APPLICATIONS OF DEEP LEARNING METHODS IN AGRICULTURE: A REVIEW

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ABSTRACT

Deep Learning is a new technique which integrates the big data analysis with modern technique for image processing and data analysis. Deep learning has big potential and is already being applied in various fields like medical research, self-driving cars, automated speech recognition, NLP (Natural Language Processing) and image restoration to name a few. The potential is vast and only limited to our imagination. In agriculture, Deep learning has been introduced recently and has already shown great promises. With this, various agriculture problems such as identification and detection of disease can be resolved. It can also help in automated identification of plants, fruits and even counting them. In this study we achieve a review of research work that use deep learning techniques, related to various cultivation problem such as disease identification or detection, food production challenges, crop mapping, crop monitoring, irrigation, weed detection, pest detection and management, fruit grading, herbicide and identification of seeds and reorganizations of species, etc. This paper focus on particular farming problems, for this specific model and structure used, the sources of data gathering, preparing of data, the overall functioning accomplished according to the methodology used for each work under study. Furthermore, we study various deep learning techniques applied in various field and also compared it existing techniques. Deep learning is performed differently in classification and regression performance from older existing techniques. Our findings indicate that deep learning provides high accuracy results. These results are much more accurate than traditional image processing technology. The deep learning model can also be extended from classification task to yield production, detections and disease segmentation.

Keywords: Deep learning, Techniques, Agriculture, Remote sensing.

INTRODUCTION

Agriculture is the backbone of Indian economy and so, the production of food is very important not just to feed the large population but also to allow people earn well. Over the years, the agriculture sector has gone through several changes to fulfil the world's growing population, which has doubled in the last 50 years (justin kitzes, Mathis Wackernagel, Jonathan loh, Audrey peller , Steven goldfinger, Deborah Cheng and kaljin tea et.al 2007) . A large increase in food production must be achieved (FAO,2009) because the global population has been continuously increasing (kitzes, et al.,2008). For this, new ways must be explored and a new system that aims at providing high nutrition quality and at protecting natural ecosystem by using futuristic farming procedures is needed. To address the multiple challenges that agriculture sector is facing, a new complex, multivariate and unpredictable agriculture ecosystem is needed. This new ecosystem must look at achieving a better understanding of the system and introduce ways that can monitor, analyze and measure all the variables associated with the sector.

Moving forward, modern agriculture (Tyagi,2016) is important for diving the challenges of cultivation production in terms of yield, the impact of environment, food security and livable (Gebbers & Adamchuk,2010; Meraj et al., 2021 a, b). This implies analysis of big agricultural data (Kamilaris, karta koullis , & Prenafeta-Boldu,2017) , and apply of new information and communication technologies (ICT) (Kamilaris, Gao, Prenafeta boldu & Ali, 2016), both for large scale ecosystem observation and short scale crop management to improve the living work of management and decision-making policy. Huge opinion is aided by remote sensing (Bastiaanssen, Molden, & Makin, 2000; Pandey et al., 2010; Pandey et al., 2013; Singh and Pandey, 2014; Bhatt et al., 2017; Sharma and Kanga 2020), satellites, airplanes and unmanned aerial vehicles (UAV) gives very large view of farming surroundings. It has many advantages in cultivation field for gathering information about sphere characteristics whenever data may be collected systematically or may cover a large area (Gujree et al., 2017; Pall et al., 2019; Romshoo et al., 2020). Image data can be collected through remote sensing. Some of the images contain a complete view of farming surroundings and show various dares (Liaghat & Balasundram,2010; Kanga et al., 2017a, b; Rather et al., 2018; Hassanin et al., 2020; Kanga et al., 2021). In cultivation area, analysis of images is a significant research tool and that's why smart data analysis methods are apply for identification, classification, detection etc. in numerous of cultivation applications (Teke, Deveci, Haliloglu,Gurbuz, and Sakarya,2013),(Saxena and Armstrong, 2014),(singh,Ganapathy subramanian

