA and its implementation through web services that would ensure the quality production of agricultural industry.

2. Precision Agriculture (PA)

The advancement of technologies has brought complete mechanization in to the field of application. Agriculture is a prime field, where the application of technology would bring astonishing outcomes. According toNtaliani, Costopoulou, and Karetsos[1]creation of effective business cases for agriculture is a tough task. Researchers are continuously exploring the various possibilities to adopt technology into agriculture. In the recent past, most of the researches are oriented towards Precision Agriculture, where an integration of ICT techniques are carried out with agricultural sciences for improved productivity.

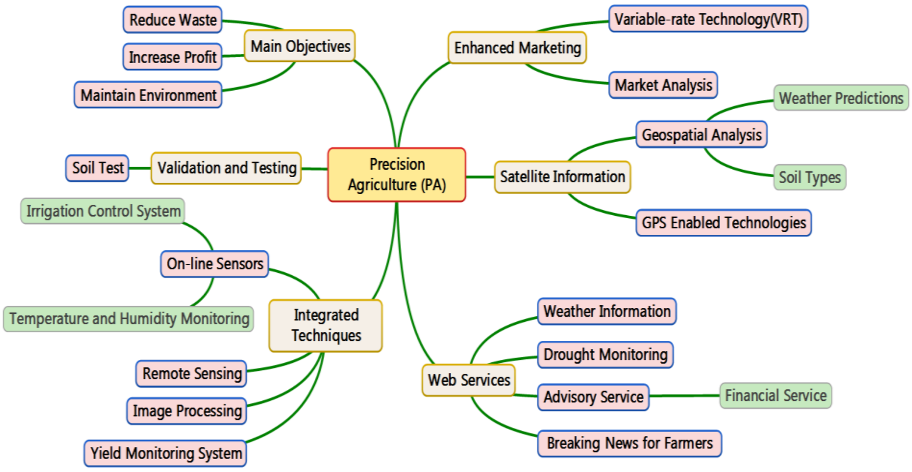

Figure 1: Mind Map for Precision Agriculture.

Though the technology initiated in later 1990s, Several researchers[2]–[5] claimed PA to be a convergence of several technologies that include GPS, GIS, remote sensing, Mobile computing and other advanced information processing methods. Ultimately, Seelan et al., emphasis was given in reducing the time duration between data acquisition and delivery of value added products to farmers [6]. Bongiovanni and Lowenberg-DeBoerexposed the sustainability of PA to estimate the environmental benefits to chemical loading and to maintain profitability[7]. McBratney et al., brought out the challenges that remains with the implementation of PA include, appropriate criteria for the economic assessment, Recognition and quantification of temporal variation, Whole-farm focus and Crop quality assessment methods[8]. As an extension to the established PA technology, in 2009, Mondal andBasu evolved with the strategies such as PA technology, PA technology package and integrated PA for developing countries like India[9]. The motive of their research is to adopt beneficial strategies to different sectors like small farms, cash crops, and plantation crops. Ultimately, Winstead et al., analyzed the adoption of PA towards yield monitoring with the help of GPS and recorded that PA technologies have been widely adopted by the large acre farms[10]. Sørensen et al., suggested the integration of information system to advice farmers, managers with formal instructions[11]. In the same way Lee et al., revealed about the usage of various sensing technologies that are used for crop management and PA[12]. In addition, it is proved that the companies which adopted PA have shown managerial improvements, higher yields, lower costs and environment impact minimization [13], [14]. Later, as the technology advanced, more information system supporting PA has been evolving to attempt on process quality and improvement[10], [11], [14]–[20] With the growth of the PA, it is being adopted all over the world and the technology is crawling to the success in most of the countries. The following section highlights the transition of agricultural industry with respect to the PA. Consequently, thermal and hyper spectral imaging had been used as a sensing technology for precision farming[16], [18], [21]–[23].

3Computational Approaches in PA

With the advancement of Information Technology and its variants, PA has grown in to smart farming system. The technology began to utilize the sophisticated system comprising remote sensed images, wireless network, sensors and Internet of Things (IoT).

