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Crop Weed Discrimation Using Machine and Deep Learning Approaches: A Review on Recent Developments

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ABSTRACT

Recently, agriculture has gained wide attention in field of automation and smart farming with the help of machine learning and deep learning technique inclusion. Significant improvement have been observed in agricultural task. In this review paper, problem regarding crop weed discrimination is discussed and ML model helps to distinguish it from crops with various automation and robotic features. Performance regarding recent studies are observed and drawn to have comparative study of different ml approaches used in each articles. Deep learning techniques outperformed the traditional method of discriminating crop weed. Thus it is very important for economy and environment also to use such smart method so that chemical sprayers usage get optimises and effective in particular crops. Finally, research gaps from previous studies and innovative future directions are also noted to help to excel proper automation in agriculture up to the next level.

KEYWORDS: Machine learning, deep learning, convolutional neural network, crop weed detection, agricultural robotics

INTRODUCTION

Agriculture assumes a vital part in the worldwide economy. Pressure on the farming framework will increment with the proceeding with extension of the human populace. Agri-innovation and precision agriculture, presently named as digital agriculture, have emerged as new logical fields that utilize data in serious ways to deal with horticultural efficiency while limiting its natural effect. The information created in present day rural tasks is given by a wide range of sensors that empower a superior comprehension of the functional climate (a communication of dynamic harvest, soil, and atmospheric conditions) and the actual activity (apparatus information), prompting more precise and quicker direction.

Crops are the soul of human progress, filling in as the underpinning of our food supply and fundamental for supporting life on the planet. Their significance couldn't possibly be more significant, as they give the food and sustenance expected for the prosperity and endurance of billions of individuals all over the planet. Furthermore, crops have extensive ecological importance, affecting soil wellbeing, biodiversity, and the general equilibrium of environments. In a world tested by environmental change and a developing populace, the meaning of yields in guaranteeing food security, financial steadiness, and ecological manageability can't be put into words, making their development and protection a question of fundamental significance for current and people in the future.

Weeds can unfavourably affect various harvests, presenting critical difficulties to horticulture. These undesirable plants rival developed crops for fundamental assets like daylight, water, and supplements. Accordingly, they can lessen crop yields by restricting their admittance to these essential assets. Also, a few weeds discharge poisonous synthetic substances that hinder the development of neighbouring plants. To battle the adverse consequence of weeds, ranchers frequently utilize different methodologies, like manual weeding, herbicide application, or carrying out incorporated weed administration practices to limit crop misfortunes and guarantee a sound, useful reap.

Different harvest weed segregation procedures have been created to recognize developed crops and undesirable weeds in horticultural fields. These strategies influence progresses in innovation and incorporate techniques like remote detecting through satellites or robots, PC vision utilizing AI calculations, and ghastly examination with particular hardware. These segregation strategies help in productive weed administration as well as add to practical farming by lessening the dependence on compound herbicides and limiting yield misfortunes because of weed contest.

Machine learning (ML) has emerged together with big data technologies and high-performance computing to create new opportunities to unravel, quantify, and understand data intensive processes in agricultural operational environments. Among other definitions, ML is defined as the scientific field that gives machines the ability to learn without being strictly programmed.

In this paper, we present a comprehensive review of the application of ML in agriculture. A number of relevant papers are presented that emphasise key and unique features of popular ML models.

CROP/WEED DISCRIMINATION AND CLASSIFICATION OF WEEDS

Crop and weed discrimination is an important task to address due to its usefulness in determining the amount of chemicals required for controlling the weeds in different crop cultivation. Most of the studies were conducted for crops like rice, cotton, tobacco etc. The machine learning approaches were prominently applied for agricultural operation.