,singh and Sarkar, 2016; Singh et al., 2017b; Kanga et al. 2020a, b). The best living method is satellite based, and uses multi spectral and hyperspectral imaging. For analysing images, most common method is Machine learning (K-means, support vector machine, artificial neural network) linear polarizations, wavelet-based filtering, vegetation indices and regression analysis are used. (Armstrong and Saxena,2014),(Singh, Ganapathys bramanian, singh , and Sarkar,2016; Ranga et al., 2020 a, b; Meraj et al., 2020 a, b; Kanga et al., 2020a, b). Apart from the existing method, a new one has been also introduced which is called as Deep learning (DL) (Lecun, Bengio, and Hinton,2015), (Lecun and Bengio,1995). Deep Learning is a subset of ML. ML is subset of AI. However, DL is similar to ANN and deeper neural network that contain various convolution layer. DL contains more hidden layers and gives higher performance as it takes more training data than testing data. DL deals with huge amount of data. That is why it gives better accuracy than existing one. Deep learning has big potential and is already being applied in various fields like medical research, self-driving cars, automated speech recognition, NLP (Natural Language Processing) and image restoration to name a few. In agriculture, Deep learning has been introduced recently and it has already shown great promises. With this, various agriculture problems such as the identification and detection of disease can be resolved. It can also help in the automated identification of plants, fruits and even counting them (Bera et al., 2021; Tomar et al., 2021; Joy et al., 2021; Chandel et al., 2021; Kanga et al., 2021).

Review of Literature

Agila N, Senthil Kumar P et.al.2020 proposed a model that detects which crop can be cultivated in that area or not based on the climatic conditions such as rain, humidity, temperature, and moisture among the sensor. The recurrent neural network recognizes the appropriate crops by categorizing the crops based on environmental condition. In this experiment Random forest classifier, Decision Tree classifier, Logistic Regression, Support Vector Machine classifier, Multilayer Perceptron (MLP) and Recurrent Neural Network (RNN) are used. In the outcome, RNN performed better than the others.

Andreas Kamilaris et.al.2018 showed that deep learning is a current and advanced method. Deep learning is used for handling image and analysis of data that provides perfect output. Deep learning provides high accuracy and performed better when compared to existing image processing techniques. In this study a survey of 40 research efforts has been done that indicates how deep learning techniques were applied to various agriculture and food production challenges. Compared with other popular existing techniques, deep learning has shown great improvement in the achievement of categorization and regression. Thus it can be seen that deep learning gives better accurate result.

When compare with exiting techniques as image processing techniques, Deep learning gives better accurate result, better performance.

Nataliia Kussul et al.2017 proposed a system that show crop classification and land using satellite imagery which is multi temporal and different sources. The main concept is unsupervised neural network that is used for optical imagery segmentation, for missing data repair due to clouds and shadows joint with supervised neural network.

This paper shows both crop estimation and monitoring test site in Ukraine for categorization of crops in a various climatic condition using Landsat 8 and Sentinel 1-A Remote sensing satellite. The Convolution Neural network gives better performance when compared with multilayer perceptron. It also helps us to differentiate some summer crops types.

Meng Zhang, Hui Lin, Guangxing Wang, Hua Sun, and Jing Fu et.al.2018 proposed method for mapping of paddy rice using CNN, multitemporal Landsat 8, phenology data, and land surface temperature. For combining the moderate resolution imaging spectroradiometer (MODIS) and Landsat data he used spatial -temporal adaptive reflectance -fusion model to obtain multi-temporal Landsat data. After that he derived the phenological factors from the Landsat like NDVI (Normalized difference vegetation index) time series for this applied threshold method. After that he derived LST from the Landsat 8 used a generalized single channel algorithm. At last to extract paddy rice information in the Dongting Lake area he used patch-based deep learning CNN algorithm, multitemporal(more than one time period) Landsat 8 spectral images, combined with phenology and Land Surface Temperature data. It proved that the proposed method achieved higher accuracy than SVM, RF method. Besides this, it showed that suggested approach has capacity of paddy rice mapping in huge amount using mild spatial resolution image, using Landsat-obtained rice area is effectively associated with government statistical data.

Liheng Zhong, Lina Hub, Hang Zhou et.al. 2018 developed a model using deep learning-based techniques for remotely sensed data. This study in Yolo Country, California has a very different irrigated cultivation. In this, for classifying summer crops using Landsat Vegetation Index (EVI) two types of deep learning methods based on Long Short-Term Memory (LSTM) and One-dimensional convolution (Conv 1D) layers were planned. And then, the results were compared with three classifiers (gradient boosting machine called XGBoost, Random Forest, and Support Vector Machine). Conv 1D achieved higher accuracy than the others. Conv 1D consist of stack of Conv1D layer and an inception module. This study proved that the Convolution 1D based deep learning model gives an useful and real method of time series description in multi –temporal categorization.

