DOI: 10.36582 2021, 2(1): 16 - 26
Al-Kunooze University College
Journal homepage: http://journals.kunoozu.edu.iq/1/issue/15/articles

A study on the use of convolutional neural networks in Indian agriculture

Abhishek Pandey[a], Dr. V. Ramesh[b]

[a]Research Scholar, SCSVMV University, Kanchipuram, Tamil Nadu, India

[b]Assistant Professor, SCSVMV University, Kanchipuram. Tamil Nadu, India

Abstract

India is primarily an agrarian nation. Agriculture in India is the core sector for food security, nutritional security, and sustainable development & for poverty alleviation. It contributes approximately 16% of GDP. Farmers in India are struggling to produce under poor environmental conditions with few tools for coping with drought, salinity, pests, and shortages of inputs and lack of appropriate technologies. In view of this problem a survey is performed on applications convolutional neural network in agriculture domain and how convolutional neural network (CNN) technology can boost the efficiency of daily operations in a traditional agriculture and maximize production volume and minimize the possibility of failure due to natural disasters, system errors, and other factors in India. Convolutional neural network is a subset of AI, a modern technique for image processing, with a great potential. Convolutional neural network techniques are successfully applied in various areas such as medical, defence, transport etc. It has recently also entered the domain of agriculture. In this study a survey was conducted on research efforts that employ convolutional neural networks (CNN), which constitute a specific class of deep learning, applied to various agricultural and food production challenges. In this study Convolutional neural networks are compared with other existing techniques, and the advantages and disadvantages of using CNN in agriculture are listed. The overall survey indicates that CNN constitutes a promising technique with high performance in terms of predication and classification accuracy. However, the success of each CNN model is highly dependent on the quality of the data set used.

Keywords

Convolutional neural network, Image processing, Deep learning, classification.

1.Introduction

Indian economy depends on agriculture. Over 70% people in India depend on agriculture business as the major source of income. In future science and technology is baseline of our country. Therefore our agriculture scientists and researchers have to think how science and technology can be used as tool to empower Indian Agriculture and to develop India. With growing population and ever growing demand for food, the scientist and researchers across the globe are busy to find innovative ways to meet this ever surging demand. Agriculture is one industry where Machine Learning scientists and researchers are working with farmers to help them with their produce. This Study begins with a research questions such as what are various applications of Convolutional neural network in Indian Agriculture and which CNN is algorithms performs better for agricultural problem. To answer these research questions a survey related to applications of convolutional neural network the field of agriculture is performed. As the agriculture resources are becoming scarcer agri scientists are using Deep learning/ CNN to help farmers make a better and more efficient use of the remaining resources. Convolutional neural network is a subset of machine learning in Artificial Intelligence (AI) that has networks which are capable of learning unsupervised from data that is unstructured or unlabelled. A convolutional neural network, or CNN, is a deep learning neural network designed for processing structured arrays of data such as images. Convolutional neural networks are widely used in computer vision and have become the state of the art for many visual applications such as image classification, and have also found success in natural language processing for text classification.

Indian farming is facing various challenges such as unavailability of good quality of seeds, lack of modern equipment, poor irrigation facilities, small and fragmented holdings of land, dealing with local traders and middleman, lack of storage facilities. With advancement of agricultural science and technology, multiple options to access modern technologies have become available. It is evident from the replacement of indigenous varieties of seeds by high-yielding varieties and traditional equipment and practices by power tillers, tractors and others machines. CNN /machine learning technologies play a crucial role in disseminating information to farmers enabling them to decide on the cropping pattern, use of high-yielding seeds, fertilizer application, pest management, marketing, etc.