For example, the discrimination between crop (i.e., rice) and weed was performed in [1] using machine learning approaches to automatically identifying and distinguish. It proposed and developed an intelligent agent which uses sensor to automate the process of distinguish between rice and weed. It uses Harris corner detection technique as a pre-processor to detect the point of intersection and localized it. Tips of roots/ branches/leaves from both weeds and rice are the corner points. It compares various ml algorithm like SVM, decision tree and Naïve bayes to get the optimum result in classifying weed. Likewise in [2] maize crop is selected to be discriminated from weed. It consist of 2 subsystem i.e., Fast Image Processing (FIP) and Robust Crop Row Detection (RCRD). FIP deliver result in real time and RCRD correct the first subsystem's mistake and deliver the accurate result. This approach produce a system which provide a good result and is acceptable under very difficult condition. For a real-time processing of weed discrimination in canola field [3] , it uses maximum likelihood classification and deep convolutional neural network. It developed a methodology to accelerate manual labelling of pixel by 2 step procedure. Various ml approaches like deep learning meta architecture (Seg Net & UNET) and encoder blocker like (VGG16 & ResNet50) are compared to optimise the end result as feature extractor and meta agriculture. Using line detection technique, it classify plant in a row as host plant and plant falling out of seeding as weed. Semantic segmentation in this paper is proving helpful for weed detection and weed mapping. Agrochemicals causes environmental pollution and other threat to the whole health system of earth. A tractor- mounted boom sprayer is introduced in [4] to spray precise dose of agrochemicals on tobacco crop. For this, here introduced SVM classifier with feature (texture, shape & colour) has proposed and compared with DL for more accurate performance in terms of easier detection of weed to optimise the amount of spray to be rested in field thus helps in protecting environment also from excessive chemical over-poured. A research was conducted on rice field by UAV for monitoring the growth of rice and protecting it from weeds. With the aim of image recognition, it collect dataset of captured rice image then CapNet is built to discriminate rice from weed. Various pre-processed method like histogram equalization and superpixel algorithm are used for image conservation and superpixel segmentation. CapNet perform reverse analysis using its five layers i.e., input layer, convolution layer, primary capsule layer, digital layer and output layer. All layers are trained to classify and predict output vector based on its step to step agreement protocol. Thus it provide more convenient method than traditional one in classifying weeds.

In [6] for detection of weed from crop in the field of sugar beets, image dataset of sugar-beet are collected by RGB image then image pre-processing is done through (i) Image enhancement (3 method for different condition to improve model robustness) (ii) Histogram equalization (for grayscale conversion) (iii) Auto contrast and deep photo enhancer. Thus input produced and optimized by comparing different I/P representation. It uses encoder decoder neural network architecture for pixel wise semantic segmentation. This is how it achieves classification in sugar beet. In [7], the research aims to provide a simple image processing technique for detection and distinguished crops (cotton) using drone based imagery. Cotton is used due to its different spectral characteristics. Then it create HSV image from RGB and analyse it for setting upper and lower parameter and applying test algorithm. Here, fuzzy reasoning method is used for classification.

ML APPROACH FOR CROP/WEED DISCRIMINATION

After the development of machine learning, many models are implemented for real-time application. Among those models, neural network, deep learning, CNN produced significant result for many classification task. Similarly agricultural operations have also been performed with the implementation of these architectures through robots. ML approach has reported a complex agricultural task of crop/weed discrimination through real-time robotic system. It performs the operation through various ML approaches and whichever outperform others will become its concluded result and it has higher performance and efficiency than others.

In [1] the authors presented an intelligent agent which can use sensor to automate the process distinguish between crop and weed. Here, rice as a crop is used and ML algorithm like SVM, Decision Tree and Naïve bayes are used to classify weed from rice. Decision Tree deliver best classification result. Its approach is to collect sample data and do pre-processing with the help of Harris point finder and then ML algorithm will be used after that. A real time image processing for crop/weed discrimination in maize field in [2] is performed with Real time image processing. Approaches like FIP and RCRD are used to deliver result in real time with correction and achieve its performance. Weed detection in canola field is done using maximum likelihood classification and deep CNN [3]. Maximum likelihood classification determine values for the parameter of the model and parameter are just blueprint for model based on that algorithm work. This approach is widely used in recent studies semantic segmentation is used for detection and mapping of weed. In [4] Identification of Tobacco crop is based on Ml for precision agriculture sprayer. Here, SVM and customized DL are approached to perform and get result. SVM perform very well in terms of efficiency and DL performs best in accuracy i.e., 100%. Their objective was to develop vision based learning model for detection of crop and weed which is very demanding nowadays. Capsule network is high in demand in [5] for crop detection having Rice as crop again. It used Histogram equalization method and SLIC algorithm for pre-processing. Various ML algorithm like SVM, CNN, CapsNet are compared to get accurate result and it was found that CapsNet is better than SVM (in terms of speed) and CNN (in terms of minimal overlapping images). Likewise semantic segmentation of crop and weed using encoder- decoder neural network has achieved higher MIOU (mean intersection of union) that is significantly higher than traditional model using UNET [6] and it doesn't require large amount of data for model training which depicts its efficiency. Another research was conducted to classify crop i.e., cotton and weed by the implementation of High Resolution Aerial Imagery through UAV (unmanned Aerial System) and novelty of the work was that after 20 iteration, objective was achieved. The proposed method used fuzzy reasoning based tactics

combined with RGB and HSV color space and spotted the white cotton ball successfully. It is recommended to use multiple classed to provide better result of applied method.