Jian-Lei Kong, Xue-Bo Jin, Yang-Yang Zheng Xiao-Y Wang, Ting-Li Su and Min Zuo et.al.2019 proposed a domain specific dataset of crops i.e Crop Deep in agriculture field. Crop Deep verities of classification and finding dataset contain 31,147 images with 49,000 marked instances from 31 verity of classes. This was supported stronger benchmark for deep learning-based classification and detection. This show that deep learning method achieve high performance than exist, classification achieve more accuracy than detection. In deep learning architecture include VGG, Res Net, Dense Net, Inception and Sqeeze Net to measure the functioning on the Crop Deep dataset and excellent applicability for management. While result motivate in standard classification and identification, latest deep learning methods has to improve when applied to crops development and management. At last, proposed YOLOv3 network has good potential application in agriculture detection tasks with broad point of speed, correct and strength

A. Kalaivani and R. Khilar et.al. 2020 proposed a model for crop classification and mapping and also measure and compare the performance with another supervised classifier model. The proposed automated system provides better accuracy than the existing. Classification result are very highly accurate than existed. The method provides sufficient support to the farmers in differentiating crops suitable for the given land cover with high accuracy and low error measure. The proposed automated system should provide better accuracy than the existing.

J. Jayanth, V. S. Shalini, T. Ashok Kumar, and Shivaprakash Koliwad et.al.2020 proposed a method for classification of filed level crop types with a time series satellite data using Landsat 7 sensor based on Deep neural network. It generates more accurate result for an in-season crop type classification. In this study used RELU Rectified Linear Unit approach which based on deep neural networks. The study area is taken in Nanjangud Taluk located in Mysuru District, Karnataka state on a Landsat from 2010 to 2015. This study proved that RLU improved overall accuracy of classification of three classes over the traditional method as a Support vector machine. This study shows an improved accuracy for classifying rice and banana with improvement over KSRCS crop field data. Moreover, the accuracy of crop type classification was verified with early-stage and bands reached a peak of DOY 250.

Kristof Van Tricht, Anne Gobin, Sven Gilliams and Isabelle Piccard et.al.2018 create a crop map for Belgium using both Sentinel- 1 radar and Sentinel-2 optical imagery. In this study author used 12day Sentinel-1 backscatter mosaics and 10 daily Sentinel -2 smoothed NDVI mosaics over Belgium based on an optimized random forest classifier to develop a multi-sensor crop mapping approach which was tested on 2017 growing season. In this predicted eight different crop types with maximum accuracy using an optimized random forest classifier. Author found that a combination of radar and optical imagery performed better classification in throughout season. Moreover, show that classification observed into accurately of forecasted classes for each pixel using random forest classifier gives that parcel boarder has a lower classification. Proved that the synergistic use of radar and optical data for crop classification provide more information that improves accuracies compared to optical only classification.

Petteri Nevavuorib, Nathaniel Narraa, Tarmo Lipping et.al.2019 designed a model based on NDVI and RGB data taking from Unmanned Aerial Vehicles for crop yield prediction. In this study main concerns are weed and crop identification, biomass estimation and yield prediction. Farmer face problems for remote sensing-based yield prediction using machine learning methods that require yield mapping devices. In this study CNN show outstanding performance to build a model for crop yield prediction. Choice of training algorithm, network's depth, ordinance method and tuning of the hyperparameters on the identification of efficiency are tested. Using CNN architecture proved that are capable of reasonable accurate yield estimates based on RGB images. CNN architecture performed much better with RGB images than NDVI images.

M. Rubwurm, M. Korner et.al.2017 proposed a deep learning approach to utilise temporal characteristics for the classification task. In this study show that identification of crop using long short-term memory (LSTM) neural network with Sentinel 2A data for huge amount of area and mark the information. Then compare these temporal neural network i.e LSTM and RNN with a classical non-temporal neural network CNN model and SVM.

Kentaro Kuwata and Ryosuke Shibasaki et.al. 2015 developed a methodology based on deep learning model using Caffe (Convolutional Architecture for Fast Feature Embedding) for crop yield estimation in U.S.A. Caffe is a framework of deep learning, developed by the Berkeley Vision and learning Centre (BVLC). For food security high accuracy estimation of crop yield are essential. In this study used a network model of two inner product layer was best algorithm, achieved RMSE. In this study mainly highlights the advantage of deep learning for agriculture yield estimation, using deep learning achieved high accuracy. Moreover, deep learning is used to extract important feature for crop yield from input data. Therefore, where data acquisition is limited deep learning is expected to estimate crop yield. The result show that deep learning is used to predict crop harvest yield.