Artificial Neural Network:

Artificial Neural Network (ANN), is a group of multiple perceptrons or neurons at each layer. ANN is also known as a Feed-Forward Neural network because inputs are processed only in the forward direction. This type of neural networks is one of the simplest variants of neural networks. They pass information in one direction, through various input nodes, until it makes it to the output node. The network may or may not have hidden node layers, making their functioning more interpretable. An ANN is configured for a specific application, such as pattern recognition or data classification, through a learning process. Learning in biological systems involves adjustments to the synaptic connections that exist between the neurons. This is true for ANNs as well.

Convolution neural network:

Convolutional Neural Networks (**ConvNets** or **CNNs)** are a category of Artificial Neural Networks that have proven very effective in areas such as image recognition and classification. A Convolutional Neural Network (CNN) is the foundation of most computer vision technologies. Unlike traditional multilayer perceptron architectures, it uses two operations called 'convolution' and pooling' to reduce an image into its essential features, and uses those features to understand and classify the image.

A Convolutional Neural Network (ConvNet/CNN) is a Deep Learning algorithm which can take in an input image, assign importance (learnable weights and biases) to various aspects/objects in the image and be able to differentiate one from the other. The pre-processing required in a ConvNet is much lower as compared to other classification algorithms. While in primitive methods filters are hand-engineered, with enough training, ConvNets have the ability to learn these filters/characteristics.

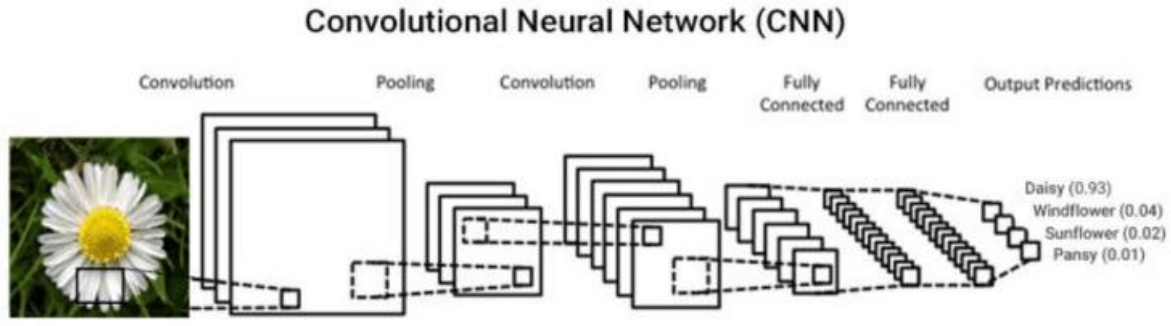

Figure 1: Convolutional Neural Network

Building blocks of CNN:

A convolutional neural network consists of various components:

Convolution layer: A "filter", sometimes called a "kernel", is passed over the image, viewing a few pixels at a time (for example, 3X3 or 5X5). The convolution operation is a dot product of the original pixel values with weights defined in the filter. The results are summed up into one number that represents all the pixels the filter observed.

Activation layer: The convolution layer generates a matrix that is much smaller in size than the original image. This matrix is run through an activation layer, which introduces non-linearity to allow the network to train itself via backpropagation. The activation function is typically ReLu.

Pooling layer: Pooling is the process of further down sampling and reducing the size of the matrix. A filter is passed over the results of the previous layer and selects one number out of each group of values (typically the maximum, this is called max

pooling). This allows the network to train much faster, focusing on the most important information in each feature of the image.

Fully connected layer: A traditional multilayer perceptron structure. Its input is a one-dimensional vector representing the output of the previous layers. Its output is a list of probabilities for different possible labels attached to the image (e.g. dog, cat, bird). The label that receives the highest probability is the classification decision.

Literature Review:

Zewen Li et al. (2020) did a survey on Convolutional Neural Networks and its Applications. This review explained brief introduction to the history of CNN, overview of CNN and the applications of one-dimensional, two-dimensional, and multi-dimensional convolution are covered. Then classic and advanced CNN models are introduced, especially those key points making them reach state-of-the-art results. Finally authors draw some conclusions and provide several rules of thumb for function selection.