To conclude, many UAV and robotic system which works on real time application have been implemented on agricultural field like rice, tobacco, maize, cotton, beet etc, for performing crop/weed discrimination by state of the art ML models.

These successful ML model should be tested on other crops also and in real time working field. Moreover, such smart herbicider sprayer should be deployed to minimize cost and weed perspectively in agricultural fields.

These are the various machine learning approaches which we are going to compared and review it for crop/weed discrimination and make out a best way possible for future scope with each logic and methods used.

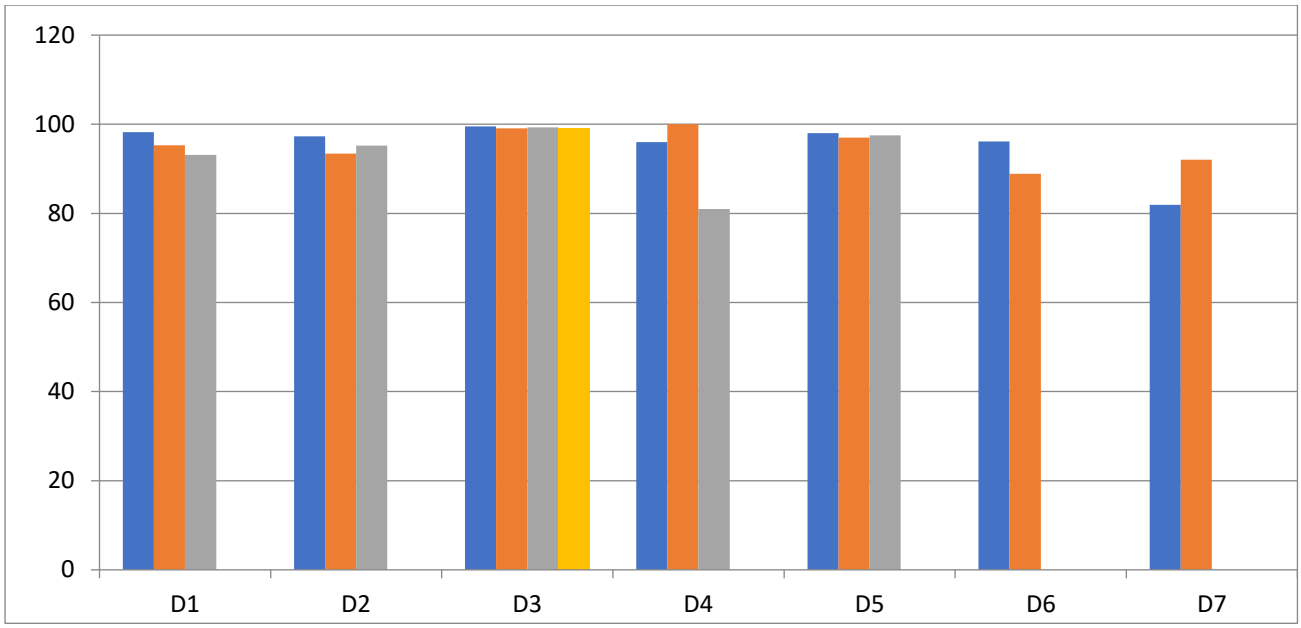
A summary of machine learning approaches used for various agricultural crops

Reference	Crop	ML Algorithm	Sensor	Features	Accuracy
[1]	Rice	Decision Tree, Support vector machine & Naïve Bayes	RCB camera	Texture and color	0.982 by DT, 0.953 by SVM and 0.931 by NB
[2]	Maize	Fast Image Processing(FIP) and Robust crop row detection(RCRD)	Conventional vieo camera	Size and shape	95% of weeds and 80% of crops detected
[3]	Canola	Maximum likelihood classification and deep CNN	RGB color camera	Color and size	0.9948 by SegNet-ResNet50
[4]	Tobacco	SVM and CNN	RGB color camera	Shape, color and texture	96% by SVM and 100% by CNN but perform slower than SVM
[5]	Rice	SVM, CNN , CapsNet	Digital color camera	Color, texture and size	CapsNet>(SVM & CNN)
[6]	Sugarbeet	Deep network and image enhancement(NIR)	UAV	Color, size	88.91% MIOU value
[7]	Cotton	Neural network, ANFIS	UAV, RGB and HSV color camera	Color, size	Successfully marked all visible cotton balls

