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Proceedings and Recommendations

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Artificial Intelligence in Agriculture

30-31 July, 2018

NASC Complex, New Delhi

Organized by

ICAR-IASRI
New Delhi

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Hyderabad

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Indian Council of Agricultural Research

Status and Prospects of Artificial Intelligence (AI) in Agriculture

Proceedings and Recommendations

ICAR-Indian Agricultural Statistics Research Institute (IASRI), New Delhi

ICAR-National Academy of Agricultural Research Management (NAARM), Hyderabad

ICAR-Indian Institute of Water Management (IIWM), Bhubaneshwar

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FOREWORD

I am delighted to learn that ICAR is bringing out 'Proceeding and Recommendations' emerged from the 'National Workshop on Artificial Intelligence in Agriculture' held in July 2018. This publication of ICAR will bring enormous possibilities of Artificial Intelligence applications in the Indian Agriculture. By taking up the initiative of recognizing the potential of AI in agriculture, ICAR is reiterating the role of technology in the progress of Indian agriculture. It is a well-known fact that, the growth rate of the country largely depends upon agricultural sector. The agricultural productivity cannot be increased substantially unless technology plays a pivotal role. Therefore, AI and IoT are the most important futuristic interventions in the agricultural research and development.

AI along with other technologies like IoT and mobile technology has the potential to enhance productivity, cut losses and increase farmers' income. Various cloud based apps can be built to take advantage of the value chains, they can address the persistent problems of price volatility and the agri-intelligence to help farmers generate better returns.

Simultaneously, we should utilize the power of AI to bridge the gaps between different regions of the nation under the Hon'ble Prime Minister's call on "Ek Bharat, Shrestha Bharat" that guarantees food security and sustainable growth with quality life.

I am pleased with the timely efforts made by the Indian Council of Agricultural Research in this direction through this publication. I hope that this publication would inspire the researchers of NARES and other tech institutions, startups and the software industry to work in the area of AI for agriculture.

(Amitabh Kant)

Date: 27.12.2018
New Delhi

त्रिलोचन महापात्र, पीएच.डी.
एफ एन ए, एफ एन ए एस सी, एफ एन ए ए एस
सचिव एवं महानिदेशक

TRILOCHAN MOHAPATRA, Ph.D.
FNA, FNASc, FNAAS
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FOREWORD

I am happy to share the 'Proceedings of National Workshop on Artificial Intelligence in Agriculture', which reflects the use of AI in development of agriculture in the country. In order to maintain food and nutritional security, the challenges are environmental safety maintenance. It will be necessary to further increase crop productivity with lesser use of water, fertilizer and chemicals. Agriculture will need to be more efficient in terms of use of existing resources/inputs. It guarantees food security even while meeting increasing societal needs for food wellbeing, quality, esteem, origin and diversity of food.

It is high time for the National Agricultural Research and Education System (NARES) to develop data driven AI initiatives in agriculture to take a successful stand. The advancement and improvement of Computer Hardware, Cloud, Rural ICT Infrastructure in India, penetration of smart devices underscores need to change the strategy in provision of agricultural information, education and advisory services to farmers in India.

In order to produce impactful AI applications, a genuine convergence between ICT experts and domain researchers need to happen as a collaborative effort. It also required to partner with private software industry and startups through an Institutional framework in PPP mode which can deliver in a time frame. I am pleased to know about the efforts made by my colleagues at IASRI, NAARM & IIWM in this direction through this publication.

(T. MOHAPATRA)

Dated the 4th December, 2018
New Delhi

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FOREWORD

At the outset, we are delightful to publish the way forward options for articulating digital solutions such as Artificial Intelligence and Machine Learning applications in Indian Agriculture in general and ICAR in specific. It's very critical time where we need to address many emerging challenges for Indian agriculture to sustain food security quality and quantity wise. To mitigate these challenges, it essential to provide right information at the right time to the right person using right and appropriate efficient channel. Artificial Intelligence is one of such tool which can be certainly effective when combined with other technologies like big data analytics, the internet of things and Cloud computing.

By 2020, computing devices out number Human to 10 to 1. It is estimated that as many as 100 billion computing devices will be connected to the Web and data generated can go up to 35,000 Exabytes. Under Digital India, all revenue villages are being connected with huge band width connectivity which enables seamless information access to farmers certainly a game changer. In this scenario, these efforts of developing AI applications are timely and collaborative efforts to be made for providing customized agro advisories to each and every farmer of India.

I am pleased to know about the efforts made by my colleagues at the Education division in this direction through this publication. I hope that this publication sets the platform and help all the stakeholders who wish to develop impactful applications.

N.S. Rathore

Dated the 4th December, 2018
New Delhi

Table of Contents

Artificial Intelligence in Agriculture: Global Status

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Introduction

While the demand for quality agricultural products is tremendously increasing year by year, the resources are constrained. Therefore, to produce more in less inputs, the man-machine interaction methods will lead to quality outputs with sustenance by removing several barriers in agriculture sector. In consideration of man-machine methods, Artificial Intelligence (AI) plays an influential role in establishing the best production and management practices. Most of the developed countries have customised AI based technologies and implemented at farm level for several purposes viz. appropriate distribution of fertilisers & chemicals in farms, intelligence irrigation, crop health monitoring, disease analysis, positioning of farm machineries and monitoring of animal health.

Farming can highly benefit from intelligent solution powered by Artificial Intelligence. Globally, AI solutions enable smart irrigation, precision farming, intelligent processing, automated pest surveillance, secure storage and distribution analysis & consumption analytics of agriculture products. The implementation of artificial intelligence in agriculture has been used more effectively for post-harvest productions, minimizing the wastage and simplifying the transportation of output products etc.

Implementation of AI in agriculture will be enabled by other advanced technologies including big data analytics, internet of things, sensors, cameras, drones and satellite images. From the analysis of various data sources such as weather data, temperature, soil analysis, moisture and growth characteristics of a crop, AI technologies will be able to predict most accurate crop insights and will also provide historical analysis of particular crop for particular region, time.

Research in Artificial Intelligence in Agriculture

Through analysis of databases, an effort was made to understand the global research trends. The analysis of research publications in last 20 years reveal that the research papers contribution towards artificial intelligence in agriculture has gradually increased from the year 2010 to 2018, there is remarkable steep rise during 2015-2018. It is indicating that research interest on artificial intelligence in agriculture is increasing globally with fast speed of 125% growth (Fig.1). A 21st January 2018 report in a National Daily 'The Hindu' reveals that during 2013-17, China produced around 38,000 documents with AI keyword, while USA around 32000 and India stands third with around 12000 documents. In citation India was fifth, therefore need to improve research quality. In agriculture, we did an effort, with the keyword 'AI in Agriculture', at present, around 9100 documents are available in 'Science Direct', most of them are research papers or book chapters (Fig. 2). Conference proceedings and abstracts are less than 200, therefore sharing knowledge through workshops and conferences is very important.

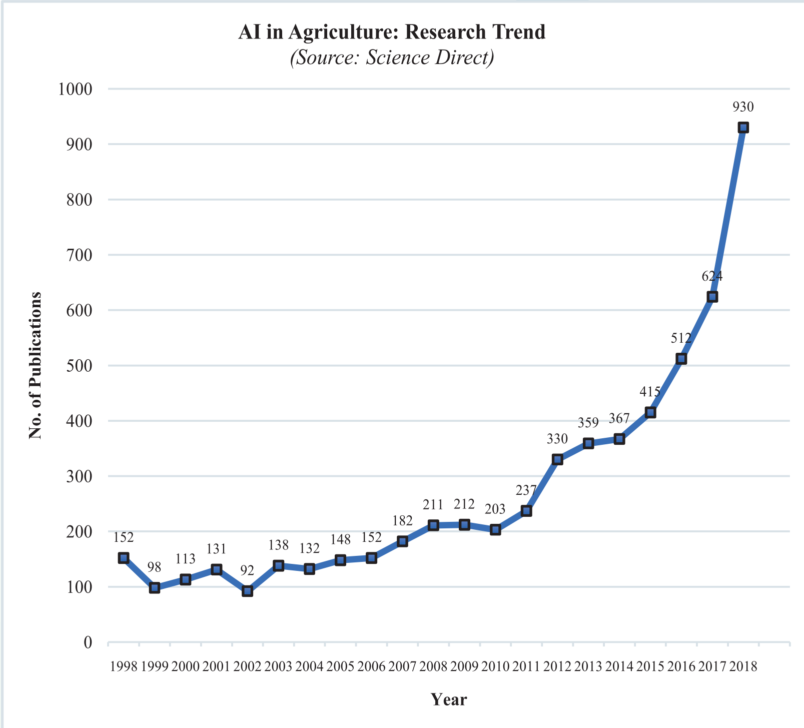

Figure 1. Global Research Trend in AI in Agriculture in Last 20 Years

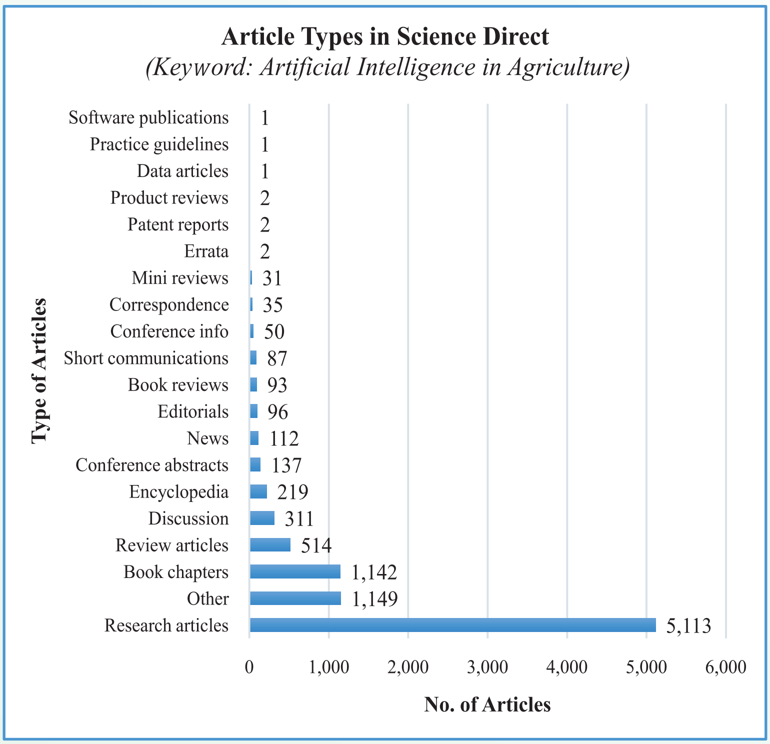

Figure 2. Distribution of Research Articles in Science Direct

There are some interesting and notable factors, if we consider the statistics from various patent authorities. The analysis of World Intellectual Property Organization (WIPO) data as available in figure 3 reveals that USA contributes around 60% of the patent filing in the field of artificial intelligence in agriculture. China follows USA with 22%, applications under and Patent Cooperation Treaty (PCT) are 16% only. It means countries are protecting mostly in their own countries first, and its good strategy too for protecting their own agricultural community. The patent applications from India are only 3%, therefore specific strategy is required by the National Agricultural Research System (NARS).

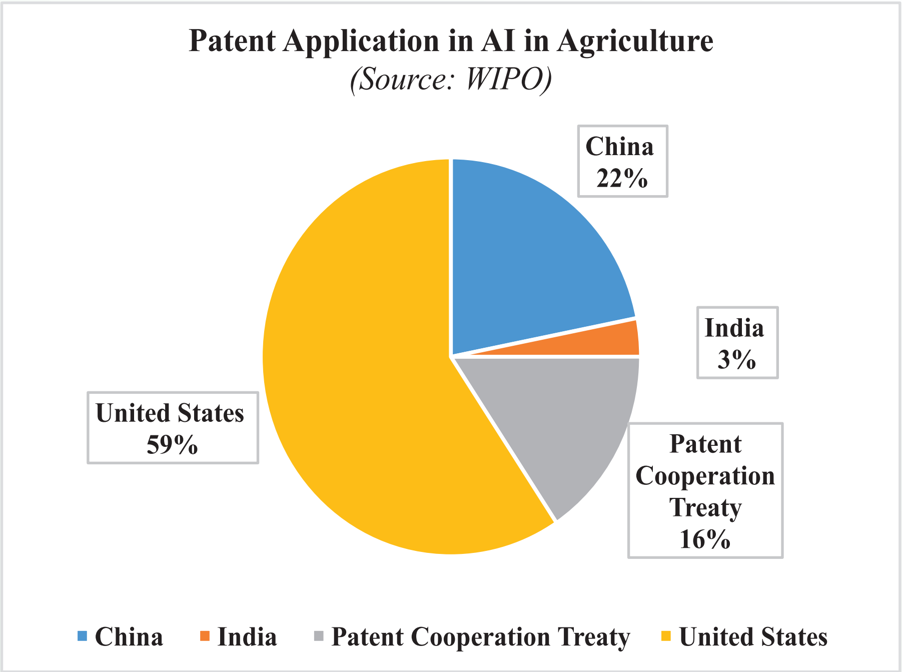

Figure 3. Patent Applications in AI in Agriculture

Globally the patent filing trends is tremendously increased year by year. The research interest and innovations using artificial intelligence in agriculture are in demand. So, researchers are working more on AI based technology to enhance agricultural productions. If we observe the Figure 4, the trends show that number of patents filed on topic artificial intelligence in agriculture is increased slightly from 1983 to 2004. There were some slight increases and decreases found between the year 2005 and 2010. Later, the filing patterns partially increased. From the year of 2015 to 2018, the results represent that there was a tremendous change in increase of filing the patents, the trend is in perfect combination of research article publications as in Figure 1.

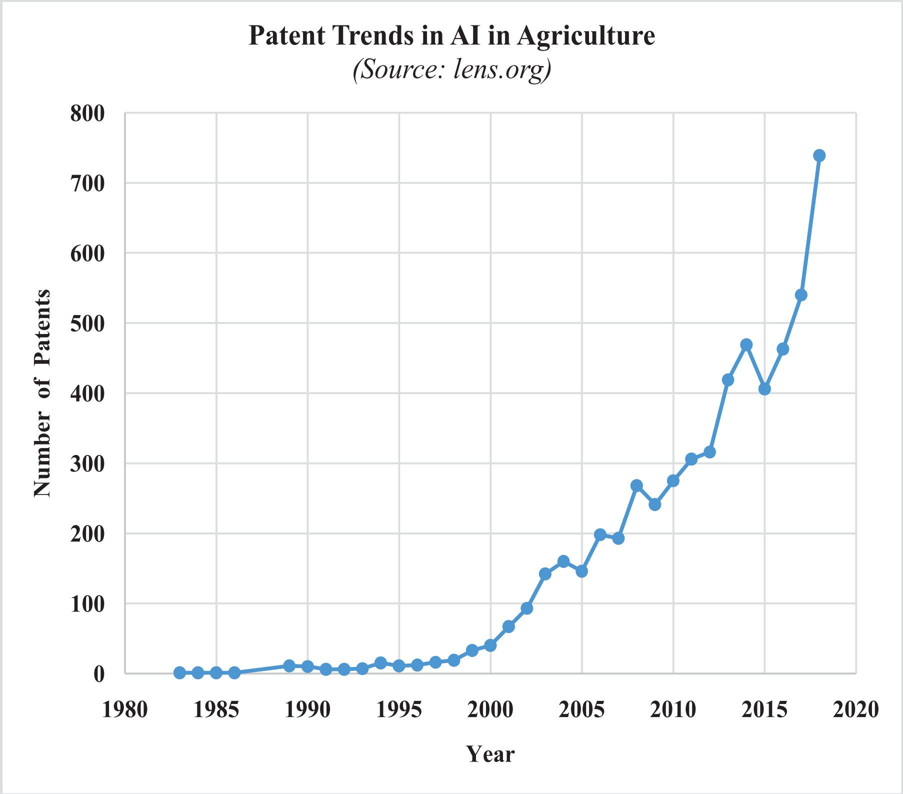

Figure 4. Patent Application Trends in AI in Agriculture

Research and Development using AI

At present, most of the multinational technology providers are working on Artificial Intelligence in agriculture and providing the platforms for researchers. Therefore, researchers must start working on the provided platforms to extract the uses of AI in agriculture easily. Another significant development is education in AI. Around the globe, most of the educational institutions have introduced Artificial Intelligence and Machine Learning (ML) in their course curriculum at bachelor's level. Design of AI and ML courses are even offered to students belonging to agricultural and allied sectors. This global initiative may lead to enhanced and efficient outputs for research and development in artificial intelligence in agriculture.

Global Challenges - Application Status

Data Science and Big Data analytics along with AI technologies enables most accurate predictions for farming community. International statistical institutions and research and development centres are already working on various data resources. The challenge areas where Research & Development using Artificial Intelligence in Agriculture can make wonderful outcomes.

Major challenges are listed below:

I. Deficient demand prediction.
II. Lack of guaranteed irrigation.
III. Maltreatment of pesticides and misuse of fertilisers.
IV. Crop yield improvement using real time advisory systems.
V. Prior detection of pest attacks.
VI. Crop damage detection and analysis.
VII. Prediction of markets for best crop practices.
VIII. Weed control and Weed –Crop discrimination.

Types of Applicability

The design and development of Artificial Intelligence technologies may offer services for agriculture in four identified following areas. Development of AI applications may cover these areas to fulfil the requirement of AI in agriculture needs.

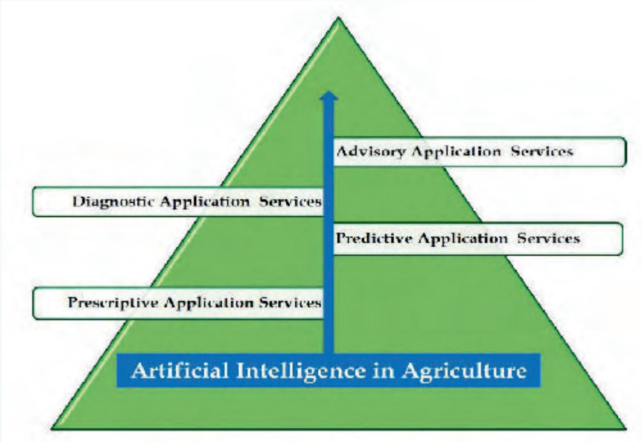

Figure 5. Application Areas of AI in Agriculture

Through literature survey, we identified some of the applications, which were developed using Artificial Intelligence and fulfil global agriculture needs. Some of the applications are open source and some of them are paid.