Sue Han Lee, Chee Seng Chan, Paul Wilkin, Paolo Remagnino et.al. 2015 studied a deep learning approach to learn special features from leaf images with classifiers for plant identification. In this study learn unsupervised features representation for 44 different plant species using CNN, collected at the Royal Botanic Gardens, Kew, England. A visualization technique based on deconvolution network (DN) is used for gaining intuition on the chosen features from the CNN model. In this study mainly focus on two points firstly replace the hand-crafted features using a CNN model to automatically learn the features representation for plant categories. Secondly, a visualization technique based on DN for identification and diagnosis features representation learnt by CNN model. That is why to avoid the use of CNN model as black-box solution and provide the researcher on how the algorithm sees or perceives a leaf. Result show consistency and superiority for different classifiers using CNN features. Moreover, the author proved that venation structure is an important feature to identify different plant species and CNN gives better accuracy than existed. This was verified by DN visualization technique by analyzing using internal and behavior of the network.

Dinh Ho Tong Minh, Dino Ienco, Raffaele Gaetano, Nathalie Lalande, Emile Ndikumana, Faycal Osman, and Pierre Maurel et.al.2018 used deep learning techniques for better comprehend of the capabilities of Sentinel- 1 radar images for winter greenery mapping. An analysis is complete on a multi-temporal Sentinel-1 data over an area Charentes – Maritimes, France. In this study show how RNN model such as LSTM and GRU can be used to deal with SAR Sentinel -1 time series. Author propose to used two deep RNN approaches to explicitly consider the temporal correlation of SAR data in order to discriminate among quality classes of winter vegetation coverage showing complex temporal behaviors. The result show proposed RNN model performs better accuracy than classical machine learning (SVM and RF).

Andreas Kamilaris, Feng Ga, Francesc X. Prenafeta-Boldu, and Muhammad Intizar Ali et.al.2016 proposed Agri-IoT a semantic framework for IoT based on smart farming applications. Agri-IoT can provide common framework for smart farming application and also integrate multiple cross-domain data streams, provide a complete semantic processing pipeline. Agri-IoT achieves this by event detection, large scale data analytics, ensuring seamless interoperability among sensors, services, processes, operations, farmers, and other relevant i.e. online information sources and linked open datasets and web-based services. This study focused on two realistic scenarios show the good performance of proposed framework of medium to large farms and also show large opportunities in farming by bringing open standard and semantics based IoT.

S. Anubha Pearline, V. Sathiesh Kumar and S. Harini et.al.2019 show recognition of plant species by two method firstly traditional method (feature extraction by classifier) and secondly deep learning method (pre-trained model with machine learning classifiers) with four different datasets as Folio, Swedish, Flavia, and Leaf12. The author observed that deep learning model yielded higher accuracy than the conventional method for all four datasets. VGG 16 or 19 deep learning architecture with Logistic Regression classifier obtained higher accuracy than Inception-v3 and InceptionResNet-v2.

Ziheng Sun, Liping Di, Senior Member et.al.2020 proposed a classification workflow to produce high quality in-season crop maps from Landsat imageries based on deep neural network (DNN) for North Dakota. In training datasets used historical crops maps taking from the agricultural department and North Dakota ground measurement. To automate the pre-processing, training, testing and postprocessing workflows processing workflow was created. After testing trained DNN model got the satisfying result on major crops such as corn, soybean, barley, spring wheat, alfalfa etc. This study mainly show that the training datasets includes more Landsat images from multiple scenes, months, and year then DNN model will be more accurate. The trained DNN model can better recognize major crops in big farms but not better in minority crops in wetland and suburban regions.

K Dokic, L Blaskovic and Mandusic et.al.2020 in this paper an analysis of paper in the field of machine learning, neural network and deep leaning was given. This paper provides a quantitative overview of papers which published in the past two decades. Also, it gives review of contribution of individual countries. The paper divided into two-part, first part gives review and second part analysis trends in the first half of the current year, with based on areas of application, selected deep learning methods, input data, crop mentioned and applied frameworks. Scopus and Web of science citation databases were used. It can conclude that to constructing neural network, TensorFlow is a dominant framework, but most researchers use Keras to simplify the process. A camera is used as input device, some crops wheat, corn and grapes are most often focus and crops analysis is the most common area for deep learning applications. At the last use of CNN has become common method for solving agriculture problems.