Patrick Kinyua Gikunda et al. (2019) performed a study on Convolutional Neural Network (CNN), the recent architectures of state-of-the-art CNN and their underlying complexities. They proposed a classification taxonomy tailored for agricultural application of CNN. Authors have presented a comprehensive review of research dedicated to applications of state-of-the-art CNNs in agricultural production systems.

Karishma Mohiuddin et al. (2019) performed a review on agriculture based on machine learning and image processing. According to them the implementation of modern technology, especially the artificial intelligence on the agricultural aspect to enhance the food growth system, to create a subtle environment of crop, and to modify the plant cultivation to produce more crops from less resource.

R. Bongiovanni et al. (2004) performed a survey on Precision Agriculture and Sustainability. According to them Precision agriculture benefits to the environment come from more targeted use of inputs that reduce losses from excess applications and from reduction of losses due to nutrient imbalances, weed escapes, insect damage, etc. Other benefits include a reduction in pesticide resistance development.

S Kaiming He et al. (2015) proposed a Parametric Rectified Linear Unit (PReLU) that generalizes the traditional rectified unit. PReLU improves model fitting with nearly zero extra computational cost and little overfitting risk. This PReLU networks (PReLU-nets), we achieve 4.94% top-5 test error on the ImageNet 2012 classification dataset. This is a 26% relative improvement over the ILSVRC 2014 winner (GoogLeNet, 6.66%).

Ahmed S et al. (2019) presented applications of CNNs in two areas. First, in computer vision, generally, that is, scene labeling, face recognition, action recognition, and image classification; Second, in natural language processing, that is, the fields of speech recognition and text classification. According to them a convolutional neural networks (CNN) is becoming the star of deep learning as it gives the best and most

precise results when cracking real-world problems.

S. Sharma et al. (2016) proposed an efficient technique for face recognition system based on Deep Learning using Convolutional Neural Network (CNN) with Dlib face alignment. They described the process involved in the face recognition like face alignment and feature extraction. Authors emphasized the importance of the face alignment, thus the accuracy and False Acceptance Rate (FAR) is observed by using proposed technique. The computational analysis shows the better performance than other state-of-art approaches. The work has been done on Face Recognition Grand challenge (FRGC) dataset and giving accuracy of 96% with FAR of 0.1.

Yann LeCun et al. (2015) did a deep survey on deep learning and its applications. According to them Deep learning allows computational models that are composed of multiple processing layers to learn representations of data with multiple levels of abstraction. These methods have dramatically improved the state-of-the-art in speech recognition, visual object recognition, object detection and many other domains such as drug discovery and genomics. Deep learning discovers intricate structure in large data sets by using the backpropagation algorithm to indicate how a machine should change its internal parameters that are used to compute the representation in each layer from the representation in the previous layer.

Katherine A. Milla et al. (2005) performed a study on GIS, GPS, and Remote Sensing. They presented various examples of Extension-related applications of GIS-GPS-RS technologies and discusses how to go about learning more and determining if these technologies would be useful.

3. Methods

In order to answer the research questions a bibliographic analysis was performed, it involved three steps:

- Collection of related works and,
- Detailed review and analysis of the works.
- A comparative analysis of various CNN architectures.

A survey is performed on various research papers on applications of convolutional neural network in Indian agriculture. The research paper from 2004-2020 selected for study. In the first step, a keyword-based search using all combinations of two groups of keywords of which the first group addresses convolutional neural network in agriculture and the second group refers to a study on various CNN architectures and

their application in Indian agriculture.

Convolutional neural network / Machine learning solutions to various agriculture problems in Indian agriculture:

Improving crop productivity –The usage of predictive analysis with the help of CNN could be extremely helpful for Indian farmers. It could help determine appropriate crops to grow in a favourable climate on a productive terrain and the sowing methodology to enhance productivity and reduce costs.