Plantix:

Plantix is an advisory and predictive services provider application which is used to identify the crops and also diseases.

PlantNet:

PlantNet is also an advisory system, which provides plant information. It identifies the plants using Artificial Intelligence visual recognition system.

PictureThis:

PictureThis is a special kind of AI application which is used to identify the flowers using deep learning and cognitive vision.

Merlin Bird ID:

Merlin Bird Id is a bird identification application, which can identify birds based on computer vision and deep learning methods.

iNaturalist:

iNaturalist is an AI based application used to identify the plants and animals

ripeSense:

ripeSense is an intelligence device which is used to predict the ripeness of fruits.

Stellapps:

Stellapps is an AI based device which analyses the flow of milk to identify the quantity of elements in milk.

ROXAN:

ROXAN is an AI technology which is used to identify the location and health characteristics of farm animals.

Daisy:

Daisy is an intelligent device for plants. It provides automatic irrigation for indoor and outdoor plants.

The advances of AI technology in agriculture are great in number and extremely important to the world. Higher crop yield and decreased use of man power, fertilizer and pesticides by application of Artificial Intelligence tools may also reduce the negative impact on natural resources and eco systems.

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Artificial Intelligence in Agriculture: Status and Prospects in India

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1. Introduction

India has emerged as sixth largest economy of the World. Agriculture and allied sectors contribute significantly to Indian economy (17-18 %) which is much higher than world's average (6.1 %) [Economic Survey, 2018]. Indian Government is putting considerable efforts in improving supply chain, marketing and productivity augmentation under the Doubling Farmers' Income agenda. Indian agriculture is primarily dependent on natural resources. Degradation of land, reduction in soil fertility, increased dependence on fertilizer/pesticides for production, pest outbreak, climate change, dependency on rain water are the major factors affecting Indian agriculture. Explosion in digitized data and technological advances in Information Communication and Technology (ICT) play pivotal role in achieving digital agriculture by using modern digital devices with AI.

AI attempts to develop tangible or intangible systems which not only behave intelligently but also display behavior to the same level as human beings think and act achieving human-like performance in all cognitive tasks using purely logical reasoning. AI is intelligence demonstrated by machines, in contrast to the natural intelligence (NI) displayed by humans and other animals. AI is the automation of activities one can associate with human thinking, like speech recognition, natural language understanding and translation, knowledge management, image analysis, decision making, learning, etc., which will make systems (including relevant data sets and computers) powerful and useful.

Natural Language Processing (NLP), Robotics, Machine Learning (ML), Soft computing techniques, Automated Reasoning, Knowledge Representation, Computer Vision, Speech Recognition, Automated Data Analytics, Virtual Reality, Augmented Reality, Deep Learning, Pattern Recognition, Image Processing, Internet of Things (IoT), Blockchain Technology, Cloud Computing, Fog and Edge Computing, etc., are some major sub-areas of AI having huge potential in solving complex problems of agriculture. AI-driven technologies are emerging to improve the efficiency with respect to crop and soil monitoring, weather forecasting, predictive agricultural analytics, markets and supply chain efficiency. The cloud computing infrastructures with the use of data ecosystems, Internet of Things (IoT) and AI enables the development of digital agriculture and strengthen the farmers in practicing smart farming, smart irrigation, smart fertilizer application, and disease/pests diagnosis/detection, smart spraying, and harvesting. Machine learning and soft computing methods with pattern recognition through image and video (drone cameras, satellite imagery) data processing are being widely used world-wide in monitoring and managing various farm operations and predicting the incidence of disease/ pests, weather forecasts, time of application and optimum dose of chemical sprays, time of harvest, life of produce, etc. Deep Learning is a subfield of machine learning concerned with algorithms inspired by the structure and function of the brain called Artificial Neural Networks (ANNs). Deep learning can solve more complex problems particularly those consisting of large number of features, because here more complex models are used, which allow massive parallelization.

Detecting deadly diseases, reducing accident risks, predicting consumer behaviour and helping farmers increase crop yields are some of the AI-based innovations that Microsoft is addressing. From Apple's intelligent personal assistant SIRI or Cortana of Microsoft to IBM's Watson to self-driving cars, AI is progressing rapidly. The Robot Sophia is an excellent example of potentials of AI. Another popular example includes Google Maps, Ridesharing in cabs, Face recognition in Facebook photo upload, Face unlock in Mobile, search and recommendation in online shopping sites, etc. The internet giant Google is moving into an "AI first" world, and is currently using AI technologies for numerous applications. In a recent Google AI event, it has been told that it is up to people's imagination to make things happen in the AI world. Google operates two of the top AI research labs in the world *i.e.,* DeepMind in London and GoogleBrain in California. Microsoft has developed Microsoft Cortana Intelligence Suite for AI. IBM has come up with IBM Watson which showcases AI applications in various areas. China has committed to become the world's leader in AI by 2030, pledging billions of dollars in the prime area of research. Many start-ups are also coming up which are utilizing capabilities of AI to provide solutions in different areas of agriculture.

There are several applications of AI in Agriculture at the International level, and many initiatives in India by the name AI and machine learning.

2. International Status

Blue River Technology company has developed a robot known as "See & Spray" that uses computer vision technology to monitor and precisely spray weedicides on cotton and soybean farm.

Harvest CROO Robotics company has developed a robot to help strawberry farmers in picking and packing of their produce.

PEAT, an AgTech company, has developed a deep learning based application **"Plantix"** for identifying the potential defect and nutrient deficiencies in soil. This application considers and correlates foliage patterns with certain soil defects, plant pests and diseases. The AI enabled image recognition solution identifies possible defects through images captured by the user's smartphone camera. Users are then provided with soil restoration techniques, tips and other possible solutions. This app is a team work from ZALF (**The Leibniz Centre for Agricultural Landscape Research)**, CABI (Centre for Agriculture and Biosciences International) and CIMMYT (International Maize and Wheat Improvement Center).

Trace Genomics, Inc. provides soil analysis services to farmers. The system uses machine learning techniques and tools to provide advices on the strength and weaknesses of soil. Services offered in the analysis of soil include not only analysis summary but also information related to bacteria and fungi through pathogen screening and microbial evaluation by performing the soil DNA analysis.

aWhere Inc. uses satellites imagery data in the farms based on many points daily data on agronomic and climatic data such as temperature, precipitation, wind speed, and solar radiation etc. and uses this for decision making by applying machine learning techniques to predict weather, crop sustainability and the occurrence of diseases and pests.

CropX an ag-analytics company has developed cloud based software solutions integrated with wireless sensors for adaptive irrigation. The solution involves taking data from field ground sensors, measuring soil moisture and temperature and uploading the data to the cloud, and offers a mapping and optimal irrigation planning as a service to the grower through a mobile application.

FarmBeats is an AI and IoT based solution given by Microsoft Research to increase farm productivity. UAV drones and sensors collect real-time data of factors that may affect the growth of the crops during cultivation processes, including wind speed, wind direction, soil moisture and temperature, CO_2, atmospheric moisture and temperature, atmospheric pressure, as well as rain and light exposure and after machine learning-based backend analytics with predictive features information is accessible to farmers on the FarmBeats app.

Alibaba Cloud- ET Brain is the innovative cloud based AI platform offering services in almost all the sectors by Chinese tech giant Alibaba. ET Agricultural Brain is built upon the Alibaba Cloud's proprietary AI for providing services in agricultural industry. The cutting-edge AI programme has been adopted by a number of leading pig farming, fruit and vegetable growing enterprises in China, and is set to revolutionize the agricultural industry.

3. Status in India

NITI Aayog and IBM have partnered for Precision Agriculture using AI. They are developing prediction models using AI to provide real time advisories to farmers. AI models for predictive insights to improve crop productivity, soil yield, control agricultural inputs and early warning on pest/disease outbreak will use data from remote sensing, soil health cards, weather prediction, soil moisture/temperature, crop phenology, etc., to give accurate advisory to farmers. The project is being implemented in ten aspirational districts across Assam, Bihar, Jharkhand, Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh.

Microsoft has partnered with United Phosphorous Ltd. (UPL), producer of agrochemicals, to create the **Pest Risk Prediction App** based on AI and machine learning to indicate the risk of pest attack in advance which is currently used in different states like Andhra Pradesh, Karnataka, Telangana, Maharashtra and Madhya Pradesh.

Microsoft in partnership with Karnataka government has developed multivariate agricultural commodity price forecasting model to predict future commodity arrival and the corresponding prices. The model uses remote sensing data from geo-stationary satellite images to predict crop yields through every stage of farming. This data along with other inputs such as historical sowing area, production, yield, weather, among other datasets, are used in an elastic-net framework to predict the timing of arrival of grains in the market as well as their quantum, which would determine their pricing. The model is currently being used for prediction of prices of Tur dal. This is scalable, and can be extended to other regions and crops.

Under the 'Bhoochetana" project, Microsoft in collaboration with ICRISAT, developed an AI based **Sowing App** that uses machine learning and business intelligence from the Microsoft Cortana Intelligence Suite. Historic climate data spanning over 30 years in Andhra Pradesh was analysed using AI to calculate the crop-sowing period. The app sends sowing advisories in regional languages like Telugu and Kannada to participating farmers about optimal date. The advisories contain essential information including the optimal sowing date, soil test based fertilizer application, farm yard manure application, seed treatment, optimum sowing depth, and more. The programme was expanded to touch farmers across Andhra Pradesh and Karnataka during the Kharif crop cycle (rainy season) for a host of crops including groundnut, ragi, maize, rice and cotton among others.

HARITA-PRIYA (Precision Technology for Agriculture) is a pilot study by Govt. of Andhra Pradesh to induct cutting-edge sensor-based technologies for real-time acquisition of micro-climatic data from farmer's field. This data is used to create advisories and alerts on irrigation schedules and pest and plant diseases. Based on this, state agriculture officers disseminate personalized crop advisories in Telugu language to farmers by way of SMS. The Centre for Development of Advanced Computing (C-DAC) Hyderabad, Central Institute for Dryland Agriculture (CRIDA), International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) and Acharya N G Ranga Agricultural University (ANGRAU) have partnered in this study. The study has been carried out in Anantapur district of AP in five villages for Groundnut crop.

4. Start-up Companies on AI in Agriculture

According to a recent survey, over one billion people work worldwide in agriculture sector generating $2.4 trillion for global economy. Technology interventions are playing promising role, and many AI start-ups have sprung up at the international and national level in the agriculture sector. Few are cited below:

Aerobotics is an US based data analytics company making use of aerial imagery and machine learning algorithms focused on precision agriculture. They help farmers to identify pest and disease at an early stage with the help of drone and satellite imagery.

AbundantRobotics is an US based startup that is providing robotic solutions for hardest jobs in agriculture. They have developed an apple-picking robot and trials are on in Washington, USA.

AgVoice, an US based startup, has developed the world's first, hands-free enabled, voice-interactive, mobile technology platform designed for food and agriculture professionals for improving efficiency in supply chain.

Indigo Agriculture is an US based agricultural technology company that works with plant microbes and digital technologies to improve yields of cotton, wheat, corn, soybean and rice. By using sophisticated genomic sequencing and computational bioinformatics, Indigo has assembled an enormous database of genomic information from these microbes.

FarmShots is another US based startup focused on analyzing agricultural data derived from images captured by satellites and drones. Specifically, the company uses satellite data for monitoring crop health. The App maps out signs of disease, pest and poor nutrition for scouting. It turns imagery into prescription map for fertilizer and crop protection application.

Motorleaf is an US based startup that enables greenhouse farmers to more accurately forecast the future harvest using AI techniques. Motorleaf develops yield-predicting algorithms and indoor growth sensors. By using these advanced technologies to monitor plant growing conditions, greenhouse vegetable and tomato producers can make better business decisions and reduce costs, energy, as well as water consumption.

SatSure, a London-based startup, that has its roots in India, is working towards supporting financial services in the agriculture sector, by using powerful algorithms that combine satellite imagery with weather and location data, and correlating the outputs with economic datasets to derive actionable intelligence in the form of crop yield estimate and localized crop risk ratings for banks, governments, insurance and re-insurance companies, and agricultural commodity traders. SatSure's crop yield indices enable clients to view both historic and predictive crop yield at both micro and macro levels, without having to rely on inaccurate survey based yield measurements.

Agricx has developed a mobile app that uses Artificial Intelligence (AI) and computer vision on images to access the quality of agri-produce. This India based company is working with Potato, Tomato, Paddy, Rice and Chilli, and planning to increase its horizon for other crops and supply-chain efficiency.

Gobasco, an Indian startup, has created an AI-optimized automated pipeline to increase the efficiency of supply-chain. Online agri-marketplace provides best prices for buyers and producers with the help of real time data analytics on data streams from multiple sources across country.

Intello Labs is an Indian startup that provides image analysis based solutions powered by advanced deep learning algorithms for agricultural product grading, crop infestation and soil conditions. This App reads the crop image and determines the product quality at real time. Images of crops are also analysed to recognize the pest, disease and foreign plant infestation in the plot.

CropIn is an Indian startup that tags farming land and conveys the information through an Android based app to various companies which enable them to connect, and data driven farming. It allows them to take advantage of real time data and insight from farms (an accurate view of their operation throughout the entire growing season) using AI based features and to improve financial, operational and agronomy aspects.

Aibono, Indian startup, is working by bringing together several small farms on a cloud platform to create smart farming collectives by leveraging Internet, AI and shared technologies in rural India and aggregating the soil data and weather condition to build an imagery of the region and advises the farmer on the right fertilizer mix.

Fasal: This Indian startup provides microclimate forecasts which are tailored to each farm location and performed at a point scale, not at a kilometer-wide spatial scale. They collect more data, the AI-based microclimate forecasting algorithm incorporates real in-field information and relates it to publicly available weather forecasts, so that farmers can benefit from real-time, actionable information relevant to day-to-day operations at the farm.

5. AI Enabled Initiatives in ICAR

Application of AI to agriculture offers novel challenges because such data are highly imprecise and uncertain, experts often disagree and data may be incomplete or unreliable. However, ICAR has already made headway in employing AI in Agriculture and are discussed subsequently under broad subareas of AI.

IoT, Expert Systems and Knowledge Management

An Electronic crop (E-crop) solution based on IoT has been developed at ICAR-CTCRI, Thiruvananthapuram. It has also developed Sree Visakham Cassava Expert System. An expert system of extension was developed as a collaborative project of ICAR-IARI and ICAR-IASRI both based at New Delhi. An ontology based Expert System tool AgriDaksh has been developed and launched by ICAR-IASRI for Maize, Tobacco, Rapeseed-Mustard and Solanaceous crops. Multi-lingual expert system using rule based inference engine for knowledge management has been developed at ICAR-IASRI for wheat crop and seed spices management. A Knowledge-based Expert System for soybean disease diagnosis has been developed at ICAR-IISR, Indore. Rice expert system for insect pests and diseases management has been developed by ICAR-IRRI, Hyderabad. Knowledge management is one of the key areas of AI and the latest knowledge representation technique i.e., Soil and Microbial ontologies have been developed based on the taxonomic information for various domains by ICAR-IASRI.

Model Building using Machine Learning/ Soft Computing Techniques

ICAR-IASRI has contributed immensely to AI by way of doing research in various machine learning techniques such as Artificial Neural Networks (ANN), Fuzzy systems, Genetic Algorithms (GA), Classification and Regression Trees (CART), Support Vector Machine (SVM), Rough Sets, etc. A study to reformulate and investigate the automated editing and imputation problem in statistical data by means of ANN has been done. A package has been developed for imputation of missing data which includes neural network based imputation along with other conventional methods of imputation. Forecasting of rice yield using neural networks was done using weather parameters. Variance estimation under heteroscedasticity using GA was done. Possibilistic linear regression analysis with fuzzy response variable for crop yield estimation has also been done. Rough set based methodology for feature selection and pattern discovery from clusters has also been done. Hybrid models by combining linear Seasonal Auto-Regressive Integrated Moving Average (SARIMA) and Nonlinear SVM models for time-series forecasting by estimating optimal hyper-parameters of these models using Particle Swarm Optimization (PSO) technique has also been developed. Tree based modeling namely CART for classification purposes in the field of agricultural ergonomics has also been attempted. Time Delay Neural Network (TDNN) model has been employed to capture nonlinear patterns in forecasting. Another hybrid model combining Auto-Regressive Integrated Moving Average (ARIMA) and Wavelet Neural Network (WNN) using morlet wavelet activation function in hidden neurons was also developed. Time lagged neural network with single hidden layer for domestic and international oil price indices was attempted. Comparative performance of two wavelet-based neural network approaches was studied. Hybrid time-series models, namely ARIMA-GARCH and ARIMA-ANN, have been developed for forecasting agricultural commodity prices. Wavelet based neural network model for predicting monthly Wholesale Price Index (WPI) of pulses in India was developed. Grey model improved by GA in situations where even a fewer observation is sufficient for model fitting for forecasting hybrid rice yield has been attempted. The parameters of Auto-Regressive Fractionally Integrated Moving Average (ARFIMA) model has been estimated by maximum overlap discrete wavelet transform (MODWT) and long memory time series prediction has been obtained by combining ARFIMA-MODWT and ANN for forecasting spot prices of mustard.