PERFORMANCE COMPARISON OF ML MODELS

Performance of ML algorithm described in this section is presented below in Fig.1. ML models are grouped by their respective researched articles (designated as D1, D2, D3 and so on) which are cited in Fig.2. These figures will addressed the research questions arise in 'Introduction' regarding its performance, speed, reliability & future scope, which we commonly used during the implementation. It should be notes here that DL/ANN algorithm perform superior as compared to traditional ML model algorithm. Like [1] evaluated that Decision Tree(DT) outperformed support vector machine(SVM) and naïve bayes (NV) for rice production ; as described in [2] reaching 95% and 80% of weed and crop hit by using FIP and RCRD models ; SegNet perform slightly better than UNET in [3] as Resnet50 show best result over union value; for crop like Tobacco [4] , SVM perform well with higher accuracy than DL; in [5] for crop rice, CapsNet is much better than SVM and performance is also superior to CNN model; an encoder decoder deep learning network give effective result as compared to traditional ml model for sugar beet crop [6] ; Fuzzy reasoning based tactics are used in [7] to manipulate image color pixel value. Therefore, upcoming research should incorporate any of the agricultural task by using successful deep learning models and its performance should then be tested offline before its implementation.

Performance comparison chart of ML models for crop/weed discrimination



D1, D2, D3, D4, D5, D6 & D7 are crops from [1], [2], [3], [4] … and so on. This performance chart indicate its percentage in various ml approaches.

CONCLUSION

In this review, Machine and deep learning algorithm are used to deal with agricultural task Robotic solution presents its way to deal with real time problem. Moreover, performance comparison of various crops working on various approaches are drawn to indicate its effectiveness for the respective task – crop/weed discrimination is addressed and performed on different crop with the help of ML approach. Various algorithms and approaches are dealt to solve the discrimination problem. It is also shown that DL approach outperform traditional ML algorithm due to their broad network and real time adaptability. Significant development are also observed in recent studies and important research gaps are identified to boost the agricultural field of further research.

A brief summary of prominent result obtained from ML approaches are presented below based on the crop level and their accuracy to deal weed discrimination.

(a) In [1], the well known Decision Tree algorithm (0.982) outperformed the traditional ML algorithm including SVM (0.953) and Naïve Bayes (0.931).

(b) In [2], FIP deliver real time result but accuracy is compromised while RCRD correct the previous mistake and they both found that 95% of weed and 80% of crop, humidity & crop/weed growth condition.

(c) In [3], ResNet50 show best result with MIOU value of 0.8288 and frequency weighted intersection over value of 0.9869.

(d) In [4], SVM outperformed the traditional method with accuracy 96% and customized deep learning got accuracy of 100% best perform slower on Rasp pi4.

(e) In [5], CapsNet is much better than SVM (for large amount of data picture) and performance is superior to CNN (for identifying overlapping pictures).

(f) In [6] & [7] also Deep network applied to perform and it doesn't require large amount of data.

FUTURE SCOPE

- Out of 7 agricultural crops, weed detection lacks a comprehensive study. They should be performed by online approach i.e., robotic system through deep learning architecture.
- When DL algorithm are applied, a combination of engineers and agronomist is required to implemented chemical spraying system which on applying to detected part of crop reduces the cost of crop protection system.
- Most of the approaches are oriented towards plant leaves only, but defects in other parts of crop can also be found if searched.
- Diversity in dataset is required to extract all the left properties of crop properly.

- Inclusion of more weed type should be done to differentiate from crop.
- It is necessary to increase more sample under different extraction condition.
- Automatic Identification of crop discrimination is the best approach for better growth of agricultural products with minimal cost and lots of algorithm.
- Work should be done in minimizing the herbicide dosage, using expert knowledge and control spraying bar in real time.
- Soil proportion will be included in study to facilitate variable herbicide prescription of different soil zones.
- Focus should be on compression so that trained model can be applied on mobile platform with less computing capability.
- Neural network application with fuzzy logic such as Adaptive neuron fuzzy inference system (ANFIS) can be included.
- Saliency map should be applied to advance visualization technique.
- A recent topic like Internet of Robotic things should be deployed for different crop. It would be able to explore new research area in agricultural field.

Research gaps from the reviewed articles implemented ML model for crop/weed discrimination

Research gaps/future scope	References
The result is obtained under controlled environment which leads to research gaps instead of this real environment with larger dataset will be helpful.	[1]
Determine optimum herbicide dosage could saved cost and environment.	[2]
A larger dataset of pixel level image could help in performance improvement.	[3]
Fuzzy logic based control could help to estimate the precise amount of chemical sprayer and more real time site specific details.	[4]
Multiple classes and samples could be more beneficial to prove the robustness of applied method.	[5]
Inclusion of NIR spectroscopy for improved segmentation accuracy.	[6]
Inclusion of Fuzzy logic would suffice the performance.	[7]

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