Soil health monitoring – Along with favourable weather conditions, soil health comprising of an adequate level of moisture and nutrient holds the key to getting the best yield. Distributed soil monitoring performed via image recognition and CNN models can be used to take corrective measures to restore soil health.

Optimization of pest and weed management – CNN techniques can be used for predicting the behaviour of pests which can be beneficial for advanced planning of pest control. Efficient pest management leads to lower crop and environmental damage.

Water Management – Efficient water management in Indian agriculture can have a huge impact on the looming problem of water scarcity. Water usage in agricultural land can be optimized by using thermal imaging cameras that continuously monitor if crops are getting sufficient amount of water. CNN, coupled with appropriate image classification models, when used in agriculture can result in improving yield production, reducing manual intervention, and decreasing instances of crop diseases.

Price realization for farmers – Predictive modelling using CNN can be instrumental in presenting more accurate demand-supply information and predicting demand for agricultural produce to farmers.

Convolution Neural Network applications in Indian Agriculture:

Convolution neural network is the state-of-the-art machine learning technology, which shows superior performance in computer vision, bioinformatics, natural language processing, and other areas. CNN has great capability in image processing, which makes it widely used in Indian agriculture research. Most applications of convolutional neural network in agriculture can be categorized as plant or crop classification, which is vital for pest control, robotic harvesting, yield prediction, disaster monitoring etc.

- Plant disease detection is very time consuming when it is done manually. Fortunately, with the development of deep learning plant disease detection can be accomplished through image processing.
- CNN can also be used in weather forecasting, which is key problem to agriculture. Crop yield prediction before harvest is crucial to farmers,

consumers, and the government in their efforts to design strategies for selling, purchasing, market intervention, and food shortage relief.

- Convolutional neural network is also used in Land cover classification (LCC) is considered as a vital and challenging task in agriculture, and the key point is to recognize what class a typical piece of land is in.
- Agriculture Companies are leveraging computer vision and CNN algorithms to process data captured by drones and/or software-based technology to monitor crop and soil health.
- Convolutional neural network is also used to track and predict various environmental impacts on crop yield such as weather changes.
- CNN techniques are used for image-based anomaly detection solution to detect crop diseases from visual inspection of leaves.
- CNN algorithms, take decades of field data to analyse crops performance in various climates and new characteristics developed in the process. Based on this data they can build a probability model that would predict which genes will most likely contribute a beneficial trait to a plant.
- CNN algorithms study evaporation processes, soil moisture and temperature to understand the dynamics of ecosystems and the impingement in agriculture.
- CNN based applications are connected with estimation of daily, weekly, or monthly evapotranspiration allowing for a more effective use of irrigation systems and prediction of daily dew point temperature, which helps identify expected weather phenomena and estimate evapotranspiration and evaporation.
- Computer vision and CNN algorithms can improve detection and discrimination of weeds at low cost and with no environmental issues and side effects.
- CNN provides accurate prediction and estimation of farming parameters to optimize the economic efficiency of livestock production systems, such as cattle and eggs production.

Various CNN Algorithms:

There are various CNN algorithms available which have been applied in the field of agriculture. Some of them are