ICAR-NIAP, New Delhi has developed models using machine learning, particularly through sets for applications in agricultural related areas. At ICAR-IIWM, Bhubaneswar, ANN model for prediction of water table depth in a hard rock basin of Nayagarh block of Odisha has been developed. ANN models have also been developed for forecasting future rainfall scenarios of Jharkhand state using global climatic variables. Various models have been developed at ICAR-NDRI, Karnal using machine learning techniques. Intelligent algorithms have been developed utilizing various machine learning algorithms (ANN, SVM, Decision Trees, Random Forests) for modelling fertility of breeding bulls in Murrah buffaloes. ANN model using yield and milk quality parameters for classification of healthy and mastitis Murrah buffaloes has also been developed. ANN models have been used for prediction of first lactation 305-day milk yield in Karan Fries dairy cattle. Neuro-Fuzzy and Neuro-Genetic models was investigated for intelligent modelling of moisture sorption isotherms in various milk products. ICAR-CTCRI, Thiruvananthapuram has developed computer simulation models using Machine Learning techniques for Sweet potato, Cassava and Elephant foot yam estimation. Application of Wireless Sensor Networks (WSN) for environmental monitoring using weather parameters to predict crop conditions for pests and diseases and remotely accessing of multi-locations data from the field was developed.

AI applications in Bioinformatics

Centre for Agricultural Bioinformatics (CABin) at ICAR-IASRI, New Delhi initiated the database and prediction server by mining the genome/proteome sequences using machine learning algorithm. The SSR were mined for various species such as BuffSatDB for Buffalo, PipeMicroDB for Pigeon Pea, TomSatDB for Tomato, WebSynCodd, GoSatDB for Goat, HProtDB for halophile protein database, SBMDB for Sugarbeet, ProtSComp for protein structure comparison, OGR for Onion, BanSatDB for Banana, TaSSRDB for Wheat, CnTDB for Coconut transcriptome, PMDTDB for Pearl Millets transcriptome, MiSNPDb for Mango SNP database, VmTDB for Vigna mungo transcriptome, GOMI prediction server for Indian Goat breed using Bayesian approach, BisGoat for breed identification using ANN approach, BISCattle for breed identification of cattle, Antimicrobial peptide server for Cattle and Fish using ANN and SVM based approach, TamiRPred: Putative miRNA discovery tool in Wheat, Polymorphism Prediction Server (PolyMorhPred), Variety Identification System for *Triticum aestivum (VISTa)*. Apart from this, DCDNC, SPIDBAR, HSplice, PreDoSS, MalDoSS, DIRProt, iAMPred, ir-HSP, hpcDATA: a web based software for Next Generation transcriptome sequence data assembly, analysis and annotation pipeline, Trait Associated Genes Prediction Tool (TAGPT), GSAQ: An R package for Gene Set Analysis with Trait Specific QTL, Portal for biological database in agriculture, Biocomputing portal and Synergetic gene regulation mediated by microRNAs and transcription factors, Simultaneous Selection of Genotypes for Yield and Stability (SISGYS). Recently, the work has also initiated towards the development of genomic data warehousing, parallelization of workflows, SNP resources for animal species, genomic resources for various crops/animals and other transcriptome resources have also been developed.

However, all these works can only form a basis for AI. It's a long way to go to include latest techniques like Recurrent Neural Networks and Deep Learning for AI model building.

6. Future Path ways for AI Applications in Agriculture

Growth driven by IOT

Huge volumes of data get generated every day in both structured and unstructured format. These relate to data on historical weather pattern, soil reports, new research, rainfall, pest infestation, images from drones and cameras and so on. Cognitive IOT solutions can sense this data and provide organisations richer insights and recommendations to take action for yield improvement.

AI can be used to create intelligent systems which can also be embedded in machines that can work with higher accuracy and speed than humans but with same responsive as humans. AI together with Internet of Things (IoT) and Sensor Technology can be a great enabler of precision agriculture. AI can also play a critical role along with remote sensing technology in wide scale implementation of Climate Smart Agriculture.

Image-based Insight Generation

Precision farming is one of the most discussed areas in farming today. Drone-based images can help in in-depth field analysis, crop monitoring, scanning of fields and so on. Computer vision technology, IoT and drone data can be combined to ensure rapid actions by farmers. The drone image data can generate real time alerts to accelerate precision farming. These artificial intelligence systems not only save time and increase safety but also reduce potential human error while improving effectiveness. Thus, automation, sensors, drones, IoT, solar power aided with AI provide new opportunities for business entrepreneurs to deliver innovative service solutions at affordable prices to the farmers.

Computer Vision

Facial recognition helps dairymen to monitor herd. By using this visual imaging analysis, one can identify how cows eat, where they eat, how long they spend eating and also how cows react to the environment. Since cows can train themselves, one can change how cows' feeds, drinks or milks. How feed is distributed and how well the feed mixer mixes, also makes a difference in feed consumption, as does the feed formulation itself.

- Also we can use the computer vision technology to identify the pest, disease, weed and automate the management of disease problems.
- Computer vision technology also can be used for grading the agricultural produce and can be integrated with existing systems like e-NAM.

Identification of Optimal Mix for Agronomic Products

Based on different parameters like soil condition, weather forecast, type of seeds, infestation in a certain area, cognitive solutions make recommendations to farmers on the best choice of crops and hybrid seeds. The recommendation can be further personalized based on the farm's requirement, local conditions, and data about successful farming in the past. External factors like marketplace trends, prices or consumer needs may also be factored into to enable farmers to make decisions to maximize return on crops.

Health Monitoring of Crops

Remote sensing techniques along with hyper spectral imaging are essential to build crop metrics across thousands of acres. It has the revolutionary potential for the monitoring of farmlands by farmers from both time and effort perspective. This technology will monitor crops along their entire lifecycle including report generation in case of anomalies.

Automation Techniques in Irrigation

Irrigation is one of the human intensive processes in farming. Machines, trained on historical weather pattern, soil quality and kind of crops to be grown, can automate irrigation and increase overall yield. Sensors are also used in automation of farm irrigation. With close to 70% of the world's fresh water being used in irrigation, automation can help farmers better manage their water problems. While labour costs may not be the biggest problem faced by Indian farmers, automation with its inherent advantages of higher reliability, less errors, etc., is picking up. For instance, automated sprayers as well as harvesters can be cost-effective, despite the upfront investment.

Skills and Workforce

As per UN World Urbanization Prospects report, by 2050, 66% of the world's population will live in urban areas. This growing urbanization will lead to a decrease in workforce in the rural areas. Innovative technologies using cognitive systems will help address this challenge by easing farmers' work and removing the need for large numbers of people to work on farm. Many operations can be done remotely, processes can be automated, risks can be identified, and issues can be solved before occurring. Farmers will be able to take more informed and rapid decisions.

Natural Language Processing (NLP) for Agro-advisory

India is a multi-lingual society with majority of farmers being non-literate. Lot of content is not reaching to the desired people due to lack of human-resource to convert it to the language of the user to ensure its end use. This gap can only be filled through the use of Natural Language Processing (NLP) which makes use of AI and Machine Learning approaches. Speech Recognition, Speech Synthesis, Machine Translation, Sentiment Analysis, Text Summarization, Optical Character Recognition, Chatbot based Question-Answering, etc., are some of the technologies that transform this need into a reality.

AI based capacity building initiatives

AI based adaptive e-learning and decision support systems can also help the students in learning new concepts and able to identify areas where students are deficient providing more focus on that content. These systems can generate new problems from source material. These online systems can actually generate better material and more comprehensive testing than typical classroom curriculum.

Maximizing profits in farm operations: Incorporation of AI technology in the form of robots, drones, crop management systems, and herd management tools enable farms to increase the yield and output of crops and animals and maximize profits in farm operations.

Higher adoption of robots in agriculture: The use of robots in the domain of agriculture and dairy farms has advantages in terms of time management, enhancement of control and reliability. Robots are highly efficient and capable entities in carrying out multiple tasks within a shorter time frame.

7. Concluding remarks

With an aim to boost innovation and entrepreneurship in agriculture, the government of India is introducing a new AGRI-UDAAN programme to mentor startups and enable them to connect with potential investors. This platform can help in Startups for AI in agriculture.

AI would be useful if applied on relevant datasets, historic, current or amalgamation of the two depending upon the purpose of application. Relevant quality data, understanding the problem context and selection of AI techniques are going to be key factors for successful applications. Identification of relevant sources and quality data from historical data sets from research, socio-economic, markets, live streaming data sets from sensors and robotics, satellite imageries, bringing data from silos to usable and shareable format is the key concern and bringing them together for AI applications is the key challenge. Data ecosystems need to be developed and strategized. As per discussion paper on National Strategy for Artificial Intelligence (NITI Aayog), focus areas for artificial intelligence in agriculture should result into enhanced farmers income, increased farm productivity and reduction of wastage. In a nutshell, AI opportunities abound.It's time to ideate, initiate and innovate.

"Data is to AI what food is to humans."

Barry Smyth, Professor of Computer Science at University College, Dublin

Acknowledgements

The authors are thankful to Scientists of ICAR-IASRI, particularly those who contributed information as part of Working Group on AI & Digital Agriculture constituted for this purpose within the institute and acknowledge the efforts made by them. The authors also wish to acknowledge the information provided by scientists of other ICAR institutes across India, especially those of computer applications.

Workshop Background

1. Genesis of Workshop
2. Artificial Intelligence in Agriculture
3. Objectives of the Workshop
4. Scope of the Workshop
5. Session Proceedings

Genesis of Workshop

Under Digital India programme of Government of India, it was realised that technology can play a crucial role in increasing the productivity and profitability of small and marginal farmers in contributing to doubling the farmer's income. Accordingly, NITI Aayog in its deliberations on AI strongly felt that government institutions should collaborate with industry for promoting AI applications.

During joint conference with Directors of ICAR institutes and VCs of Agricultural Universities on March 8, 2018, it was decided to identify the areas in agriculture domain where artificial intelligence can be applied. For this purpose, series of discussions at various levels were held to initiate work in this important area. To take AI forward in ICAR, a senior level delegation from ICAR visited Australia and New Zealand during May 2018, and studied the real time applications of AI in agriculture. Further, an empirical survey was done by ICAR-National Academy of Agricultural Research Management (NAARM) during March-April 2018. Afterwards, a "National Dialogue" on application of AI in agriculture was organized at NAARM on June 1-2, 2018. The main purpose of the national dialogue was to sensitize the scientists of National Agricultural Research System (NARS) about AI, and to compile the ongoing AI research in various institutes of ICAR. Several issues related to R&D, integration and strategic policy were identified during the national dialogue. Assimilating the complete data from empirical survey and national dialogue, NAARM developed a **policy brief on 'Application of AI in Agriculture'** (https://naarm.org.in/wp-content/uploads/2018/07/AI_iot_policy.pdf), which was released by Shri Amitabh Kant, CEO, NITI Aayog during present workshop. All these initiatives were planned inputs for 'National Workshop on Artificial Intelligence in Agriculture' conducted by ICAR institutes namely IASRI, NAARM and IIWM during July 30-31, 2018 under overall supervision of ICAR.

Artificial Intelligence in Agriculture

Artificial Intelligence (AI) is intelligence demonstrated by machines, in contrast to the Natural Intelligence (NI) displayed by humans and other animals. AI is the automation of activities one can associate with human thinking, like speech recognition, natural language understanding and translation, knowledge management, image analysis, decision making, learning, etc. Natural Language Processing (NLP), Robotics, Machine Learning (ML), Soft Computing Techniques, Automated Reasoning, Knowledge Representation, Computer Vision, Speech Recognition, Automated Data Analytics, Virtual Reality, Augmented Reality, Deep Learning, Pattern recognition, Image processing, Internet of Things (IoT), Blockchain Technology, Cloud Computing, Fog and Edge Computing, etc., are some of the major sub-areas of AI having huge potential in solving complex problems of agriculture.

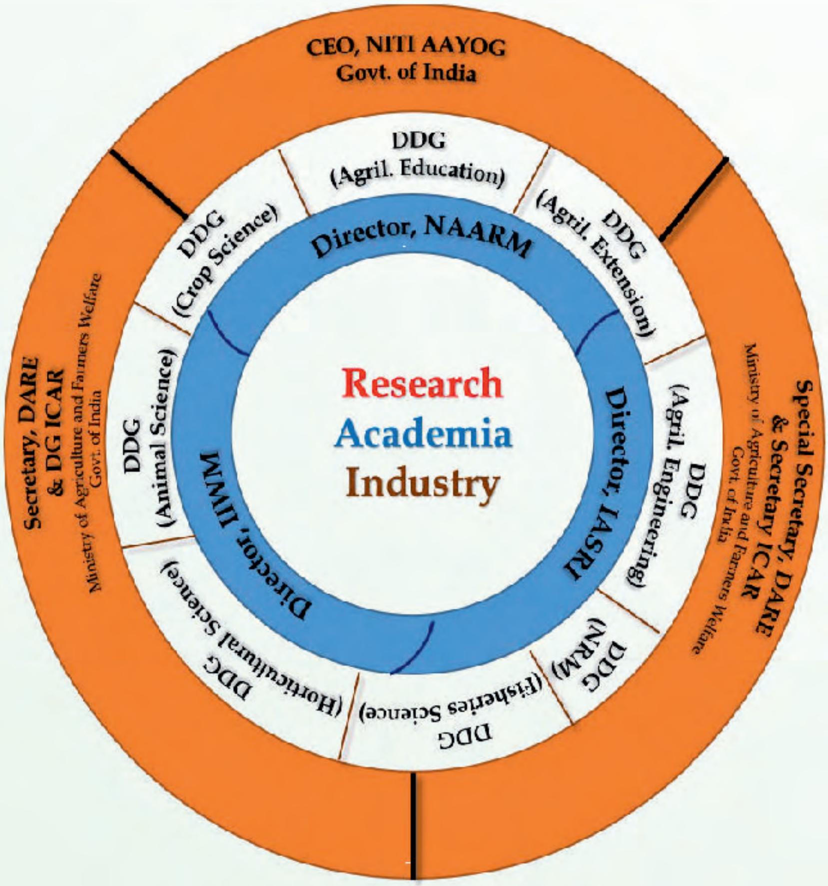
Relevant quality data, understanding problem context and selection of AI techniques are going to be key factors for successful applications. But there are few key concerns, 1. Identification of proper & appropriate data sources from hardcore research data sets or live streaming data sets from sensors, robotics or satellite images, 2. Bringing data from silos to usable and shareable format for AI applications. Therefore, data ecosystems need to be developed and strategized.

Objectives of the Workshop

- To discuss various plausible AI based applications in agricultural research and development
- To explore the possibilities of incorporating AI based systems in potential areas of agriculture
- To provide a platform for agricultural scientists in ICAR to deliberate on AI and its implementation in agriculture

Key Stakeholders in the Workshop

The NITI Aayog and ICAR have given very high importance to the workshop. Around 150 researchers and professionals from research & academic institutions and industry participated. The involvement of the key stakeholders has been depicted in the diagram below.



Industry Partners	Academia Partners
AgriCx Lab Pvt. Ltd., Mumbai	Ambedkar University, Lucknow
C-DAC, Hyderabad & C-DAC, Noida	IIIT, Hyderabad
CropData Technology Pvt. Ltd., Nagpur	IIT, Kharagpur
IBM, Gurugram	IIT, Mandi
KPMG, Gurugram	University of Delhi, New Delhi
NVIDIA, Bengaluru	University of Hyderabad, Hyderabad
Oracle India Pvt. Ltd., Gurugram	ICAR- Research Institutes
SAS, New Delhi	ICAR – Head Quarters
TCS, Thane	ICAR - DKMA

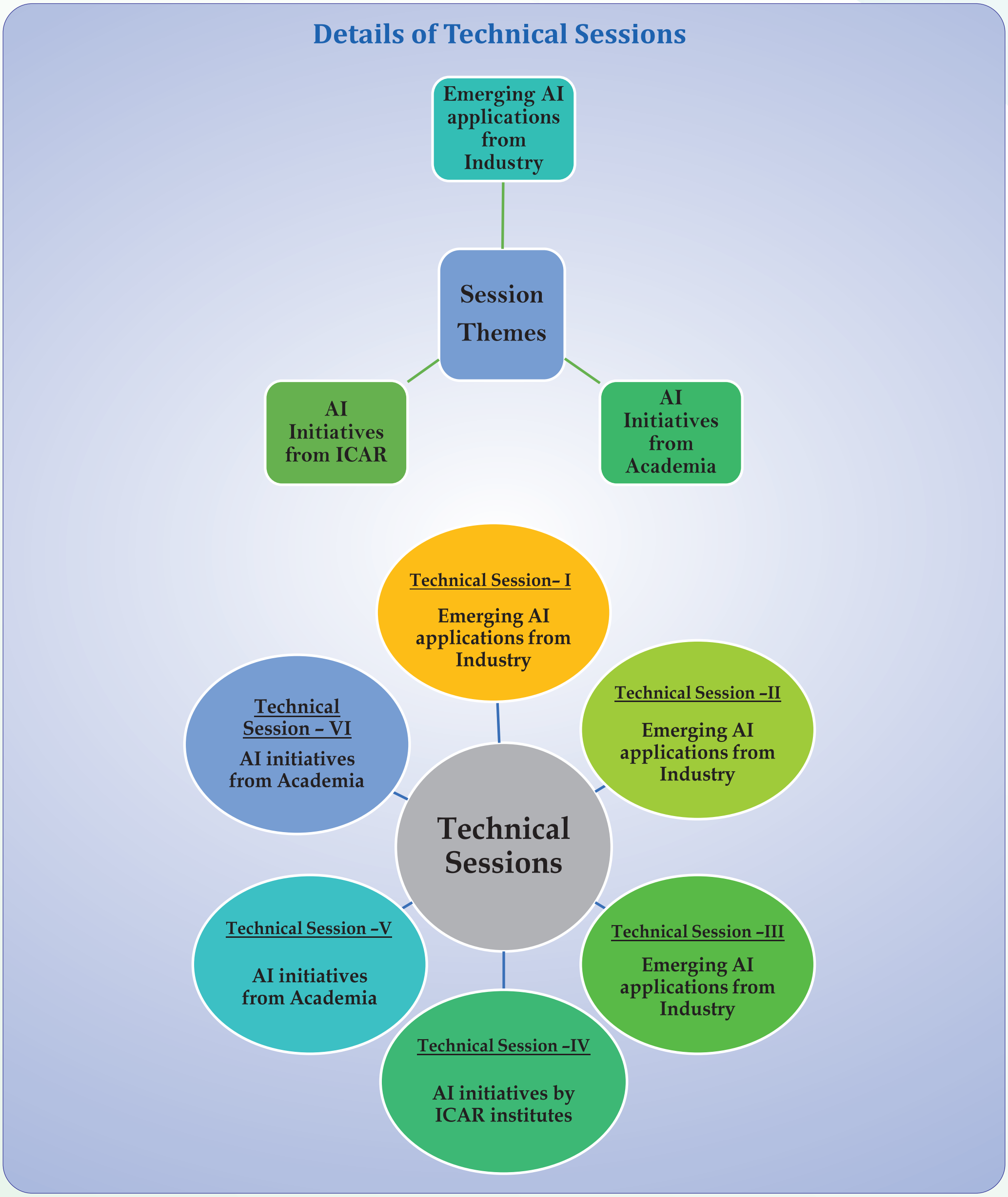
Scope of the Workshop

The national workshop essentially aimed to stimulate discussions on use of Artificial Intelligence (AI) in agriculture. It also focused on throwing light as to how AI techniques can be incorporated in agricultural research for enhancing the productivity. It aimed to facilitate learning from experiences, help generate insights and explore pathways to initiate the use of AI in Agriculture. The national workshop focused on:

- Better understanding of the links between different stakeholders working on AI in agriculture
- Preparation of status paper on use of AI in ICAR institutes
- Identification and prioritization of research areas in AI under ICAR
- Fostering strong linkages with CDAC, IITs, University of Delhi, pioneer AI research labs like IBM, Oracle, TCS, etc., IoT hardware vendors and other private organizations
- Development of AI and IoT as specialized areas
- Development of network project/scheme in which multi-institutional sub projects in priority areas of AI and IoT can be taken up in PPP mode. Those areas of AI will be given importance wherein AI technology is readily available and its application in agriculture can solve problems faced by farmers/Agri-industry besides areas in which AI techniques can help ICAR scientists to do their research more efficiently

Session Proceedings

The workshop was organized on July 30-31, 2018 involving different stakeholders to elicit their experiences and visions in the area of artificial intelligence to derive an action plan for implementation in agriculture. The detailed deliberation of the workshop is given in the following sections and chapters. The technical sessions were designed into several themes.