3.1 Image Processing in PA

During the infant stage of PA, the usage of remote sensed images for smart farming was limited due to the rare availability of quality remote sensed images to pursue analysis and decision. Recently, as the remote sensing technology have seen tremendous growth with the help of satellite imaging system, the experimentation based on the remote sensed images has geared up. These images have been used to find nitrogen in corn [24] to predict damage in wheat[25], to detect and help in insecticide applications[26], [27], to estimate clay concentration [28]. In the subsequent years, imaging technology has taken an important role. As a result, use of airborne remote-sensing for weed mapping in crops has been demonstrated by Bennett & Brown[29]. A Yield monitoring system has been attempted by Basso et al., [30].

A combined modeling and indices-based approach to predicting the crop chlorophyll content from remote sensing data had been suggested by Haboudane et al., [31]. A method for minimizing the effect of leaf chlorophyll content and to develop algorithms to predict the leaf area index of crop canopies based on both simulated and real hyper spectral data were carried out by Haboudane et.al [31]. Portable Hyper spectral Tunable Imaging System had been demonstrated to extract spectra of typical agronomic scene components (end members) such as sunlit and shaded leaves and soil for spectral mixture analysis [26].Image analysis supported precision agriculture with the use of hyper spectral images and other modalities have been attempted by many researchers to show case the effectiveness of imaging in precision agriculture. A computer-based image processing system was developed to allow the user to input digital images of the sampled field and perform a set of pixel-image transformations to compute the percentages of pixels representing weed has been suggested by Ribeiro et al., [32].

3.2 Artificial Intelligence (AI) in PA

Artificial Intelligence is playing a vital role with Precision Agriculture in recent years. Robots and Sensor devices are controlled by set of AI algorithms and Machine Leaning Tools. It also uses Knowledge Base System (KBS), Decision Support System (DSS), and Recommender System to build an effective commutation media and cultivating farmer to help in farming.

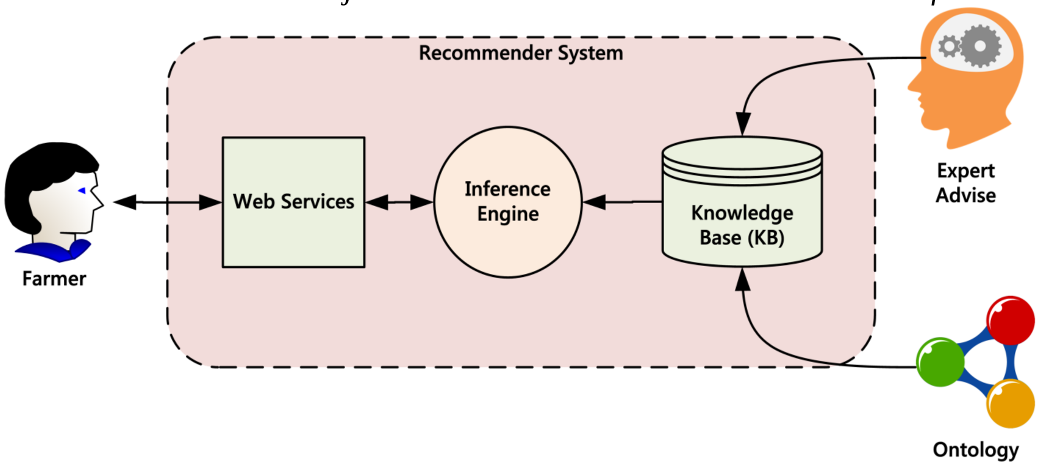

Figure 2: Recommender System Based on AI.

4 Web Services in PA

Web Services are set of standards used for communication between famer and knowledge base system over Internet. Farmer can communicate in their local language through hand held devices to any nodal knowledge repository using web services. Inference Engine will parse the input data from the farmer and send back the result after processing with the help of knowledge base (Figure 2).

Fileto et al., Proposed POESIA (Processes for Open-Ended Systems for Information Analysis)[33]. It focuses on domain ontologies to (i) conceptually organize vast collections of services, (ii) uncover and select data and services according to their utilization scopes, and (iii) check semantic and structural consistency properties of compositions of Web services. Wiegand et al., described a Web-based query system for semantically heterogeneous geospatial data[34]. The goal is to provide DBMS type query capabilities to a proposed statewide land information system. Web services along with GIS also had been widely adopted for PA. The milestones in the research of utilizing web services in PA have been tabulated in Table 1.