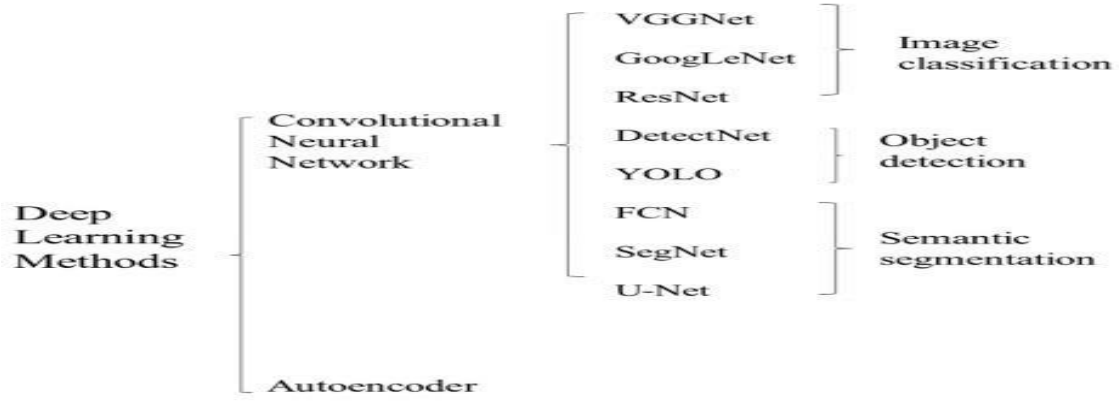

Figure 2: Various Convolution neural network algorithms

- **AlexNet (2012) –** In 2012, Alex Krizhevsky (and others) released AlexNet which was a deeper and much wider version of the LeNet and won by a large margin the difficult ImageNet Large Scale Visual Recognition Challenge (ILSVRC) in 2012. It was a significant breakthrough with respect to the previous approaches and the current widespread application of CNNs can be attributed to this work.
- **ZF Net (2013) –** The ILSVRC 2013 winner was a Convolutional Network from Matthew Zeiler and Rob Fergus. It became known as the ZFNet (short for Zeiler & Fergus Net). It was an improvement on AlexNet by tweaking the architecture hyperparameters.
- **GoogLeNet (2014) –** The ILSVRC 2014 winner was a Convolutional Network from Szegedy et al. from Google. Its main contribution was the development of an Inception Module that dramatically reduced the number of parameters in the network (4M, compared to AlexNet with 60M).
- **VGGNet (2014)** – The runner-up in ILSVRC 2014 was the network that became known as the VGGNet. Its main contribution was in showing that the depth of the network (number of layers) is a critical component for good performance.
- **ResNets (2015) –** Residual Network developed by Kaiming He (and others) was the winner of ILSVRC 2015. ResNets are currently by far state of the art Convolutional Neural Network models and are the default choice for using ConvNets in practice (as of May 2016).
- **DenseNet (August 2016) –** Recently published by Gao Huang (and others), the Densely Connected Convolutional Network has each layer directly connected to every other layer in a feed-forward fashion. The DenseNet has been shown to obtain significant improvements over previous state-of-the-art

architectures on five highly competitive object recognition benchmark tasks. Check out the Torch implementation here.

3. Results

In this study, a survey of CNN-based research efforts applied in the agricultural domain was performed. This survey examine various application of CNNs in Indian Agriculture; to examine the particular application in a smart farm, listed technical details of the architecture employed and overall prediction accuracy. We did a comparative analysis of applications of various CNN algorithms applied to various phases of agriculture like crop selection, sowing, preventing crops from diseases, harvesting, packaging, transporting, marketing, selling etc. being performed shown in Table 1. The aim of the current survey to motivate researchers to experiment and applying CNN algorithms to solve various agricultural problems in India.

CNN Models	**Parameters**	**Key Features and Pros/Cons**
LeNet	60k	First CNN model. Few parameters as compared to other CNN models. Limited capability of computation.
AlexNet	60M	Known as the first modern CNN. Best image recognition performance at its time. Used ReLU to achieve better performance. Dropout technique was used to avoid overfitting.
OverFeat	145M	First model used for detection, localization, and classification of objects through a single CNN. Large number of parameters as compared to AlexNet
ZFNet	4 2.6M	Reduced weights (as compared to AlexNet) by considering 7 × 7 kernels and improved accuracy
VGG	133M–144M	3 × 3 receptive fields were considered to include more number of non-linearity functions which made decision function discriminative. Computationally expensive

		model due to large number of parameters
GoogLeNet	7M	Fewer number of parameters as compared to AlexNet model. Better accuracy at its time
ResNet	25.5M	Vanishing gradient problem was addressed. Better accuracy than VGG and GoogLeNet models
DenseNet	7.1M	Dense connections between the layers. Reduced number of parameters with better accuracy
MobileNet	4.2M	Considered the depth-wise separable convolution concept. Reduced parameters significantly. Achieved accuracy near to VGG and GoogLeNet
VGG-Inception	132M	A cascaded version of VGG and inception module. The number of parameters were reduced by substituting 5 × 5 convolution layers with two 3 × 3 layers. Testing accuracy was increased as compared to many well-known DL models like AlexNet, GoogLeNet, Inception-v3, ResNet, and VGG-16.