Inaugural Session

Sh. Amitabh Kant, CEO, NITI Aayog, Govt of India was the Chief Guest of the inaugural session. Dr Trilochan Mohapatra, Secretary DARE & DG, ICAR, Sh. Chhabilendra Roul, Special Secretary, DARE & Secretary, ICAR, and several DDGs and ADGs from ICAR graced the occasion.

At the outset, Dr Ch. Srinivasa Rao, Director, ICAR - NAARM, welcomed the chief guest, all the dignitaries and participants.

Sh. Amitabh Kant delivered the inaugural address and appreciated ICAR for taking up the initiative of deploying AI in agriculture. He emphasized that the required growth rate greatly depends upon the agricultural growth of the country. He further said that the agricultural growth cannot be increased substantially unless technology plays a vital role. AI has potential along with other technologies like IoT and mobile technology to enhance the productivity, cut losses and increase the farmers income. He said that this workshop is very timely and need of the hour. Based on the recommendations of the workshop, a concrete programme should be formulated which can take care of the need of small and marginal farmers. He stressed on value chains, price volatility and the agri-intelligence to help farmers to have better income and returns. He pointed out the key challenges being faced by farming community and the need for immediate intervention of latest technologies like AI, IoT etc.

Dr Trilochan Mohapatra, Secretary, DARE & DG, ICAR in his presidential address, called for collaborative research work to be carried out by the scientists of ICAR in the area of AI and other latest technologies like IoT, Deep Learning, etc. He expressed that a doable and implementable action plan need to be prepared along with cost effective solutions. He requested to deliberate upon the symbiosis and synergy between Indian Council of Agricultural Research knowledge base and the private sector to develop an Inter-Institutional framework in PPP mode which can deliver results within the time frame.

Mr. Chhabilendra Roul, Special Secretary, DARE & Secretary ICAR, emphasized on the integration of AI and IoT applications in agriculture. Multiple initiatives have been taken up in the area of ICT by the council, and these initiatives can be further enhanced by the application of AI, he added. He also mentioned that joint partnership between AI research labs with ICAR institutions will be the key factor to bring AI revolution in agriculture. He also proposed a formal vote of thanks at the end.

Dr L.M. Bhar, Director, ICAR-IASRI, presented an overview of the status of AI in agriculture. He gave a brief on the AI based initiatives being taken in ICAR. On this occasion, a Policy Brief on AI and IoT: Implications for human resources in Indian NARES, prepared by ICAR-NAARM, Hyderabad, was also released. About 150 delegates from various private organizations, software companies, IITs, Central Universities, Startups, various ICAR institutes participated and deliberated in the workshop.

Technical Sessions

The workshop was held in six technical sessions under three thematic areas viz.,

1) Emerging AI applications from industry

2) AI initiatives by ICAR institutes

3) AI initiatives from Academia

Thematic Area: Emerging AI applications from Industry

Technical Session – I

Chairman: Dr Trilochan Mohapatra, Secretary DARE & DG, ICAR and Co-Chaired by Dr K. Alagusundaram, Deputy Director General (Agricultural Engg. & NRM), ICAR, New Delhi.

Rapporteurs: Dr Sudeep Marwaha, Professor and Head, Division of Computer Applications, ICAR-IASRI, New Delhi

Presentations:

S.No	Title of the Talk	Name of the Speaker
1	Modernize with disruptive AI technologies	Mrs. Nandini P.V., Oracle India Pvt. Ltd., Gurugram
2	AI in precision agriculture	Mr. Mohit Bhasin, KPMG, Gurugram
3	Cognitive IoT in agriculture	Mr. Sanat Sarangi, TCS, Thane
4	Application of AI & remote sensing in Indian agriculture	Dr Jitendra Singh, IBM, Gurugram

Modernize with Disruptive Technologies - AI, Machine Learning, Intelligent Bots, Blockchain, and Internet of Things

Nandini P.V.
Oracle India Pvt. Ltd., Gurugram
nandini.p.v@oracle.com

The focus of the presentation is about how modern disruptive technologies are paving the way to modernize the existing business processes of agriculture domain across end-to-end value chain of agriculture business processes. The paper also explores Oracle's capabilities in IoT, AI, BI, Chatbot and blockchain which are powerful on their own, but transformational when combined to demonstrate the value to all key elements of agriculture domain. The capabilities of IoT, AI, and blockchain are so powerful that they require a shift in the way you run your business. Transformation is no longer a once-in-a-lifetime change, nor is it about simply adapting your organization to work with one new technology. In this new digital world, technological disruption has become a constant process of evolution, and only those that keep pace with the latest developments will succeed.

Innovative technologies have always enabled us to do new things. However, because they have generally come along in isolation, they have been easier to adopt and exploit. Now, multiple innovations are emerging at once—from IoT, Blockchain, AI, virtual and augmented reality, among others to transform agriculture domain.

To understand these three transformational technologies, it helps to think of them as interconnected organic processes. IoT is like your nervous system, sensing the world by collecting and transmitting data via billions of connected devices around the world. AI is like your brain, analyzing all of that data and using it to think and make decisions, or perform actions that only humans could previously carry out. Blockchain is like your memory, creating a secure, indelible record of transactions and data exchanges. Further, Chatbot provides enhanced AI driven user experience.

While they're highly powerful in their own right, when used together, IoT, AI, and blockchain become truly transformative. By harnessing all three, you can radically streamline and enhance existing processes. You can create new products and services for a generation of digitally experienced consumers and deliver impactful results to farmers. You can use insights to improve farmer income, consumer experience and make more-informed decisions. And you can drive your agriculture business to new levels of success.

Things to remember when preparing your business for transformational technologies:

- Focus on big three: IoT, AI, and blockchain
- Remember that cloud levels the playing field. You can't get there without it
- Understand that these technologies are underpinned by vast amounts of data. The AI-enabled Oracle Autonomous Database makes data management far simpler and more cost-effective

• Appreciate that embracing transformational technologies and realizing their full potential may require a change in business processes or models

• Remember that Oracle solutions allow you to integrate transformational technologies across the entire business suite, giving you the efficiency and agility

Getting There – Way Ahead

IoT: To realize the business benefits of IoT, the enterprise must:

- Build and adopt an ecosystem of IoT-enabled devices
- Source, store, and manage enormous amounts of data
- Adopt sophisticated analytics and machine learning capabilities
- Create new IoT applications that exploit data insights
- Integrate IoT into existing applications and workflows
- Deploy end-to-end security
- Monitor and manage the entire value chain

AI & Machine Learning: To exploit the true value of machine learning in the real world, the enterprise must:

- Recognize opportunities for enhanced intelligence within the business or supply chain
- Accumulate and store enormous amounts of data—both internal and external, structured and unstructured
- Attract and retain the right talent with the right skills to put machine learning to work
- Deeply integrate machine learning into applications both old and new
- Deploy it across multiple functions, rather than narrow use cases
- Apply it to existing infrastructure and capabilities, instead of starting from scratch
- Consider the ethical and moral questions regarding the scope of AI implementation

Blockchain: Barriers to blockchain adoption include:

- Cost and availability of compute resources
- Lack of regulation of blockchain miners
- Everyone who joins a blockchain network must agree to be bound by its rules
- Blockchain contracts are currently untested in court
- Blockchain must be integrated with existing systems of record
- Few current use cases offer compelling or immediate return on investment
- Traditional stakeholders remain risk-averse

<u>ChatBot</u>: Benefits of providing AI based ChatBot service to improve digital experience to users:

- Will help to improve their speed of services and reach out to farmers on channels they are most comfortable with.
- No need to install mobile apps, which are seeing a clear decline in usage. Chatbots are available anywhere, anytime. These are easy to use by today's digital citizens
- BOTs Insights on usage of BOTs, which region / locations are engaging with BOTs more, which channels (website or mobile app) are being used more, which queries are being asked more frequently, which queries are being unanswered so that the BOT can be trained appropriately, most popular user phrases, etc.

- Leveraging Chatbots can speed up interactions and reduce wait times for users by way of answering queries with complete accuracy, pulling knowledge instantly from a database, and freeing up valuable time of farmer and the call center executives, etc.
- Can help farmers get clarifications to their queries instantly from the knowledge base eliminating waiting times to talk to call center agents and providing self-service
- Provide 24/7 availability and high accessibility to farmers on their preferred channel, hence ensure stickiness and improved services

AI in Precision Agriculture

Mohit Bhasin
KPMG, Gurugram
mohitbhasin@kpmg.com

The presentation provides an insight on numerous IoT applications in farming such as collecting data on temperature, pest infection, and soil content, which can be used to take informed decisions. The key advantages of IoT over the traditional farming practices are increased farm productivity, better integration of the agriculture value chain, more accurate future outlook, and rapid product development initiatives from involved companies. However, there are certain disadvantages of IoT, such as high upfront investment, low awareness levels among farmers, adoption rates remain poor among developing economies. The structural impact explains the impact of the digital technologies such as robotics, drones, autonomous vehicles, IoT, connected devices, telematics, big data analytics, mobility, social, genomics, 3D printing on the agriculture business across the value chain such as agriculture inputs and equipment manufacturers, crop planning and preparation, farming/crop management, harvesting, animal husbandry, primary processing and storage, trading & primary logistics.

The paper emphasizes on the farming/crop management and harvesting as the low impact areas for the IoT and the major key activities covered via IoT in the agricultural activities. It also provides the insight regarding the economic impact of the IoT on the increased revenue for agro-input providers, enhanced food productivity for farmers while at the same time providing sustainable management of resources. Few of the industry solutions and case studies on IoT were provided by Monsanto's Field Scripts, My John Deere, Farmsight, COWLAR, Winfield Solutions, Dupont's Pioneer, etc. The case studies discussed in detail regarding the use of IoT in agriculture as weather forecast, smart drones, farming data, crowd sourcing, flee of agribots, soil sensors, autonomous tractors, and connected livestock. The other case study was COWLAR, which produces smart neck collars monitor dairy cows 24x7. Installation is seamless and only takes a minute. Designed to ensure no disruption on any farm operation, the rugged, waterproof and non-invasive monitoring system is comfortable for the cow to wear, and requires little to no maintenance. It can simply be strapped to a cow's neck and get actionable recommendations on how to increase milk yield, improve reproduction rates and detect illness early. All Cowlars communicate wirelessly with a solar powered base unit that has a two-mile range.

There were certain constraints for IoT in Indian agricultural scenario such as small and dispersed land holdings, complexity involved, scalability of implementation, affordability of IoT technology. The paper also raised concerns regarding privacy and security, availability of internet connectivity, low awareness about IoT devices and systems, lack of investment, issues regarding impact on environment, influence on human moral decision making. There is an opportunity wherein SAUs can be collaborated with technological institutes to obtain knowledge on IoT. The funds can be used to provide IoT facilities in research stations and KVKs. Training can be provided to ICAR research and technical staff on a pilot basis.

Cognitive IoT in Agriculture

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Internet of Things (IoT) refers to an interconnected web of sensor-based systems configured to interact with each other to meet specific objectives. Data generated from such systems and deep insights derived from this data to help take specific actions is what makes IoT cognitive. In 2006, Tata Consultancy Services (TCS) Innovation Labs, Mumbai developed a precision agriculture technology platform called mKRISHI® (m = mobile; krishi = agriculture) to offer personalized advisory services to farmers. Local-language mobile apps enabled farmers to send queries from anywhere, anytime, and receive personalized responses. Thus, mKRISHI® platform combined multiple technologies such as cellular networks, mid-range mobile handsets, remote sensing, and IoT to measure ambient conditions in order to help bring information regarding local weather, fertilizer requirement based on soil conditions, pest control, and current local market prices in a rich format to even low-end mobile handsets of the farmers. Farmers can also send crop images to experts for improved analysis and advisory.

Similarly, ICAR has been proactive in starting nation-wide initiatives for IoT in agriculture. For example, Moosense is a precision livestock management system developed as a part of the ICAR-NAIP initiative where numerous systems were deployed to understand animal behaviour such as a smart weighbridge that sends weight of the four limbs over a relay of wireless nodes, intelligent feed and fluid dispensing system based on precise needs of the animal, system for automated micro-climate control, and wearable devices for activity monitoring. For example, of how cognitive IoT can make a difference, activity monitoring was seen to make significant headway in (silent) heat detection of buffaloes which historically has been a challenge for the human eye.

It becomes useful to aggregate farmers having small and marginal land-holdings in India into collectives or their modern avatar, Farmer Producer Organization (FPO), to empower them with technology. The mKRISHI® platform, when injected into an FPO, converts it into a PRIDE (Progressive Rural Integrated Digital Enterprise) which is a vibrant digital entity connected to the agriculture ecosystem of input companies, post-harvest players, policy makers, and knowledge partners.

With PRIDE as a framework for scale-up of digital agriculture services across the country, IoT interventions in agriculture followed up. We successfully validated the Jhulsacast disease-forecast model for Potato Late Blight in collaboration with ICAR - CPRI (Central Potato Research Institute) with the help of ground-based sensors and mobile-based participatory sensing systems deployed by us. Over the years, such models usually hosted centrally on the cloud have become much more data-intensive with a continuous cycle of evolution. The edge of the IoT also presents an exciting cognitive landscape. We have worked on automatically identifying agricultural activities associated with Package of

Practices (PoP) through wearables. For example, we have characterised the hand-plucking activity in Tea which could be useful to impart training to workers help improve the quality of leaves picked.

For focused crop-specific health and growth studies with precise micro-climatic measurements, we have created demo farms to carry out comprehensive monitoring of various parameters below and above the ground. Low-cost solutions have been developed to measure critical parameters such as soil moisture which would help expand the reach of IoT to the farmers at large scale. The mKRISHI® platform started by offering agro-advisory services and dissemination of PoP to farmers. We added over time a layer of niche digital services called InteGra to bring sensors, computer vision, remote sensing, AI and other Industry 4.0 elements to bring about a transformation in agriculture. AI-based automated pest & disease recognition services from field scouted images and associated contextual information are proving useful for experts to help them issue the appropriate advisory to stakeholders. AI will continue to have a pervasive effect on the entire agriculture value chain from farm to fork re-imagining the delivery of services.

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Application of AI and Remote Sensing in Indian Agriculture

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'IBM Research' has been working in the area of applied agriculture research for last few years. We have developed a large geo-spatial data platform, best in class AI & ML capabilities, data collection and processing capabilities, access to hyperlocal weather data from The Weather Company (an IBM subsidiary), remote sensing data from multiple satellite systems, and IOT data as presented in the workshop. We would like to explore opportunities to collaborate in the area of precision agriculture. The field experience, data, and scientific knowledge of ICAR/IASRI can complement our technology capabilities in precision agriculture.

IBM's Precision Agriculture expertise is helping smallholder farmers to make precise field-level decisions across various stages of farming life-cycle. Also, the ability to monitor and track the overall food supply chain using IBM. Blockchain services can not only save food waste but enable food safety.

IBM has recently launched a "Decisions Platform for Agribusiness" that includes advisories and insights to help improve farming outcomes, and to enable organizations associated with the Agriculture and Food value chain to use data driven decisions.

Some of the key capabilities of this platform include:

1. A foundation for making better data driven decisions by ingesting, analyzing, and distributing high quality Agri-data in a deeply integrated manner
2. Best-in-class historical, current, forecast, and agriculture indices from The Weather Company®, an IBM Business
3. Ability to perform geospatial analytics that combines data, such as satellite imagery, weather data from farm equipments, soil sensors, and more, to furnish agricultural insights
4. Access to key Agri-Services. Ex: Yield prediction, pest and disease risk prediction, Crop health monitoring, soil moisture estimation, acreage estimation, etc.