Table 1. Computational Approaches in PA.

Concept	Authors	Highlights
Web Services and Agriculture	Fileto et al. [33]	Proposed POESIA (Processes for Open-Ended Systems for Information Analysis) Used domain ontologies to (i) conceptually organize vast collections of ser- vices, (ii)

		uncover and select data and services according to their utilization scopes, and (iii) check semantic and structural consistency properties of compositions of Web services. Illustrated the POESIA approach through a real application scenario: the agricultural zoning of C. Arabica in the Centre-South
Web Services and GIS	Wiegand et al. [34]	Described a Web-based query system for semantically heterogeneous geospatial data. Our goal is to provide DBMS type query capabilities to a proposed state-wide land information system. Developed an ontology and query rewrite system on top of an XML Web DBMS to handle semantic heterogeneity. We focused our efforts on resolving differences at the value level.
Web Services and GIS	Di [35]	Discusses the geo-object and geo-tree concepts that the system is based on, the system architecture, the interoperable geospatial web service framework, and the individual components of the system. Discusses the use of the system in NASA EOSDIS data environment to make petabytes of NASA EOS data and information, especially those in ECS data pools, easily

		accessible by broader user communities.
Web Services and GIS	Morris [36]	Focused on two major geographic information issues The role played in the development and utilization of emerging geospatial Web services The challenges of long- term preservation of digital geospatial data in light of a shift to distribution methods that make the content ever more ephemeral
Semantic Web Services and GIS	Macário& Medeiros[37]	Proposed a annotation framework to attack the problems, which supports semi-automatic Semantic annotations of various kinds of digital content, directed towards the agriculture context. Some basic issues addressed are: Adoption of standardized metadata to describe and exchange the data Description of information in terms that allow common understanding (e.g., ontologies) Exposure to data to find and retrieve Design efficient retrieval mechanisms
Geospatial Web Services	Lieberman, Pehle, & Dean[38]	Geospatial information and Open Geospatial Web Services Geospatial Semantic Web, an interoperability experiment Semantic challenges on the Spatial Web

Geospatial Web Services	Tripathy, Adinarayana, &Sudharsan[39]	An attempt has been made to express how data mining integrated with agriculture including pest scouting, pesticide and climatological parameters are useful for optimization of pesticide usage and better management. A mathematical model framework is on progress to be simulated for visual interpretation.
Geospatial Web Services	Macario, de Sousa, & Medeiros[40]	Presented a framework for alleviating problem based on semi-automatic annotation of geospatial data. Presented a case study in agriculture-Agricultural Planning in Brazil.
Geospatial Agriculture	Kutz at al. [41]	Demonstrated use of geospatial data, the 2002 Agricultural Cropland Data Layer (CDL) for the mid-Atlantic region, to characterize agricultural, environmental, and other scientific parameters for the Chincoteague Bay subbasin using geographic information systems. The CDL has numerous applications for studying agriculture. These can be summarized as: better understanding of agricultural processes at various geospatial scales; improved estimates of pollutant loadings from agricultural

		activities (ecological processes and services plus impact to adjacent systems; use in "real world" trans- port and fate studies; approximating the potential for human exposure and targeting public health issues and pesticide applicator training; provision to monitoring programs of chemicals that should be detectable; use for homeland security purposes including bioterrorism; and Planning for agricultural manufacturing facilities (ethanol and high fructose corn syrup).
GIS and Agriculture	Shelestov et al. [19]	Describesd a distributed system for agricultural monitoring in Ukraine at two levels, namely, at ministerial level and at agricultural enterprise level. Crop monitoring is performed using data and products obtained by moderate and high-resolution remote sensing satellites. The system includes a geoportal with a Web interface and a desktop geographic information system (GIS) with additional functions of automatic data retrieval and business-logic analysis. The system is constructed using open-source software that conforms to OGC standards for