Table 1: Comparison of state-of-the-art deep learning models.

The above table explains various CNN algorithms and their applications in agriculture.

4. Discussion

Convolutional Neural Networks (ConvNets or CNNs) are a category of Neural Networks that have proven very effective in areas such as image recognition and classification. Convolution neural network is the state-of-the-art machine learning technology, which shows superior performance in computer vision, bioinformatics, natural language processing, and other areas. This study presents applications of deep

learning in India agriculture, in particular the the areas of plant and leaf disease detection, plant recognition, land cover classification, fruit counting and identification of weeds belong to the categories where the highest precision has been observed. In this survey we discussed various CNN algorithms and compare them with respect to their applications in agriculture.

The aim is for the current survey to motivate researchers to experiment with CNN and Deep learning in general, applying them to solve various agricultural problems involving classification or prediction, related not only to computer vision and image analysis, but more generally to data analysis.

5. References

1. R. Bongiovanni and J. Lowenberg-Deboer, "Precision agriculture and sustainability"., Precis. Agric., vol. 5, no. 4, pp. 359–387, doi: 10.1023/B:PRAG.0000040806.39604.aa, 2004.
2. Katherine Milla and Alfredo Lorenzo, "GIS, GPS, and remote sensing technologies in Extension services: Where to start, what to know"., Journal of Extension., Volume 43 no. 3, 2015.
3. S Kaiming He, Xiangyu Zhang, Shaoqing Ren and Jian Sun, "Delving Deep into Rectifiers: Surpassing Human-Level Performance on ImageNet Classification"., IEEE International Conference on Computer Vision , 1026-1034 (2015). doi: 10.1109/ICCV.2015.123.
4. Karishma Mohiuddin and Mirza Mohtashim Alam, "Plant species classification using deep convolutional neural network"., ACTA SCIENTIFIC AGRICULTURE, ISSN: 2581-365X, Volume 3, Issue 5, 2019.
5. Mads Dyrmann, Henrik Karstoft and Henrik Skov Midtiby, "A Short Review on Agriculture Based on Machine Learning and Image Processing"., Biosystems Engineering, Volume 151, Pages 72-80, doi: https://doi.org/10.1016/j.biosystemseng.2016.08.024, 2016.
6. Zewen Li, Wenjie Yang, Shouheng Peng and Fan Liu, "A Survey of Convolutional Neural Networks: Analysis, Applications, and Prospects"., arXivLabs. https://arxiv.org/abs/2004.02806v1, 2020.
7. Ahmed S. Shamsaldin, Pola Fattah and Tarik A. Rashid, "A Study of the Applications of Convolutional Neural Networks"., UKH Journal of Science and Engineering., doi: 10.25079/ukhjse.v3n2y2019.pp31-40, 2019.
8. Patrick Gikunda and Nicolas Jouandeau, "State-Of-The-Art Convolutional Neural Networks for Smart Farms: A Review"., Intelligent Computing - Proceedings of the Computing Conference., pp 763-775, 2019.
9. Sharma, S., Shanmugasundaram and K., Ramasamy, "FAREC — CNN based efficient face recognition technique using Dlib"., International Conference on Advanced Communication Control and Computing Technologies (ICACCCT)., doi: 10.1109/ICACCCT.2016.7831628, 2016.
10. LeCun, Y., Bengio, Y. and Hinton, "Deep learning"., Nature **,** volume 521, pages436–444(2015).