Important Points Emerged from Session-I

- IoT applications have wide scope in managing cold storage and supply chain logistics for monitoring and product quality assurance
- Blockchain technology also have numerous use cases in tracking and tracing of agriculture commodities from farmers to consumers
- Machine Learning (ML) developer platforms help to automate ML & help decision science
- ICAR, SAUs and Industries can collaborate with technological expertise and create a new knowledge bank to improve agricultural productivity
- IoT and AI technologies, despite having initial set-up costs, can be beneficial in the long run and hence become profitable
- The areas of immediate applications of AI have been identified like real time soil moisture monitoring, pest & disease identification, surveillance & forecasting, crop area estimation through remote sensing, yield estimation of field and horticultural crops, livestock management, predictive maintenance of farm machinery,crop stress and field validation for confirmation of crop health, etc.

AI, IoT & BLOCKCHAIN TECHNOLOGY WOULD PROTECT FARMERS AND CONSUMERS THROUGH STRONG LOGISTICS, TRACEABILITY, REAL TIME APPLICATIONS AND SUPPLY CHAIN. ICAR, SAU & INDUSTRY NEED TO WORK IN COLLABORATION

Thematic Area: Emerging AI Applications from Industry

Technical Session – II

Chairman: Dr Ch. Srinivasa Rao, Director, ICAR – NAARM, Hyderabad

Rapporteurs: Dr Ranjit Kumar Paul, Scientist, ICAR-IASRI, New Delhi

Presentations :

S.No	Title of the Talk	Name of the Speaker
1	AI and its application in precision agriculture with special reference to drone technology	Dr V.K. Tewari, Professor, Department of Agricultural Food & Engineering, IIT, Kharagpur
2	Emerging research trends in cross language information retrieval	Dr S.K. Dwivedi, Prof. & Head, Dept. of Computer Science, Ambedkar University, Lucknow
3	Machine learning approaches and applications to precision agriculture	Dr Atul Negi, Professor, Department of Computer Sciences, University of Hyderabad, Hyderabad

AI and its Application in Precision Agriculture with special reference to Drone Technology

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Lot of work has been done at IIT, Kharagpur for the past 10 years in collaboration with various departments for development of instruments for agricultural use. This paper is oriented towards Application of Image Processing in Agriculture, and significant technologies developed and methodologies used are given below:

- Image processing is used for identifying ripening of pineapple
- Image processing is used for detection of disease in Paddy and use of sensor to spray chemical at appropriate location
- Harvesting robots have been developed with applications in agriculture
- Cotton harvest problem has been taken for picking up the cotton ball using image analysis and robotics
- There are many possible applications of drones in agriculture
  Drones are available in market but we are trying to make a drone with 50m radius (for small farm) with small payload of 500 gm only (weight 1.2kg) so that small farm can be covered. We are trying to make small size of drone so that farmer can take the photo and disease/infestation can be analyzed, and sprayed accordingly.
    - Drones can be used for crop spraying (pesticide, fertilizer and herbicides).
    - Health assessment of plant
    - Irrigation
    - Crop monitoring
- Identification of disease in crop at different stages using image processing.
- Machine has been developed for cutting sugarcane buds using image processing. This machine can cut 700 pieces of buds in one hour.
- Machines have been developed using robotics and image analysis for spraying of pesticides, fertilizers, insecticides, and the same was tested at university field.
- Working on technology/hardware on the soil sensors which can be monitored online and nutrient content of the soil can be measured.

Emerging Research Trends in Cross Language Information Retrieval

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Cross Language Information Retrieval(CLIR) has gained momentum in recent years due to its wide applicability and usages especially in India where different languages are spoken in different regions. Communications and transfer of valuable information to various stakeholders in agriculture especially to farmers would make it more productive for everyone.

Some of the recommendations are:

- A central specialised corpus for agricultural domain was developed which would be helpful for CLIR systems development
- Major thrust areas and domain within the broader agricultural umbrella be identified for designing CLIR systems
- Language pairs for Indian languages was identified where it is more beneficial to get the information in desired language. Further foreign languages may also be included to access information directly related to advancement in this field
- While initiating CLIR project in agriculture, main focus should be on using NLP based interface where information can be hassle free and easily accessed by normal persons/farmers. Online applications/real time translation systems will be of much use

Machine Learning Approaches and Applications to Precision Agriculture

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Expert Systems are useful AI tools for aiding several tasks of agricultural scientists. However, the knowledge acquisition bottleneck caused the failure of Expert Systems. Recently the accuracy of systems using machine learning increased dramatically by use of the Deep Learning (DL) systems. The success of DL systems was even surpassed by GANs (Generative Adversarial Networks). While conventional ANN are discriminative algorithms which map features to labels. Generative algorithms do the opposite and attempt to predict features given a certain label. A system can get better performance by pitting discriminative and generative models and training based on the competitive performance.

All ML models need high quality of labelled data. It is required that suitable data storage and retrieval methods are adopted to pick up data from the IoT sensors in the field, put the proper contextual information to the data like the location, date, time, etc., details and store with full annotation as to crop details, etc. Computer Vision problems are the core of the making productive agricultural robots to identify fruit, pests or weeds, etc. As there is a lack of sufficient data then the approaches of GANs as explained above are useful for generation of synthetic imagery. Solution of the crucial semantic segmentation problem is required for high accuracy of vision systems useful in agricultural applications. Recent literature (Computers and Electronics in Agriculture 151 (2018) 61–69) has shown useful work to crop yield prediction and nitrogen status estimation. In another work (Computers and Electronics in Agriculture 151 (2018) 376–383) big data and machine learning approaches have shown useful for crop protection. Some recommendations are given below:

- Build AI and ML systems for Indian agriculture systematic approaches to store, retrieve and share high quality labelled data are needed. Data storage and processing centres with GPU processing capabilities for Deep Learning approaches are needed. While commercial IT companies might be recommending to out-source these services over their cloud services, but, it may lead to leakage of data which may detrimental to the nation.
- A core research group of AI-ML researchers are looking to the progress of ML techniques and approaches so as to recommend appropriate methods and

techniques for application to Indian agriculture. As more powerful ML approaches like GANs, one shot and zero shot learning, etc., are being developed, their applicability to agriculture domain also must be developed.

- Roboticization of agriculture might be inevitable. Indian automotive sector can be approached to build suitable robots, drones, etc.
- Specific study on image database of pathologies, pests, insects, etc., with videos and high definition images has been made for the computer vision research where these elements are isolated from real world images captured from the fields. These must be segmented and labelled properly. Then, these images or videos might be provided to DL-GAN systems for building trained systems.
- It is very clear that successful modern agriculture practice needs highly trained educated practitioners, such as, in IT industry a young trained and educated work force is needed. Jobs in the application and use of agricultural technology are to be created with suitable salary incentives. Suitable exams, tests, practical exams, etc., may be conducted to choose such type of work force. The numbers and scale of growth of high tech agriculture engineer has to be matching or surpassing IT industry work force.

Important Points Emerged from Session-II

- The drone technology developed specially for farm need to be encouraged by funding for design and development of robot units for commercial production
- The robotic system need to be developed for various farm operations such as harvesting of cotton, sugarcane bud cutting & planting, fertigation and irrigation. Ultrasonic sensor based spraying system may be developed as field prototype and for commercial production
- There is a need to organize short courses in AI and IoT for one or two weeks for working agriculture scientists and engineers
- There is a need to collate and consolidate huge data available in a structured or defined manner from all the divisions of ICAR. Also, an opportunity may be explored to share the data publicly to encourage entities to explore the data and provide actionable solutions
- The sanitized and ground truth data can be shared publicly so that it can provide real data-points for upcoming start-ups to work on them and come up with actionable solutions
- Different bots are replacing mobile apps and simple command can trigger a series of instructions in the background aiding the user

CREATE AWARENESS THROUGH SHORT COURSES.

DEVELOP ROBOTICSYSTEMS AND DRONE TECHNOLOGY.

ENCOURAGE RESEARCH FUNDING FOR DESIGN &DEVELOPMENT

Thematic Area: Emerging AI Applications from Industry

Technical Session – III

Chairman: Dr Joy Krushna Jena, Deputy Director General (Fisheries Science & Animal Science), ICAR, New Delhi

Rapporteurs: Dr V. Ramasubramanian, Principal Scientist, ICAR-IASRI, New Delhi

Presentations :

S.No	Title of the Talk	Name of the Speaker
1	Blockchain and AI/ machine learning systems	Mr. Sachin Suri, CropData Technology Pvt. Ltd., Nagpur
2	IoT in Agriculture: Case studies on pest and disease forewarning models	Mr. Santhosh Sam Koshy, CDAC, Hyderabad
3	Reinventing agri-produce quality testing using AI	Mr. Saurabh Kumar, AgriCx Lab Pvt. Ltd., Mumbai
4	Use of AI in quality grading	Dr Unnikrishnan, A.R., NVIDIA, Bengaluru

Blockchain and AI/ Machine Learning Systems

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At CropData Inc., a well layered approach for products and services that connects to the farmers at the village level to marketplace is in place. In the buyer-seller conundrum, wherein the buyer has all the say and farmer is at the former's disposal. Hence, we stepped into help the farmers to get the right price for his produce. Because of our initiative at Punjab, a farmer's marketplace is in place, where our technician first interacts with the farmer and prepares a crop condition report. Thereafter, a contract agreement is signed followed by field verification, aggregation into lots. This is followed by online bidding connecting to markets all over. Once harvesting is over, the farmers deliver the produce and the payment is made at the logistic hub on the basis of expected income. The bottom most layer as the 'Farmer Last-mile Interface Layer' as the Primary Infrastructure called Dr KRISHI platform wherein extension services are provided by means of crop health diagnostic and advisory services, distress communication services, agriculture knowledge services and trust service for government benefits. Upon this layer, comes AG DATA platform for data analytics services for performing production and marketing analytics. Thereafter, the KRISHCO platform for doing verification and correspondence services with respect to crop conditions, banks and insurance companies, ATM services and advertisement services. The topmost layer is the AGRIOTA platform (as Buyer Interface Layer -the Secondary Infrastructure) for performing agricultural marketing services viz., electronic forward marketplace for unprocessed crop, electronic spot market and logistic services. Dr KRISHI platform of CropData secures farmer productivity by means of agriculture extension infrastructure and services, crop condition verification/ certification and monitoring, and also by specific and timely advisory to farmers. Blockchain has been weaved into AI/machine learning system for quantifying inherent risks, and enable farmers to remain directly connected to agricultural trading market place. Because the information is stored as Blockchain, everyone has a copy and hence, has end-to-end transparency. At the same time, they are secure and traceable.

CropData has integrated its data management system with AI based mathematical aggregate to manage various operations. CropData, thus, combines production security through extended KYC (last mile scientific verification) and crop protection advisory, with income security (online trading marketplace) with end-to-end transparency, neutrality and risk management. CropData aims at inverting the value chain by reversing the production driven market scenario to a demand driven one. Thus, the present regime with backward looking, producing before selling, short-term strategy, silo approach, chain inefficient features will be replaced with forward looking, selling before producing, long-term strategy, chain approach, chain optimized capabilities. The ultimate objective of CropData is to benefit the farmers and food processing industry with greater income, reduced inflation, better price discovery, better visibility and management of crop production and better relationship between government and farmer (F2F).

IoT in Agriculture: Case Studies on Pest and Disease Forewarning Models

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This paper introduces the concept of the Internet of Things (IoT) technology, and presents its applicability in agriculture domain. It also discusses various facets of IoT technology like key requirements and challenges of IoT, enabling technologies that make IoT a reality, etc. IoT enabling technology, Wireless Sensor Networks (WSN), under category of Remote Monitoring and Data Access which states that these networks may be configurable based on the wireless communication range required, according to the application domain. The paper concludes on IoT technology description with an overview of WSN and presents the general system architecture of a WSN, pertaining to the agriculture domain. It also presents the technical capabilities of CDAC, Hyderabad in this area, and lists out two applications that have been developed and deployed in the area of IoT in agriculture i.e., HARITA-PRIYA and IIOR-DSS. HARITA-PRIYA (Precision Technology for Agriculture) is a pilot study assigned to C-DAC to induct cutting-edge sensor-based technologies for:

- Real-time acquisition of micro-climatic data from farmers' field
- Timely assessment of crop condition
- Personalized agro-advisory services to the farmers

In this regard, C-DAC developed and deployed an IoT system for groundnut farmers in Anantapur district of Andhra Pradesh to forewarn the outbreak of Leaf Miner pest and Leaf Spot disease. Advisories were issued to the farmers in local language through SMS. 74 IoT nodes with five sensors each were deployed in five villages and in one KVK, covering 450 acres of groundnut farms of 710 farmers. IIOR-DSS is an attempt to develop a decision support system for castor graymold disease using IoT data as the source. Deployment is carried out in three villages and in research farm to aggregate on three parameters. i.e., temperature, relative humidity and leaf wetness from the fields. A decision support model is being developed based on the correlation of the weather parameters with disease incidence. SMS advisories will be issued to the farmers based on this model.

In conclusion, C-DAC has indigenously developed the IoT technology to interface multiple agriculture sensors, been and was field tested which was a robust mechanism for timely data generation. Further, C-DAC is very keen to work with agriculture researchers through small pilot projects through which key weather driven problems may be addressed. C-DAC is willing to support, work and hand hold organizations which are interested in undertaking research in the area of IoT in agriculture. Data is critical and key to any analytics application, whether AI based or ML based. Moreover, such data should be readily and timely available for long durations so that better models can be developed. C-DAC will be able to provide such data, based on the requirements of agriculture researchers so as to enable them to perform their research activities. Dissemination models should be developed to ensure personalized and localized advisories issued to farmers based on their crop challenges.

Reinventing Agri-produce Quality Testing using AI

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Across the supply chain of "agri-output," the grade and quality assessment is inefficient leading to inefficiency in pricing. The primary reason for the same is that there is no viable method to assess the quality of large quantities of agri produce available today.Moreover, whether it is a farmer, trader or a food producer, they all deal in large quantities of "agri-output. "Some of the generic problems faced in agri-produce supply chain are:

Archaic, manual and human intensive grade assessment model.

- Sometimes, the minimal sample size is tested at 0.1% of the total "agri-output" being purchased. Thus, rendering the assessment statistically inaccurate and prone to significant deviation in actuality
- Grading and sorting machinery are extensive and expensive, therefore, making adoption difficult
- Huge assaying load at the time of harvest and no method available today can handle the load
- Mostly quality assessment and rejection is done at the point of consumption where already the seller has made a significant investment in transporting the goods to the destination. (e.g., on an average Rs 70,000/- is spent on transporting truckload of potato from Indore to processing factories in Karnataka)

AI / ML models have significantly improved and automated the quality assaying of Agri Produce - Image processing models are used to detect following parameters:

- Automatically detect shape, size, color and visible defects from the image captured from Mobile camera
- Analyses spectral signature through AI model to determine chemical composition in the crop without any expert required to manage the process
- Miniaturized hyper spectral camera data processed by AI models to identify internal defects without destroying the sample

With the modernized models it is easy to achieve the following:

- Click the image of the sample and get results within 30 seconds
- A lot will be rejected or accepted automatically based on the threshold (set by the enterprise admin)
- Complete traceability on who graded, where, when and the reason for acceptance or rejection.
- Overall grade assessment of lot can happen under seven minutes (Productivity Gain)
- Better accuracy when compared to manual method (Improved Accuracy)
- Increase in sample size is possible due to low processing time, and making the process statistically more accurate
- Least amount of training required for the user to start using the application

Some recommendations for further improvement can be done on following lines:

- Creation of spectral signature database in NIR range esp. 400 to 1100 nm. AI models can be built around to detect chemicals with low cost device
- Support of new and novel innovations in use of AI in agriculture

Disruptive Possibilities with AI for Agriculture in India

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The paper explored in brief, the status and current adoption of AI and Deep Learning across industries, its applicability for agriculture research and in improving precision agriculture, discussed possible interventions that could apply for India and closed with specific recommendations that ICAR could take to enable disruptive possibilities with AI for agriculture in India. The following points were elaborated:

AI Revolutionizing Industry: The big bang of modern AI, was made possible by breakthrough of three fundamental things - combinations of all algorithms that came together in the Deep Learning approach; the enormous amount of data made available by mobile internet, and the discovery of using NVIDIA GPU computing to accelerate Deep Learning. The combination, which was set off during 2012, allowed computers to magically look at an image and determine what the important features are. It learns all the features hierarchically and represents information/knowledge by extracting it out from raw data all by itself. The ability to learn hierarchically and from raw data makes these deep neural networks robust, diverse, and with the ability to generalize enabling perception by sensing the real world, sensing the raw data. For the first time, a deep learning network was trained by data, but not coded by engineers, could do all this across domains.

Since 2012, a massive race of breakthroughs like recurrent neural networks, reinforcement learning, unsupervised learning, generative adversarial networks, etc., followed enabling path breaking capabilities and innovations like self-driving cars, self-tagging of photographs, video search, super human speech recognition, capability to train robots to translate vision to kinematics- for hand to eye co-ordination, ability to use auto encoders to enhance images, say to fill in the missing spots in an image or video, ability to do things like style transfers, generating voice, natural language translation to support true conversational AI, etc. Modern AI enables, 'automatically', straight to insight from any of the basic inputs like text, audio, image or video data to help address the foundational problems in any business or research problem, whether it is 'detection', 'classification', 'segmentation', 'prediction' and/or 'recommendation'. Applicability of AI is across domains; for any business or research domain, and is transforming and revolutionizing every industry. The stage is now set for the next stage of AI where computers are now able to automate programmes. Automation of Automation!

The New Computing Paradigm: Programming is about coding instruction. Deep Learning is about creating and training neural networks. The network can then be deployed in a data centre to infer, predict and classify from new data presented to it. Networks can also be deployed into intelligent devices like cameras, cars and robots to understand the world. With experiences, new data is collected further to train and refine the neural network.