		geospatial information management.
Web Service and Agriculture	Jalbani et al. [42]	Addressed common problems of data store and exchange in a dissimilar way A simple weather forecast web service has been practically implemented and tested.
Web Service and Agriculture	Deng et al.[43]	Presents a Web service approach to building the Global Agricultural Drought Monitoring and Forecasting System (GADMFS), an open, interoperable, and on-demand geospatial Web service system, for meeting the demand. Addressed the support of decision making with improved global agricultural drought data and information dissemination and analysis services
Precision Agriculture	Zhang, Wang, & Wang[44]	Provides an overview of worldwide development and current status of precision-agriculture technologies Develop information- and knowledge-based technology modules to provide strong support to agriculture in China. These modules may include GPS, GIS, sensors and data-acquisition systems for detecting spatial variability of soils and plants, yield monitors, yield mapping systems, precision water-saving irrigation systems, spot sprayers, animal

		identification systems, information-management and decision-support systems, and multi-media systems.
Precision Agriculture	Pierpaoli et al. [45]	Two Models have been proposed for PA Utility based model Predictive model Focus on the design of an appropriated adoption process and on innovation's features.
Precision Agriculture	McBratney et al. [8]	Decision-support systems for implementing precision decisions remains a major stumbling block to adoption has been discussed in detail Critical research issues are discussed, namely, insufficient recognition of temporal variation, lack of whole-farm focus, crop quality assessment methods, product tracking and environmental auditing.
Precision Agriculture	Bongiovanni&Lowenberg-DeBoer[7]	By using site-specific knowledge, PA can target rates of fertilizer, seed and chemicals for soil and other conditions. One example is that spatial management of N can reduce overall N application, and reduce N on sensitive areas, while maintaining profitability.
Precision Agriculture - Application	Corwin & Plant[46]	Geospatial measurements of apparent soil electrical conductivity (ECa) are the most reliable and frequently used measurements to characterize

		within-field variability of edaphic properties for application to SSM. Site-specific crop management (or site-specific management, SSM) refers to the application of precision agriculture to crop production. Site-specific
Precision Agriculture - Application	McBratney et al.[8]	A generic research programme for precision agriculture is presented. A typology of agriculture countries is introduced and the potential of each type for precision agriculture discussed
Precision Agriculture - Application	Nash, Korduan, & Bill[18]	Three use-cases were outlined in which OpenGIS web-services could be utilized to automate data flows. These illustrated some of the many potential applications of such services in precision agriculture, such as accessing base data, transferring spatially referenced data either between partners in an agricultural business workflow or between soft- ware running geospatial and/or mathematical models, or as a high-level interface to (wireless) sensor networks.
Precision Agriculture - Application	Mondal&Basu[9]	A survey of farmers was initiated to ascertain the adoption and use of precision agriculture technologies as well as the barriers to and incentives for adoption.

			Approximately 180 Alabama farmers participated in this pilot project which is being replicated across the U.S. to compare adoption and perceptions of precision agriculture.
Web Service & Precision Agriculture - Application	Hau et al.	[47]	CropScape (the name invented for a new interactive Web CDL exploring system) was developed to query, visualize, disseminate, and analyse CDL data geospatially through standard geospatial Web services in a publicly accessible online environment.

5. Tools for PA

Consequently, thermal and hyper spectral imaging had been used as a sensing technology for precision farming [12], [16], [18], [22], [23].

5.2. Artificial Intelligence (AI) in PA

The internet of thing is changing much about world and farmers get benefited more from it in various ways. Sophisticated sensors in chips are embedded in the physical things that surround farming fields each transmitting valuable data that could better understand how various environmental conditions of crops such as weather, temperature, water level, and soil condition. IoT is a platform for farmers that brings this diverse information together and provide the common language for the devices and suitable to communication with each other.

6. Conclusion

A study on precision agriculture is carried out to explore the significance of ICT in agriculture. The study performed focused on three main aspects of computing that helped PA to improve. The aspects discussed in the article include Image processing, AI and Web services. The study revealed that the integration of these three computational approaches leads to the development of a complete knowledge based system that helps the farmers in decision making process with respect to crop management, pesticide diffusion, climate prediction and other environmental factors.

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