Luis Santos, Filipe N. Santos, Paulo Moura Oliveira and Pranjali Shinde et.al. 2020 In this paper performs a survey of different deep learning methods which is applied to various agricultural problems, such as disease detection or identification, classification of plants or fruits and fruit counting etc. In this paper focus the particular utilized model, data 'sources, the function of each study, the utilized hardware and the chances of real time application to study eventual integration with independent robotics system. It concluded that deep learning provides high accuracy than other traditional image processing techniques.

A.Kamilaris and F.X. Prenafeta-Boldu et.al. 2018 In this study a review of Convolution neural network-based research factors are applied in the cultivation field, In this specific area and problem are examined which is based on ,giving technical details of the models engaged, give detailed data 'sources used and measure overall accuracy fulfilled. CNN compare with other techniques and finding indicates that CNN performed high accuracy than other traditional techniques. Moreover, personally, the author's experience of applying CNN to detection missing greenery from sugar cane plant in Costa Rica that was successfully applied and CNN is mainly dependent on the size and quality of data set which is used for training the model, in points of various classes and marking accuracy. Still, quality of dataset gives the success of each CNN model is mainly dependent on the quality of data set. The author motived that CNN can be applied in different field.

Yu Dong Zhang & Zhengchao Dong & Xianqing Chen & Weniuan Jias & Sidan Du & Khan Muhammad Shui hua wang et.al.2017 In this authors designed a 13 layer CNN which used three type of data augmentation method as image rotation, Gamma correction, and noise injection. Also compare max pooling with average pooling and max pooling give better result than average pooling. For training model stochastic gradient method is used. Author observed using data augmentation can increase overall accuracy. This method is effective in image-based fruit classification achieved 94.94% accuracy superior to five state of the art approaches in terms of overall accuracy.

DEEP LEARNING TECHNIQUES

S.NO.	Agricultural Area	Problem Description	Deep learning model used	References
1.	Leaf classification	Classify leaves of different plant species	Author defined CNN + RandomForest classifier	Hall, Dayoub Sunderha uf,McCool, , uf, & Upcroft,2015
2.	Leaf defect identification	In healthy leaves used 13 different types of plant diseases	CaffeNet CNN	Sladojevi c, Culibrk, Anderla, Arsenovic, and stefanovi c,2016
3.	Plant defect identification	Detecting 26 diseases and 14 crops categories	AlexNet, GoogleNet et CNNs	Mohanty, Hughes, & Salathe, 2016

4	Land cover mapping	Detecting 21 land-use classes contain various spatial features	Author defined CNN + Multiview model averaging	Luus, Salmon, van den Bergh, &Maharaj ,2015
5	Crop type classification	Extract information about cultivated land	Author defined CNN	Lu et., 2017
6	Plant recognition	Accept 7 opinion of different plants: fruit, leaf, stem entire plant, branch, flower, and scans	AlexNet CNN	Reyes, Caicedo, & Camargo,2015
7	Plant recognition	Recognize 44 different plant species	AlexNet CNN	Lee , Chan , Wilkin, & Remagni no, 2015
8	Plant phenology recognition	Mapping the phenotyping of Arabidopsis in four augmentations	Convolution Neural Network + Long Short-Term Memory	Namin, adeh Esmaeilz, Najafi, Brown and Borevitrz
9	Crop/Weed identification and mapping	Identification and mapping of sugar beet plants and weed	Author defined CNN	Potena, Nardi, & Pretto, 2016
10	Crop yield evaluation	Evaluate corn crop yield of country level in U.S.	Author defined CNN	Kuwata & Shibasaki, 2015

CONCLUSION

This paper presented a review of DL-based research efforts applied in the agriculture area. We examined different techniques which have already been used in different fields of agriculture. We also discussed problem descriptions and technical details of the models. In many papers, the result of DL is compared with the existing technologies in terms of performance. Our finding indicates the DL reached higher accuracy in the majority of reviewed work; it gives better accuracy and excellent result than other image processing techniques.

In future work we try to apply a different method of deep learning as explained in this review to other locations of cultivation where these methods have not yet been used. Some locations have already been detected for this. The main benefits of deep learning are encouraging for further use so we can move towards smarter, more secure food production.

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