Learnings from billions of devices make all the devices on the network more intelligent. The computing model that NVIDIA pioneered is at the convergence of visual computing, high performance computing, and AI technologies that will redefine the relationship between man and machine. NVIDIA's invention of GPU in 1999 sparked the growth of the PC gaming market, redefined modern computer graphics, and revolutionized parallel computing. NVIDIA is now leading the way in AI computing. As a new computing model, Deep Learning is changing how software is developed and how it runs. Deep Neural Networks will reap the benefits of both the exponential advance of GPU processing and large network effects, i.e., they will get smarter at a pace way faster than Moore's Law. Whereas the old computing model is "instruction processing" intensive, this new computing model requires massive "data processing". To advance every aspect of AI, NVIDIA has an end-to-end AI computing platform one architecture that spans training, inference and the billions of intelligent devices that are coming our way.

AI revolutionizing agriculture: AI enables precision agriculture to the next level, and will impact every aspect of agriculture from research to every stage like field preparation, planting and seeding, crop care, nutritional value upgrade of produce and harvesting to storage improvement, distribution, sales and marketing of the produce. AI will have significant impact on agricultural productivity at all levels of the value chain. It will help making new means of farming possible, shifting agriculture process from the traditional batch process to real-time process, enabling individualized at plant and soil level addressability, make the farm equipments automatic, smart and autonomous. AI enables the 'right input', the right 'amount', at the 'right time' and at the 'right place' to reduce the inputs and to maximize the yield. AI adoption and application is revolutionizing agriculture at an unprecedented pace already. Examples of interventions and innovations that are already in production use includes: agriculture robots use advance machine learning techniques to make decisions based on visual data about whether a plant has a pest, and then deliver an accurate, measured blast of chemical pesticides to tackle the unwanted pests; accurate prediction services that can with >99% accuracy; predict yield from satellite imagery data; robots that be trained to autonomously harvest sensitive crops without damaging the produce; use of agriculture drones with advanced sensors and digital imaging capabilities for real time monitoring of the farm for identifying irrigation problems; soil variation; pest and fungal infestations, and to assist in assessing crop growth and production, etc.

AI for agriculture in India: AI adoption across the value chain will not just help reduce exploitative dependence on resource intensive practices in India, but also help fight the vagaries and impact of increasingly unpredictable climate, help address and manage; with better predictability and monitoring, the variability in commodity prices arising out of globalized value chains and fluctuating agricultural growth rate. Given unique Indian conditions like smaller per farmer land holding, higher dependency on cereal crops, low gross cropped area under irrigation etc., India will have to adopt a differentiated approach to enabling AI enhanced precision farming techniques and leveraging it benefits. This could be a combination of co-operative, government supported, and public-private company partnership based interventions and initiatives. The outlook should be to enable the four core tenants: Data, Deep Learning Algorithms & AI services, Farm mechanization technology and equipments and skilling & reskilling of the farmers and agriculture researchers. In the immediate term itself, with minimal interventions and innovative public private enablement efforts, disruptive solutions can be realized to support areas like soil health monitoring and restoration, crop health monitoring and providing of real time action advisories to farmers that to with advanced local language based advisory to farmers using conversational AI, increasing the share of price realization to farmers, predictive analytics for reducing crop wastage, etc.

Important Points Emerged from Session-III

In this session, applied cases pertaining to specific AI problems were discussed by the industry. They presented the following real time applications which are in use, and has tremendous potential for scalability:

- Blockchain can be weaved into AI/machine learning system for quantifying inherent risks involved in farming and enable farmers to remain directly connected to agricultural trading market place. CropData Inc. has integrated its data management system with AI based mathematical aggregate to manage various operations in Haryana and Punjab
- C-DAC has used IoT based Wireless Sensor Network (WSN) for pest and disease forewarning and irrigation scheduling by monitoring various parameters like temperature, relative humidity etc.
- Intello labs has used IoT for digital grading of food like fruits, vegetables, spices etc. The devices will be useful if made at low cost and can be implemented with minimum infrastructure requirement covering wide geographical area
- AgriCx has developed a IoT based hyper spectral device called *AgriCx-Arc* to grade food quality enabling remote transaction and transparency thereby building trust between all stakeholders involved

BLOCK CHAIN, IOT, AI AND WIRELESS SENSOR NETWORKS TECHNOLOGIES FOR DATA INTEGRATION WITH MARKET, GRADING, CONSUMER CONFIDENCE BUILDING AND FARMING SURVEILLANCE

Thematic Area: AI Initiatives from ICAR

Technical Session IV

Chairman: Dr Ashok Kumar Singh, DDG (Agril. Extension), ICAR, New Delhi

Rapporteurs: Dr K.K. Chaturvedi, Senior Scientist, ICAR-IASRI, New Delhi

Presentations :

S.No	Title of the Talk	Name of the Speaker
1	Application of AI in agriculturewith specific reference to water management	Dr S.K. Ambast, Director, ICAR-IIWM, Bhubaneswar
2	Experiences of ICAR-NAARM in AI and IoT applications in agriculture	Dr S.K. Soam, Joint Director, ICAR-NAARM, Hyderabad
3	Use of AI techniques in agricultural water management	Dr Arjamadutta Sarangi, Principal Scientist, ICAR-IARI, New Delhi
4	E-Crop in IoT solutions for precision farming	Dr V.S. Santhosa Mithra, Principal Scientist, ICAR-CTCRI

Applications of Artificial Intelligence in Agriculture with specific reference to Water Management

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There is an immense potential for use of artificial neural networks in: (i) estimation of actual evapotranspiration and root zone soil moisture from satellite image derived hydrological parameters, (ii) delineation of waterlogged/ salt affected cropped land and economic losses due to it, and (iii) prediction of farmers' decision making, its impact on crop yield and improving land and water productivity in saline irrigated environment.

As water management in agriculture is the mandate of IIWM, AI applicability pertains to two broad areas of research: i) the sensor-based irrigation application, and ii) the theoretical framework to assess water resources. There is a need to develop IoT based automated irrigation system where sensors can be used to capture the soil moisture and temperature data, and based on that irrigation application can be developed. In addition to the standalone monitoring station, wireless sensor based monitoring system can be developed which is composed of number of wireless sensor nodes and a gateway. This system can provide a unique, wireless and easy solution with better spatial and temporal resolutions. In addition to employing technologies in monitoring agriculture for automating the irrigation system, there is a need for some intelligence which allows machines to apply it in interpreting agricultural data captured and accordingly analyze data towards predicting the output rather than following traditional rule based algorithm. So, towards this, 'machine learning' -a part of AI plays a key role which allows devices to learn without being explicitly programmed. Machine Learning has also got its applications in crop selection and yield estimation where many effective machine algorithms identify the input and accordingly output the relationship in crop selection yielding the approximated prediction. AI's application for groundwater resource management is worth investigation, given the scarce availability of data, even at the global scale. Moreover, physical-based numerical modelling of groundwater is difficult because of the complex interaction of input variables, such as weather and aquifer parameters. Among the available AI tools on water resource management, our focus will be on ANN, Support Vector Machine (SVM), and wavelet-based modelling and forecasting, so also on their hybrids, for example, the wavelet-artificial neural network (WA-ANN) and Wavelet-Support Vector Regression (WA-SVR). Moreover, AI tools have been successfully used to downscale NASA's Gravity Recovery and Climate Experiment (GRACE) records at management scale, which needs to be implemented in India. Thus, there is enormous scope of applications of AI in agriculture, particularly in benchmarking system performance, resource management, farmers' decision making and improving land/ water productivity. Moreover, sensor-based automated irrigation systems should be developed using IoT technologies.

Experiences of ICAR-NAARM in AI and IoT Applications in Agriculture

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The ICAR-National Academy of Agricultural Research Management (NAARM), Hyderabad has done following activities related to AI and IoT in agriculture:

- January 2018: Inclusion of two sessions in a training programme
- March-April 2018: Questionnaire survey with about 200 trainees at NAARM
- May 2018: Literature and databases search; Observations at Australia/ New Zealand
- June 2018: Conducting a two-day National Dialogue
- July 2018: Writing a policy brief

In questionnaire survey with newly recruited agricultural scientists, it was found that 37% of respondents felt that these AI and IoT can be used for prediction services.

Type of Service	No of Ideas	%
Prescriptive Service	22	23%
Advisory Service	21	22%
Prediction Service	36	37%
Diagnostic Service	18	19%

Through literature survey, few useful applications have been identified, which can be incorporated by ICAR scientists in their R&D agenda. The empirical study from NAARM found that the research publications and citations have been increasing tremendously in last two-three years.

Plantix	Merlin Bird ID	TensorFlow	Agribotix
PlantNet	iNaturalist	CropIN	Daisy
PictureThis	ripeSense	YUKTIX	SmartFarms, smartAMCU,
Merlin Bird ID	CCMobile App-(ConnectedCrops)	ROXAN	ConTrak, AgRupay, MooKare

Use of AI Techniques in Agricultural Water Management

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Artificial Intelligence (AI) is a way of making a computer, a computer-controlled robot, or a software think intelligently in the similar manner the intelligent humans think. Moreover, AI tools emulate the cognitive response of human thinking process. In order to implement the AI enabled protocols, there is a requirement of data which can be termed as the response of human behaviour in taking up any activity. In agriculture, the AI tools can be applied to different activities *viz.* precision farming with variable rate fertilizer and irrigation applications, robotics in agriculture, predictive agriculture pertaining to sowing of seeds and targeting different diseases and pests, etc.; soil and crop monitoring using big data analysis and IoT; climate smart agriculture and supply chain analysis, etc. Further, these tools are also applied in judicious agricultural water management both at field and watershed scales. Different tools used in hydrology and water management are ANN (Artificial Neural Network), ANFIS (Adaptive Fuzzy Inference System), MARS (Multivariate Adaptive Regression Splines), SA (Simulated Annealing) and GA (Genetic Algorithm), etc. ANN tools are used for estimation of surface runoff from rainfall events in a watershed system. ANN models are developed using the observed data of rainfall and runoff from watersheds by following the training, testing and validation procedures.

It was observed that by use of ANN and by incorporating a few watershed morphological parameters, the geomorphology based ANN predicted the surface runoff with coefficient of determination (R^2) ranging from 0.8 to 0.9 as compared to the regression models with R^2 of 0.65 to 0.8. Also, ANN models with minimal data input performed on par with process based models *viz.* SALTMOD, which require more input data in simulating the drainage water quantity and quality parameters under sub surface drained agricultural fields. Besides this, the ANN models are also being used for estimation of actual evapotranspiration for wheat crop using meteorological parameter of an observatory. Further, the ANN model is being used for prediction of grain yield under varying fertilizer and irrigation regimes using the experiment generated data. The MARS is used for identifying the most sensitive parameters for use as input to ANN tools in surface runoff predictions. The ANFIS model is being used in prediction of yield of greenhouse rose. Nonetheless, AI tools can be used for irrigation scheduling pertaining to different crops under varying methods of irrigation. Subsequently, AI programmes can be incorporated in the microcontroller of soil moisture sensing devices to automate the irrigation scheduling activity. The VRI (Variable Rate Irrigation) module in the precision farming can be modelled using ANN for judicious application of irrigation water. The AI tool can be used as an image recognition, interpretation and analysis tools in different DEMs with geo-spatial tagging for irrigation water management. Crop yield and water productivity can be modelled using AI techniques with minimal data. Different interfaces in GIS and mobile phone applications can be developed for assisting the stakeholders on getting information of good agricultural practices besides real time solutions to different problems using the background generic data base, heuristics, models and expert logic.

Electronic Crop (e-Crop) an IoT Solutions for Precision Farming

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e-Crop is a revolutionary IoT technology developed by ICAR-CTCRI that empowers the present day farmers with a high crop yield at a very low cost of investment, irrespective of its area of cultivation. It is a single point solution for many problems in agriculture. The main advantage of this IoT device is that it retrieves real-time information about the various soil and weather parameters for analysis, and thereby, giving the respective farmer with precise advisory.

Problems solved by e-Crop:

- e-Crop helps to achieve higher productivity by reducing yield gap. This product daily calculates plot by plot yield gap and quantifies, N, P, K, water requirement and other management strategies for efficient input uses. Also send this information to owner of the plots daily as SMS
- Through the daily/frequent application of nutrients and water, its total requirement for the entire season is less (About 25-50% reduction) whereas yield increase at least by 100%
- Reduced application of the chemicals and water save resources and minimizes damage to environment
- Farmers' profit multiplies by yield increase as well as by the lowering of cost of cultivation
- e-Crop predicts crop's yield, plot by plot using the weather and soil data of individual fields
- The forecasts sent by the e-Crop devices from different fields can be pooled automatically to obtain yield prediction at national/state/regional-level for different times in future with very high level of accuracy. This is an alternate and better solution for present day yield forecasting which is being done using crop cutting experiments at 8500 locations across the nation
- Predictions by pest and disease models installed in e-Crop are more accurate because the predictions are based on the microclimatic data and this helps in better pest and disease control
- The adaptability of e-Crop can be extended to other crops, pests/diseases, etc., by forming a workgroup to achieve this task. Efforts are already on towards reach this goal.

Important Points Emerged from Session-IV

- Capacity building initiatives to sensitize and enhance the skills in the field of AI & IoT in agriculture are to be taken in a mission mode. A critical mass of scientists/researchers can be trained abroad in the identified universities/ organizations in the group of four or five scientists from each organization working in the area of AI and IoT including data management and curation
- CTCRI has developed a device that estimates potential yield at the field level. IoT based crop simulation models were used for developing 'electronic crop' devices that simulate crop growth in real-time, in response to weather and soil parameters data collected through sensors
- Creating an AI cell in ICAR to work as national level nodal point, which can facilitate collaborations, networks, training and monitoring of AI & IOT projects.Earmarking of committed funds for basic and applied research in the area of AI and IoT as a prioritized subject domain, and research projects are to be initiated
- Development of algorithms/process/ models need to be initiated which are having direct application of modern tools of AI and machine learning models in agriculture
- Custom hiring of farm equipment through mobile app (like Uber for Taxi) may be developed for enabling small farmers to make the proper use of equipment on sharing basis rather than purchasing the same
- ANN based applications have been explored in various problem domains of integrated water management system like:(i) estimation of actual evapotranspiration and root zone soil moisture from satellite image derived hydrological parameters, (ii) delineation of waterlogged/ salt affected cropped land and economic losses, and (iii) prediction of farmers' decision making, its impact on crop yield and improving land and water productivity in saline irrigated environment
- System/ developed models need to be strengthened for applicability at the farm levels efficient drainage effluent salinity, root zone salinity, crop evapo-transpiration, hydrology and irrigation scheduling in green houses

EFFECTIVE USE OF AI TECHNOLOGIES DEVELOPED BY NARS. IDENTIFY INNOVATIVE APPLICATIONS LIKE UBER TAXI SERVICES/NRM/PREDICTION SERVICES/MICRO-LEVEL FIELD PLANNING. EARMARKING COMMITTED FUNDS FOR AI RESEARCH AND MODELLING

Thematic Area: AI Initiatives from Academia

Technical Session - V

Chairman: Dr S.K. Ambast, Director, ICAR-IIWM, Bhubaneswar

Rapporteurs: Dr Soumen Pal, Scientist, ICAR-IASRI

Presentations :

S.No	Title of the Talk	Name of the Speaker
1	Deep learning and its applications	Dr Aditya Nigam, Assistant Professor, IIT, Mandi
2	Recommender system and Blockchain technology	Dr Punam Bedi, Professor, Dept. of Computer Science, University of Delhi, New Delhi
3	Towards building a smart system to empower a farmer to diagnose farm problems	Dr P. Krishna Reddy, Professor, IIIT, Hyderabad

Deep Learning and its Applications

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Due to the recent drift of technology and enhanced computation power (using GPU's) this new paradigm of deep learning based architectures got extensively explored. These architectures have been exploited by all communities to solve almost all types of computer vision as well as image processing problems. Algorithms have to be implemented over GPU enabled systems, so as to be optimized over very high dimensional parametric space.

Recently, in all top-tier conferences like CVPR, ECCV, ICCV, NIPS, ICLR huge amount of work has been presented to exploit the power of CNN, RNN, Auto encoders, GANS and other related deep learning architecture to solve problem in the domain of Computer Vision, Image Processing, Speech Processing, NLP etc. This will be a practical oriented workshop which will cover extensive hands-on sessions on Deep Learning.

Deep Learning has huge amount of impact on Computer Vision and its related applications in various fields such as medical imaging, biometrics and even agriculture. During the session we have discussed about the following things:

1. Basics of neural networks and the intuition towards classification
2. Introduction of convolutional neural network
3. Basics of object detection using CNN, RCNN and FRCNN
4. Finally, we have discussed few deep learning applications for agriculture such as crop and yield detection and estimations using the above techniques

Recommender System and Blockchain Technology

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The trend of defining Artificial Intelligence (AI) or using it to get work done is changing day by day. Initially, it was more of making the machines to do the work which humans do better. But, now the idea is changing towards utilizing the machines do some work intelligently better than humans. Recommender Systems (RS) are one such attempts to choose the best alternatives among potentially overwhelming choices where humans mostly get confused due to information overload. Recommender systems are defined as intelligent applications that provide assistance to users by giving personalized product recommendation based on user's preferences. These systems use the opinions of members of a community to help individuals in that community, by identifying information most likely to be interesting to them or relevant to their needs. It uses a function to find the relevance score used for ranking the relevant items for recommendation given user model (e.g. user's ratings, preferences, demographics, situational context) and items (with or without description of item characteristics). These systems are different from Information Retrieval (IR) systems in a way such that users do not know what he is exactly looking for rather seeing the product might feel that this is interesting while in case of IR systems user knows what is he actually asking for. Conventionally, there are four types of Recommender Systems such as Content-based, Collaborative Filtering (CF), Knowledge-based, and Hybrid. Collaborative system uses the taste and preferences of similar or like-minded people in the community. CF uses either neighbourhood methods or model based methods. In Content based filtering method,users are recommended with products which the user have liked in the past. In knowledge-based RS, products that fit based on the needs or the requirements of the user are recommended. Hybrid RS uses the combination of various techniques. Various evaluation measures for the traditional recommender systems are precision, recall and F-measure.

Major challenges in Recommender Systems are sparsity which is having very few product ratings or very few users registered with the system. Another problem is cold start which refers to the situation when a new user or new product has just entered the system, and there is no prior information about the product is available in the system. Scalability issue is also there as the rating of database grows, the performance decreases. One of the major problems is privacy of the user. It is a major future challenge to develop RS using privacy protected data. Several other prospects of the RS have also been reviewed so far in several research works which talks of trust and the distrust of the user on the system. Semantically enhanced RS using ontologies can also be developed for generating better recommendations.

Towards Building a Smart System to Empower a Farmer to Diagnose Farm Problems

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Information technology based agricultural knowledge delivery systems developed over last two decades can be categorized as pull-, push- and hybrid systems. The pull-based systems assume that the farmers and other stakeholders pull the information. Call centres and several web portals come under this category. However, the experience shows that the majority of poor and marginal farmers were not covered by such systems as farmers are unable to pull the actionable agricultural information from such systems due to low knowledge levels, communication gap and perceptual problems. The push-based systems vary with respect to the degree of generalisation to personalization. The radio, video, proactive SMS- and voice-based services push generic information to farmers. The eSagu system (Here, the word `*Sagu*' means `Cultivation' in Telugu language) which is being developed at IIIT, Hyderabad can be considered as a "personalized farm-specific push-based system" with the feedback. In eSagu, agricultural experts generate expert agro-advice based on the latest information about the crop situation received in the form of both digital photographs and text. The scientific agro-advice is provided to every farm (or field) at regular intervals, i.e., once in every ten days from sowing to harvesting. Since 2004, the expert advice has been delivered to thousands of farms of several crops at different places in India. The impact studies show that the farmers have realized considerable monetary benefits by reducing the quantity of fertilizer application, number of pesticide sprays, besides getting the additional yield. There are scalability issues with farm-specific eSagu system.

By combining the merits of push- and pull-based systems, effort has been made to develop a hybrid system called, "location-specific eSagu system". In this system, a sample number of farms are selected for each major crop of a location (a group of villages). The agricultural experts provide expert advice to these farms at regular intervals based on photographs and text. The expert advice is made available to all the farmers in the village by displaying colour printed sheets of both photographs and advice text on the notice boards in the corresponding villages. The implementation results show that, in addition to reducing input costs and improving crop productivity, the system is also enabling community discussion and knowledge sharing/empowerment.The experiences of "Location-specific eSagu system" show that farmers are suffering from knowledge gap and communication gap and requires further help in converting location-specific knowledge into farm-specific knowledge in a timely manner. Motivated by the experience and observations of eSagu developments, we have started research (funded by India – Japan Joint Research Laboratory Program) to develop a framework to empower farmers to diagnose crop problems by enabling the farmer to ask a question for his/her crop problem and get the solution. It can be noted that the next generation farmers will have a smart-phone with Internet connection. After seeing the crop problem, the proposed "Smartphone-based Farm Problem Diagnosis App", could guide the farmer to pose the corresponding question and get the answer. As a result, every farmer is empowered to access farm-specific actionable knowledge and increased number of farmers will be covered as they could pull actionable timely knowledge whenever required.

Important Points Emerged from Session-V

Some of the applications developed as use cases by using AI applications in academia are listed below:

- An extension to the village-level e-platform named eSagu, has been developed as a scalable personalized system

- Recommender System can be used for increasing the adoption rate of the agricultural technologies among farmers, precision farming for optimizing farm inputs, thereby, resulting in increase in crop yield and income. The potential of Recommender System was also highlighted for market price prediction of the agricultural commodities

- Deep Learning algorithm can be useful for the farmers in taking decisions on optimal land and crop allocation in a cluster based on the market demand and price

DEVELOPING SCALABLE PERSONALIZED SYSTEMS, RECOMMENDER SYSTEMS AND DEEP LEARNING ALGORITHM FOR FARMING INPUTS DECISIONS AND MARKET PRICE PREDICTION

Thematic Area: AI Initiatives from Academia

Technical Session - VI

Chairman: Dr P.S. Pandey, ADG (EP&HS), Education Division, ICAR, New Delhi.

Rapporteur: Dr Alka Arora, Principal Scientist, ICAR-IASRI, New Delhi

Presentations :

S.No	Title of the Talk	Name of the Speaker
1	IoT and AI in agriculture	Mr. Satyajit Dwivedi, SAS, New Delhi
2	Natural language processing in agriculture: Scenario and challenges	Mr. Karunesh Arora, C-DAC, Noida

IoT and AI in Agriculture: Capabilities and Applications

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Traditional Analytics Approach is not enough to handle sensor data, drones' data and things like robotic automation. IoT data provides a big opportunity for application of advance analytics concepts of Artificial Intelligence and Machine Learning. Following are major points of discussion:

- Artificial Intelligence is the science of training systems to emulate human tasks through learning and automation. A subset of AI is Machine Learning and a subset of machine learning is deep learning which is used to reduce the preprocessing time (requirement for feature extraction in classical ML) for building applications around image classification and video classification but it is important to demystify the definitions
- Evolution of Artificial Intelligence started in the 1950's when neural networks were introduced. But now it has evolved into deep learning. However, the need of data is paramount for AI, ML and Deep Learning
- With the availability of more computing power at a cheaper cost and large IoT datasets, it is possible to build more complex models with better algorithms. This is Deep Learning
- Also, with the emergence of streaming analytics capabilities most of the AI / ML algorithms for specific use cases needs to be deployed in the edge devices
- Therefore, it is important to look at enterprise analytics application-based solution approach in the design process or any test bed modeling. The outcome of the deployment of Artificial Intelligence can be integrated in three ways.
    - Advisory output to agriculture scientists
    - Conversational systems (such as chatbot) that can provide expert advice to farmers / maintenance staff
    - Control Level Integration (adjust parameters directly such as controllers, set points in canal automation, agriculture field pump operation)
- The advent of AI / ML and Streaming Analytics capabilities have brought out a plethora of applications of AI possible in the field of agriculture
    - Soil condition monitoring, irrigation requirement, precision agriculture
    - Canal surveillance, crop yield prediction / vegetation damage assessment / pesticide control
    - Canal automation water demand forecasting, gate operations
    - Predictive maintenance of tillers, tractors, irrigation pumps
    - Livestock counting, tracking and tracing, body condition identification
    - Chatbots for farmers advise, engineering maintenance advise, pest control
- The capabilities of Deep Learning methods for video analytics, image classification, forecasting and the need of a robust central platform for AI innovation at IASRI were presented.

Natural Language Processing in Agriculture: Scenario and Challenges

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India is a multi-lingual and multi-cultural country. The penetration of English in various domains and specially in agriculture is very low (< 10%). Information these days has become a commodity and can be said that it is the right of a human to have information in his or her language.

Lot of content is not reaching the desired people due to lack of human-resource to convert it to the language of the user to ensure its end use. This gap can only be filled through the use of Language Technology which makes use of AI and Machine Learning approaches. Speech Recognition, Speech Synthesis, Machine Translation, Sentiment Analysis, Text Summarization, Optical Character Recognition, Chatbot based Question-Answering, etc., are some of the technologies that transform this need into reality.

Some of the applications, which need focus, are given below:

- Customization and development of machine translation to enable generation of local language extension and proliferation material
- Speech-based interfaces to access information through mobile apps and web
- Speech-based access of weather forecast, mandi rates and other information
- Indian language chatbots to answer agriculture-related queries
- Query submission in spoken form which can be answered by experts later
- Indian language sub-titling of e-learning material and development of e-Learning material in local languages
- Facilitating experts to make use of tools and systems for converting their answers in local languages
- Aggregation of various knowledge resources with a single point access

Important Points Emerged from Session-VI

- Natural Language Processing (NLP) making use of AI and ML approaches can effectively be used in the areas of Speech Recognition, Speech Synthesis, Machine Translation, Sentiment Analysis, Text Summarization, Optical Character Recognition, e-learning, Chatbot based Question-Answering, etc., to address the multi-lingual and multi-cultural issues of the country in disseminating information
- Aggregation of various knowledge resources with a single point access may be addressed
- The following resources need to be developed to address above mentioned problems, and can be developed in collaborative manner
  - Term banks (Terminologies/Vocabularies/dictionaries) for agriculture domain and sub-domains in Indian languages
  - Parallel corpus and translation memories (Sentence-level translated pairs) in huge quantity
  - Phonetic dictionary of agriculture domain terms for adaptation of speech based systems
  - Collection and compilation of audio and corresponding texts of agriculture-specific programmes from All India Radio and *Kisan* Channel
  - Listing of all scattered knowledge resources and establishing a framework for accumulating these resources in incremental fashion
- With the emergence of streaming analytics capabilities, most of the AI / ML algorithms for specific use cases needs to be deployed in the edge devices. The outcome of the deployment of Artificial Intelligence can be integrated in farm advisory, conversational systems (such as chatbots) and control level integration

AGGREGATION OF KNOWLEDGE RESOURCES, CHATBOTS, OCR, TEXT CONVERSION THROUGH NLP. TERM BANKS AND PHONETIC DICTIONARY. COMPILATION OF AUDIO TO TEXT FROM RADIO AND *KISAAN* CHANNEL AUDIO. LIVE STREAMING OF FARMING ADVISORY USING AI

Plenary Session and Recommendations

Chairman: Dr Trilochan Mohapatra, Secretary, DARE & DG, ICAR

Rapporteur: Dr Dwijesh Chandra Mishra, Scientist, ICAR-IASRI

Sh. Chhabilendra Roul, Special Secretary, DARE & Secretary ICAR, Dr Joykrushna Jena, Deputy Director General (Fisheries Science & Animal Science), ICAR were also present during the plenary session. Dr Sudeep Marwaha, Professor and Head, Division of Computer Applications, ICAR-IASRI presented an overview of the deliberations of the workshop and communiqué to the panel assembled. The communiqué was an outcome of the discussions during the workshop.

Recommendations from the Workshop

During the Plenary session, the following recommendations and suggestions were emerged:

- Agriculture being a complex and multi-featured sector, synergy is required between public and private sector to deliver the required farming solutions through new AI applications/ devices/algorithms. AI to be used not only for quality production, but also for the improved input use efficiency, post-harvest operations, product traceability, technology transfer and marketing support through logistics and supply chain management
- Skilled manpower is required on various latest AI technologies like deep learning, block chain, machine learning, natural language processing, image analysis, ontology development, expert systems, forewarning systems, etc. Capacity building initiatives to sensitize and enhance the skills in the field of AI & IoT in agriculture is to be undertaken on a mission mode to develop sizeable trained scientists/researchers
- ICAR institutes have captured meta data that warrants suitable integration and adequate storage at a central place
- Several ICAR institutes have shown their capabilities in AI applications through development of devices for precision agriculture/ high input use efficiency, solving farming problems. Therefore, mechanisms should be explored to develop projects in PPP mode with well-defined targets and outcomes
- Multiple crops/commodities based joint projects must be developed in various areas of AI/IoT under a central network project/Scheme so that the integration of the developed tools can be made possible and an ecosystem of AI based agriculture can be constructed. The projects should include public IT organizations and universities along with private partners and FPOs
- Multi-lingual information and knowledge delivery for reaching out to all farmers of the country can be achieved by integrating the transliteration and translation tools,

text to speech and speech to text technologies, chatbots, etc., in all the official Indian languages. If required, the existing technologies may further be enhanced/ customized to meet the requirement of agriculture domain

- Earmarking of committed funds for basic and applied research in the area of AI and IoT as a prioritized commodity/subject domain, and research projects are to be initiated
- ANN-based applications have been explored in various problem domains of integrated water management system like: (i) estimation of actual evapotranspiration and root zone soil moisture from satellite image derived hydrological parameters, (ii) delineation of waterlogged/ salt affected cropped land and economic losses, and (iii) prediction of farmers' decision making, its impact on crop yield and improving land and water productivity in saline irrigated environment. The AI has good potential in conservation agriculture also.

Recommendations by Sh. Chhabilendra Roul, Special Secretary, DARE and Secretary, ICAR

- Need of the public-private partnerships in identifying specific gap areas to remove the hiccups while introducing the AI in agriculture research and information dissemination
- There is a need to collate and consolidate huge data available in a structured or defined manner from all the divisions of ICAR. Also, an opportunity may be explored to share the data publically to encourage entities for exploring the data and provide actionable solutions

Recommendations by Dr Trilochan Mohapatra, Secretary, DARE and DG, ICAR

- Strengthen the capacity building mechanism by collaborating with universities and leveraging potential Ph.D. students; organize regular national and international trainings and workshops; encourage public private partnerships and collaborations for introducing technological advancements; centralized data/knowledge management and deployment; interoperability of various systems developed by ICAR institutes and enhancing the features and adaptability of the ICAR institutes' websites and systems
- ICAR institutes should identify 4-5 problems in agriculture which can be addressed using AI. Eventually, the developed AI applications should be validated at different locations
- A Centre of Excellence with four sub-centres on 'Application of AI in Agriculture' should be established at five different locations (East, West, North, South and Centre) of India. Prioritize AI applications in terms of importance and feasibility of implementation
- A working group should be formed for each problem consisting of various persons working with the sub-parts of the problem so that they can be integrated smoothly

Researchable Issues

It was suggested that ICAR institutes should identify 4-5 problems in agriculture which can be addressed using AI. Eventually, the developed AI applications should be validated at different locations. Following are few identified areas to start with:

- Real time soil moisture monitoring, pest & disease identification, surveillance & forecasting, crop area estimation through remote sensing, yield estimation of field and horticultural crops, livestock management, predictive maintenance of farm machinery, crop stress and field validation for confirmation of crop health, etc.
- Blockchain technology for tracking and tracing of agricultural commodities from farmers to consumers. IoT applications have wide scope in managing cold storage and supply chain logistics for monitoring and product quality assurance.
- Developing Robotic system for various farm operations such as harvesting of cotton, sugarcane bud cutting and planting, fertigation, irrigation. Ultrasonic sensor based spraying system may be developed as field prototype and for commercial production.
- Developing IoT based Wireless Sensor Network (WSN) for pest and disease forewarning and irrigation scheduling by monitoring various parameters like temperature, relative humidity etc.
- Digital grading of food grains, fruits, vegetables, spices etc. The devices will be useful if made at low cost and could be implemented with minimum infrastructural requirement covering wide geographical area.
- Developing algorithms / process / models which have direct application of modern tools of AI and machine learning in agriculture.
- Custom hiring applications of farm equipment through mobile app (like Uber for Taxi) for enabling small farmers to make the proper use of equipment on sharing basis rather than purchasing the same.
- Exploring various problem domains of integrated water management system like: (i) estimation of actual evapotranspiration and root zone soil moisture from satellite image derived hydrological parameters, (ii) delineation of waterlogged/ salt affected cropped land and economic losses, and (iii) prediction of farmers' decision making, its impact on crop yield and improving land and water productivity in saline irrigated environment.
- Developing models for applicability at the farm level efficient drainage affluent system, root zone salinity, crop evapo-transpiration, hydrology and irrigation scheduling in green houses.
- Creating term banks (Terminologies/Vocabularies/Dictionaries) for agriculture domain and sub-domains in Indian languages; working for development of phonetic dictionary of agriculture domain terms for adaptation of speech based systems.
- Listing of all scattered knowledge resources and establishing a framework for accumulating these resources in incremental fashion.

List of Delegates

Sl. No.	Name	Designation & Affiliation
1.	Sh. Amitabh Kant	CEO, NITI Aayog, New Delhi
2.	Dr Trilochan Mohapatra	Secretary (DARE) & Director General, ICAR, New Delhi
3.	Sh. Chhabilendra Roul	Special Secretary (DARE) & Secretary (ICAR) , New Delhi
4.	Dr Anand Kumar Singh	Deputy Director General (Horticulture) & Deputy Director General (CS)/ Acting, ICAR, New Delhi
5.	Dr K. Alagusundaram	Deputy Director General (Engineering) & Deputy Director General (NRM)/Acting, ICAR, New Delhi
6.	Dr Joy Krushna Jena	Deputy Director General (Fisheries)& Deputy Director General (AS)/Acting, ICAR, New Delhi
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9.	Dr P.S. Pandey	Assistant Director General (EP&HS), ICAR, KAB-II, New Delhi
10.	Dr S.K. Ambast	Director, IIWM, Bhubaneswar
11.	Dr S.K. Soam	Joint Director (I/c), ICAR-NAARM, Hyderabad
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23.	Dr Nachiket Kotwaliwale	Head, APPD, ICAR-CIAE, Bhopal

24.	Dr C.D. Singh	Principal Scientist, ICAR-CIAE, Bhopal
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30.	Dr K. Viswanatha Reddy	Scientist, ICAR-CTRI, Rajahmundry
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41.	Dr S.K. Malik	Principal Scientist, ICAR-HQ, New Delhi
42.	Dr A. Arunachalam	Principal Scientist, ICAR-HQ, New Delhi
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44.	Dr Niranjan Singh	Scientist, ICAR-NCIPM, New Delhi
45.	Dr Rupasi Tiwari	Principal Scientist, ICAR-IVRI, Bareilly
46.	Dr S. Mohanty	Principal Scientist, ICAR-IIWM, Bhubaneswar
47.	Dr Dilip K. Panda	Principal Scientist, ICAR-IIWM, Bhubaneswar
48.	Sh. N.P. Singh	ICAR-HQ, New Delhi
49.	Dr S.S. Lathwal	ICAR-NDRI, Karnal
50.	Dr K.P. Suresh	ICAR-NIVEDI, Bangalore
51.	Dr Amrender Kumar	Principal Scientist, ICAR-IARI, New Delhi
52.	Sh. Bonick Cherian	M/o Skill Development and Entrepreneurship
53.	Dr Seema Jaggi	Principal Scientist and Head(A), ICAR-IASRI, New Delhi

54.	Dr Rajender Parsad	Principal Scientist, ICAR-IASRI, New Delhi
55.	Dr Cini Varghese	Principal Scientist, ICAR-IASRI, New Delhi
56.	Dr Susheel Kumar Sarkar	Scientist, ICAR-IASRI, New Delhi
57.	Dr Sukanta Dash	Scientist, ICAR-IASRI, New Delhi
58.	Dr Arpan Bhowmik	Scientist, ICAR-IASRI, New Delhi
59.	Dr Anindita Datta	Scientist, ICAR-IASRI, New Delhi
60.	Dr Tauqueer Ahmad	Principal Scientist and Head, ICAR-IASRI, New Delhi
61.	Dr Prachi Misra Sahoo	Principal Scientist, ICAR-IASRI, New Delhi
62.	Dr Pradip Basak	Scientist, ICAR-IASRI, New Delhi
63.	Dr Amrit Kumar Paul	Principal Scientist, ICAR-IASRI, New Delhi
64.	Dr Ranjit Kumar Paul	Scientist, ICAR-IASRI, New Delhi
65.	Dr Himadri Shekhar Roy	Scientist, ICAR-IASRI, New Delhi
66.	Dr K.N. Singh	Principal Scientist and Head(A), ICAR-IASRI, New Delhi
67.	Dr V. Ramasubramanian	Principal Scientist, ICAR-IASRI, New Delhi
68.	Dr Prawin Arya	Principal Scientist, ICAR-IASRI, New Delhi
69.	Dr Mrinmoy Ray	Scientist, ICAR-IASRI, New Delhi
70.	Dr Sudeep Marwaha	Principal Scientist and Head(A) , ICAR-IASRI, New Delhi
71.	Dr Alka Arora	Principal Scientist, ICAR-IASRI, New Delhi
72.	Dr Anshu Bhardwaj	Principal Scientist, ICAR-IASRI, New Delhi
73.	Dr Mukesh Kumar	Principal Scientist, ICAR-IASRI, New Delhi
74.	Sh. Shahnawazul Islam	Scientist, ICAR-IASRI, New Delhi
75.	Dr Soumen Pal	Scientist, ICAR-IASRI, New Delhi
76.	Dr Anil Rai	Principal Scientist and Head(A), ICAR-IASRI, New Delhi
77.	Dr A.R. Rao	Principal Scientist, ICAR-IASRI, New Delhi
78.	Dr S.B.Lal	Senior Scientist, ICAR-IASRI, New Delhi
79.	Dr K.K. Chaturvedi	Senior Scientist, ICAR-IASRI, New Delhi
80.	Dr D.C. Mishra	Scientist, ICAR-IASRI, New Delhi
81.	Dr Ajit	Principal Scientist & In charge-PME, ICAR-IASRI, New Delhi
82.	Dr Shashi Dahiya	Senior Scientist, ICAR-IASRI, New Delhi
83.	Sh. Pal Singh	Scientist, ICAR-IASRI, New Delhi

84.	Dr Anu Sharma	Senior Scientist, ICAR-IASRI, New Delhi
85.	Sh. Sanjeev Kumar	Scientist, ICAR-IASRI, New Delhi
86.	Md. Sameer Farooqi	Scientist, ICAR-IASRI, New Delhi
87.	Dr U.B. Angudi	Senior Scientist, ICAR-IASRI, New Delhi
88.	Dr V.K. Tewari	Professor and Head, Dept. of Ag. Food & Engg., IIT, Kharagpur
89.	Mr. Santhosh Sam Koshy	CDAC, Hyderabad
90.	Dr S.K. Dwivedi	Prof. & Head, Dept. of Comp. Sci., Ambedkar Univ., Lucknow
91.	Dr P. Krishna Reddy	Professor, IIIT, Hyderabad
92.	Dr Aditya Nigam	Assistant Professor, IIT, Mandi
93.	Mr. Jitendra Singh	IBM, Gurugram
94.	Ms. P.V. Nandini	Oracle India Pvt. Ltd., Gurugram
95.	Mr. Sachin Suri	Managing Director, Crop data Technology Pvt. Ltd., Nagpur
96.	Mr. Devendra Chandani	Intello Labs Pvt. Ltd., Delhi
97.	Mr. Saurabh Kumar,	AgriCx Lab Pvt. Ltd.,Mumbai
98.	Mr. Unnikrishnan, A.R.,	NVIDIA, Bangalore
99.	Mr. Satyajit Dwivedi	SAS, Delhi
100.	Mr. Karunesh Arora	CDAC, Noida
101.	Dr Poonam Bedi	Professor, Dept. of CS, Delhi University
102.	Dr Atul Negi	Professor, Dept. of CSE, University of Hyderabad
103.	Dr Sanat Sarangi	TCS, Thane
104.	Mr. Rohit Singh	Oracle, Delhi
105.	Sh. Mohit Bhasin	KPMG, Gurugram
106.	Sh. Aditya Tiwari	TCS
107.	Ms. Rachna Pandey	KPMG, Gurugram
108.	Sh. Abhay Adil	KPMG, Gurugram
109.	Dr A. Sarangi	Principal Scientist, ICAR-IARI, New Delhi

Programme Schedule

Day 1:- 30 July, 2018 (Monday)		
09.00-09.25	**Registration**	
09.30-11.00	**INAUGURAL SESSION**	
11.00-11.30	High Tea	
Technical Session I: 11.30-13.20		
Chairman: Trilochan Mohapatra, Secretary DARE & DG, ICAR **Co-Chairman**: K. Alagusundaram, DDG (Ag. Engg.) and DDG (NRM)/ Addl. Charge, ICAR, New Delhi		
Rapporteur: Sudeep Marwaha ICAR-IASRI, New Delhi		
11.30-11.50	Modernize with disruptive AI technologies	Nandini P.V., Oracle India Pvt. Ltd., Gurugram
11.50-12.10	AI in precision agriculture	Mohit Bhasin, KPMG, Gurugram
12.10-12.30	Cognitive IoT in agriculture	Sanat Sarangi, TCS, Thane
12.30-12.50	Application of AI and remote sensing in Indian agriculture	Jitendra Singh, IBM, Gurugram
12.50-13.20	Discussion	
13.20-14.15	Lunch	
Technical Session II: 14.15-15.45		
Chairman: Ch. Srinivasa Rao, Director, ICAR-NAARM, Hyderabad		
Rapporteur: Ranjit Kumar Paul, ICAR-IASRI, New Delhi		
14.15-14.35	AI and its application in precision agriculture with special reference to drone technology	V.K. Tewari, Department of Agricultural Food & Engineering, IIT, Kharagpur
14.35-14.55	Emerging research trends in cross language information retrieval	S.K. Dwivedi, Department of Computer Science, Ambedkar University, Lucknow
14.55-15.15	Machine learning approaches and applications to precision agriculture	Atul Negi, Department of Computer Science, University of Hyderabad, Hyderabad
15.15-15.45	Discussion	
15.45-16.00	Tea	
Technical Session III: 16.00-18.10		
Chairman: Joykrushna Jena, DDG (Fish. Sci.) and DDG (Animal Sci.) / Addl. Charge, ICAR, New Delhi		
Rapporteur: Ramasubramanian V., ICAR-IASRI, New Delhi		
16.00-16.20	Blockchain and AI/ machine learning systems	Sachin Suri, Cropdata Technology Pvt. Ltd., Nagpur
16.20-16.40	IoT in Agriculture: Case studies on pest and disease forewarning models	Santhosh Sam Koshy, C-DAC, Hyderabad
16.40-17.00	Use of AI in quality grading	Devendra Chandani, Intello Labs Pvt. Ltd., Delhi
17.00-17.20	Reinventing agri-produce quality testing using AI	Saurabh Kumar, AgriCx Lab Pvt. Ltd., Mumbai
17.20-17.40	E-Crop in IoT solutions for precision farming	V.S. Santhosa Mithra, ICAR-CTCRI, Thiruvananthapuram
17.40-18.10	Discussion	

Day 2:- 31 July, 2018 (Tuesday)		
Technical Session IV: 09.30-11.00		
Chairman: Ashok Kumar Singh, DDG(Agricultural Extension)		
Rapporteur: K.K. Chaturvedi, ICAR-IASRI, New Delhi		
09.30-09.50	Application of AI in agriculture	S.K. Ambast, ICAR-IIWM, Bhubaneswar
09.50-10.10	Experiences of ICAR-NAARM in AI and IoT applications in agriculture	S.K. Soam, ICAR-NAARM, Hyderabad
10.10-10.30	Use of AI techniques in agricultural water management	Arjamadutta Sarangi, ICAR-IARI, New Delhi
10.30-10.50	Disruptive possibilities with AI for agriculture in India	Unnikrishnan, A.R., NVIDIA, Bangalore
10.50-11.20	Discussion	
11.20-11.30	Tea	
Technical Session V: 11.30 -13.00		
Chairman: S.K. Ambast, Director, ICAR-IIWM, Bhubaneswar		
Rapporteur: Soumen Pal, ICAR-IASRI, New Delhi		
11.30-11.50	Deep learning and its applications	Aditya Nigam, IIT, Mandi
11.50-12.10	Recommender system and Blockchain technology	Punam Bedi, Department of Computer Science, University of Delhi, Delhi
12.10-12.30	Towards building a smart system to empower a farmer to diagnose farm problems	P. Krishna Reddy, IIIT, Hyderabad
12.30-13.00	Discussion	
13.00-14.00	Lunch	
Technical Session VI: 14.00-15.10		
Chairman: P.S. Pandey, ADG (EP&HS), Education Division, ICAR, New Delhi		
Rapporteur: Alka Arora, ICAR-IASRI, New Delhi		
14.00-14.20	IoT and AI in Agriculture: Capabilities and applications	Satyajit Dwivedi, SAS, New Delhi
14.20-14.40	Natural language processing in Agriculture: Scenario and challenges	Karunesh Arora, C-DAC, Noida
14.40-15.10	Discussion	
15.10-15.30	Tea	
Concluding Session: 15.30-17.30		
Chairman: Trilochan Mohapatra, Secretary, DARE & DG, ICAR		
Rapporteur: Dwijesh Chandra Mishra, ICAR-IASRI, New Delhi		
15.30-17.00	Recommendations; Capacity building; Data/ Knowledge management; PPP mode	Sudeep ICAR-IASRI, New Delhi
17.00-17.20	Concluding remarks	Trilochan Mohapatra, Secretary, DARE & Director General, ICAR C. Roul, Special Secretary, DARE
17.20-17.30	Vote of thanks	Lalmohan Bhar, Director (A), ICAR-IASRI, New Delhi
17.30-18.00	High Tea	

List of Speakers

Sl. No.	Name	Designation & Affiliation
1.	Ms. P.V. Nandini	Oracle India Pvt. Ltd., Gurugram
2.	Sh. Mohit Bhasin	KPMG, Gurugram
3.	Dr Sanat Sarangi	TCS, Thane
4.	Mr. Jitendra Singh	IBM, Gurugram
5.	Dr V.K. Tewari	Prof. and Head, Dept. Ag. Food & Engg., IIT, Kharagpur
6.	Dr S.K. Dwivedi	Prof. & Head, Dept. of CS, Ambedkar Univ., Lucknow
7.	Dr Atul Negi	Professor, Dept of CSE, University of Hyderabad
8.	Mr. Sachin Suri	MD, Cropdata Technology Pvt. Ltd., Nagpur
9.	Mr. Santhosh Sam Koshy	CDAC, Hyderabad
10.	Mr. Devendra Chandani	Intello Labs Pvt. Ltd., Delhi
11.	Mr. Saurabh Kumar	AgriCx Lab Pvt. Ltd., Mumbai
12.	Dr V.S. Santhosh Mithra	Principal Scientist, ICAR-CTCRI, Thiruvananthapuram
13.	Dr S.K. Ambast	Director, IIWM, Bhubaneswar
14.	Dr S.K. Soam	Joint Director (I/c), ICAR-NAARM, Hyderabad
15.	Dr A. Sarangi	Principal Scientist, ICAR-IARI
16.	Mr. Unnikrishnan, A.R.,	NVIDIA, Bangalore
17.	Dr Aditya Nigam	IIT, Mandi
18.	Dr Poonam Bedi	Deptt. of CS, Delhi University
19.	Dr P. Krishna Reddy	IIIT, Hyderabad
20.	Mr. Satyajit Dwivedi	SAS, Delhi
21.	Mr. Karunesh Arora	CDAC, Noida

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6. Dr SudeepMarwaha, Head (A), Computer Applications Division & Professor (Computer Applications)
7. Dr Ajit, Principal Scientist & Scientist In-Charge, PME
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6. Dr Alka Arora, Principal Scientist
7. Dr K.K. Chaturvedi, Senior Scientist
8. Dr Mrinmoy Ray, Scientist

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1. Dr Anshu Bharadwaj, Principal Scientist
2. Dr Alka Arora, Principal Scientist

R&D and Strategic Policy Issues from 'National Dialogue on AI and IoT Applications in Agriculture' held at ICAR-NAARM during 1-2 June 2018

(*Policy Brief available on web link*)

https://naarm.org.in/wp-content/uploads/2018/07/AI_iot_policy.pdf

Research and Development Issues

Crop Sciences

The two important input factors made available:

i) Good Quality Data

- Collection and quality analysis of data: Data should be collected in coordination with computer applications' experts keeping in view of crop/expert models
- For keeping pace with the dynamic environmental conditions, data should be collected on real time basis
- Data generated through AICRP trials and satellite data should be optimized
- Integration and validation of existing data
- Digital herbarium/databases like germplasm, climate, field data, etc., need to be integrated
- Forecasting and crop biomass estimation

ii) Sensors

- Need-based sensors, kind of material that remains sensitive for many years, efficient and cost effective. Safe disposal of field sensors
- Handy neuro-chips for farmers, a kind of Fit bit
- Application of drones
- Development of electronic eye for several purposes

Natural Resource Management (NRM)

- ICAR should consider undertaking a mega project on development of AI tools for validation and integration of available data on weather, soil and other natural resources
- Soil nutrient mapping using appropriate IoT and AI should be given priority for conservation and sustainable utilization of resources

- Development and adaptation of indigenous sensors for monitoring of natural resources like soil and water should have sufficient focus so that cost effective and robust sensors are available for deployment of IoT
- UAV based tools, protocols and gadgets need to be developed for data collection, modelling, decision making and input application
- A digital database on different crops, diseases, insects, pests, animal breeds and their diseases, etc., should be developed so that image processing, audio processing and other such tools in conjunction with AI could be deployed

Animal & Fisheries Sciences

- Animal tracking system; health monitoring system
- Traceability of animal products
- Quality check system at primary milk cooperative society level
- Feed/input management and monitoring
- Water quality management
- Accuracy of sensors (calibration for quality data)
- Biomass estimation

Strategic Policy Issues

- Policy support for developing competent skill in these area; training to young and middle level scientists in AI and IoT in identified institutions abroad.
- ICAR-NAARM need to act as nodal point for providing capacity building programs in AI/IoT to the NARES which can be extended to industry and agri start-ups as well.
- Access to data from AICRPs/KRISHI and other sources through sharing of APIs enabling real time access thus creating a central data warehouse.
- Incentives for students to pursue courses of study that will allow them to create the next generation of AI.
- Encourage investment in projects / infrastructure to support and deliver AI based services, and partnering with private industry need to be promoted.
- Developing integrated flagship programs such as 'Niche Area Excellence' in identified consortia of ICAR institutions.
- ICAR need to play much bigger supportive role for implementing AI and wide spread of AI applications to farmers by strengthening linking with private industries. The kind of hand holding and support is required for private businesses in terms of capacity building and domain consultancy.

Photo Gallery

Shri Amitabh Kant, IAS, Chief Executive Officer, NITI Aayog delivering inaugural address

Shri Amitabh Kant releasing 'Policy Brief on Application of AI in Agriculture' along with Dr T. Mohapatra, Secretary, DARE and DG, ICAR; and Dr L.M. Bhar, Director ICAR-IASRI

Dr T. Mohapatra, Secretary, DARE and DG, ICAR welcoming Shri Amitabh Kant, CEO, NITI Aayog

Dr Ch. Srinivasa Rao, Director, ICAR-NAARM delivering welcome address

Shri C. Roul, IAS, Special Secretary, DARE delivering his remarks

Dr T. Mohapatra, Secretary, DARE and DG, ICAR in plenary session

Dr A.K. Singh, DDG (Agrl. Extension & Crop Science) ICAR, Chairing a technical session

Dr J.K. Jena, Deputy Director General (Fisheries Science & Animal Science) ICAR, Chair of a technical session, felicitating Speaker

Dr K. Alagasundaram, Deputy Director General (Agricultural Engg. & NRM) Chairing a technical session

Dr P.S. Pandey, ADG (EP&HS), Chairing a technical session. Dr Alka Arora, Principal Scientist, ICAR - IASRI as Rapporteur

Dr S.K. Ambast, Director, ICAR-IIWM felicitating the Speaker in a technical session

Dr Ch. Srinivasa Rao, Director, ICAR-NAARM Chairing session with Dr V.K. Tewari, Professor, IIT - Kharagpur, and Dr Atul Negi, Professor, University of Hyderabad

Dr R.K. Jain, Dean, ICAR-IARI interacting in a session

Dr O.P. Yadav, Director, ICAR-CAZRI with Dr L.M. Bhar, Director, ICAR-IASRI, and Dr Rajender Parsad, Principal Scientist, ICAR-IASRI

Dr S.K. Soam, Joint Director (I/c), ICAR-NAARM delivering his talk

Dr Sudeep Marwaha, Professor & Head, ICAR-IASRI

Dr Punam Bedi, Professor, Delhi University delivering her talk

Dr Anshu Bhardwaj, Principal Scientist, ICAR - IASRI organizing events

Mr. Mohit Bhasin from KPMG delivering his talk

Mr. Satyajit Dwivedi from SAS delivering his talk

Dr V.S.S. Mithra, Principal Scientist, ICAR - CTCRI delivering his talk

Dr Soumen Pal, Scientist, ICAR - IASRI as Rapporteur in a technical session

Dr Susheel Kumar Sarkar, Scientist ICAR - IASRI and Dr Ranjit Kumar Paul, Scientist ICAR - IASRI

Delegates in the workshop

Delegates in the workshop

Delegates in the workshop

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