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# Weed detection by using image processing

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**ABSTRACT**

In agricultural regions, the procedure of weed removal is crucial. Weed removal in the classic way, takes longer and requires greater physical effort. The idea is to eliminate weeds from agricultural fields automatically. The proposed study uses a deep learning algorithm to detect weeds growing between crops. Deep learning method also known as deep learning is used to analyse the main properties of agricultural photographs. Weeds and crops have been identified using the dataset. Convolutional neural network (CNN) uses a completely attached surface with rectified linear units (RELU) to differentiate weed and crop. It extracts features of crop using deep learning. The CNN uses features of proceeded image to extract region of interest (ROI). A deep learning network features are used to identify crop. In total of 1280 images are used for testing the system, and 10 images are used to find the confidence score.



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## 1. INTRODUCTION

The need of food in world is increasing day by day. There is shortage of water, land, labors for the farming. There is need to improve agriculture outcome of the farmers. The appropriate herbicides are to required to remove weed and increase production of crop. Crop and weed need to be differentiated to remove weed from crop with less efforts. To remove weed from crop with less efforts its correct identification is must. Herbicides should not affect on the crop at farm. Convolutional neural network (CNN) is a technique used to identify weed correctly. The images are captured using camera and with the help of deep learning techniques weeds are detected. After detecting the weeds it is remove from the crop using herbicides [1]–[7].

The methods proposed in the literature for detection of weeds are either specific to a particular crop, or the algorithms stated are not as efficient as in the proposed work [7]–[15]. The use of drones, robots is also included in few of the papers in the literature [16]–[24]. The use of robots and drones increases the cost overhead of the project. The proposed system is affordable and efficient as compared to the existing systems proposed in the literature. The factors like more cost, less efficient algorithms, to remain specific for a particular crop is the motivation behind the proposed system. The proposed system uses CNN algorithm to identify weed from crop. The features of weed are recognized using deep learning techniques. The main features of the weed images are identified using deep learning. The subsequent sections of this paper describes literature survey, methodology followed by result analysis [25]–[31].

Yu *et al.* [1] stated herbicide utility can notably reduce herbicide statistics and weed manage fee in turf weed. Spot showering relies upon on device imaginative and prescient-primarily based totally identifiers for unbiased weed manage. This work uses totally relies on correct identification of weed. Osorio *et al.* [2] stated weed management is one of the important component; understanding area of concern dealing with weed images. This paper describes strategies for weed evaluation in mild of profound studying photo dealing visible tests with the aid of using professionals. Tiwari *et al*. [3] stated weeds gift within side the harvests cause a decrease in crop creation. The weeds soak up supplements to be used for crop. So, a way needs to be find to detect the weed and herbicide to be showered to remove from crop.

Umamaheswari *et al*. [4] stated people's organization is taught approximately, the financial problems of insecticides used for weed. There is a continuously growing hobby for meals to be met with the aid of using agribusiness makers. To reduce the ecological problems and deal with meals security, IoT is primarily based totally on accuracy in farming. Accuracy in agriculture reduces capital expenditure and increase quality of product and it use. Badhan *et al*. [5] proposed a actual weed detection framework based on AI. A sound absed gadget and 3-D harvest creation is used.

A motion based technique is used to create 3-D factor. The AI based version for cucumber and Onion crop is prepared with the help of suitable dataset. Sarvini *et al.* [6]-described weed identification is very essential for crops, weed is dangerous for crops. The ordinary techniques of weed identification are very time consuming and ineffective. The tradition technique of weed detection requires lot of efforts. The AI based techniques are more suitable and accurate for the weed detection.

Jin *et al*. [7] proposed any other approach in a contrary method, a detailed studying and photo coping with innovation. In a clear way an organized CNet version changed into applied to differentiate greens and draw bouncing packing containers round them. Thereafter, the leftover inexperienced articles are losing out of leaping packing containers that have been taken into consideration as weeds. The version spotlights on spotting simply the greens and therefore, attempts now are no longer to address one-of-a-kind weed species.

Asad and Bais [8] described increasing use of in farming to increase production, in different weather conditions and the environment. To avoid detrimental effects accuracy in agriculture process is required. The evaluation made using advanced PC imaginative and prescient strategies like profound studying calls for big marked agribusiness information. Liu and Bruch [9] described weed area frameworks are big solutions for one of the cutting-edge rural problems that unmechanized weeds manipulate. Weed vicinity moreover offers a technique for reducing or taking away herbicide use, assuaging agrarian ecological and wellness sway, and in addition growing maintainability. Le *et al.* [10] described a FT_BRC photo dataset (disbursed on line with three thousand plus weed images) is changed into an accrued through a digital brought on a compact streetcar below common-sense discipline situations from an enterprise. The results of weed are damaging for crop so weed detection is required.

As a summary of the existing work it is observed that, in the literature either several deep convolutional neural networks are used, or there is use of drone technology, IoT based architecture, use of color images, use of machine learning algorithms, weed detection in only soybean crop, manual labeling of pixels or autonomous weed control using robots. All the techniques suggested in the literature are limited, with an increased cost overhead or are not efficient. The complete efficient and automated solution for weed detection is not provided by any of the authors. The summary of the literature survey is given in Table 1 in Appendix.

Weed is harmful to crop as it sucks the required nutrition from the land. The visual based identification is a basic method of manual crop detection. The manual process needs more labor and time as well. The more use of herbicides is dangerous for environment, health and crop. The solution is to use image processing and deep learning techniques to detect weed correctly from crop. The proposed system describes a method of weed identification and classification.

## 2. METHOD

### 2.1. Image acquisition

The proposed methodology is developed using a dataset of weed images. The methods extracts weed using the tasks followed by images capture, edge identification, and image type identification. Weed images are captured using high quality camera. The images are compared with images stored in the dataset. New images are contentiously added in the dataset. The accuracy of the proposed system increases as the number of records in the dataset are more.

### 2.2. Image pre-processing

Image processing module performs some basic processes to get required picture for processing. To obtain accurate and clear image, the algorithm performs various operations like gray scale, conversion, sharpening, filtering, edging, smoothing and image segmentation. The quality of image is improved in pre-processing phase by improving image features and reducing noise. The black and white photos are of different shades of gray. The value of each pixel is measured of the gray scale image.

The quality of image in the form of sharpness, smoothness is improved using various tasks in the image pre-processing. The images are made more sharp with the help of filters. Noise is minimized of the image with the help of smoothing. Multiple algorithms are used to enhance quality and sharpness of the image in the task of image pre-processing. The image pre-processing is the very important, required and fundamental step in the image identification.

### 2.3. Image segmentation

There are set of operations included in the image recognition. The image recognition have a diversified set of applications including number plate recognition, and CCTV surveillance. In the process of image segmentation the actual image is translated into binary valued image using maximum valued method. The digital image is characterized into several parts depending on the values of the each image component. The pixels with similar values are clubbed. The values are used to identify different portion of image. In short image characterization process is usd to extract key features of the object for future analysis.

### 2.4. Feature extraction

The system does further operations on the separated picture in this module. The module deals with feature extraction to extract overall information of the weed image. The image processing, machine learning help to classify weed images. The important features of the weed images are extracted and used for classification based on the range of values. The main point in the image classification is to identify most dynamic features for classification of images. The feature extraction is a key in the image processing to handle the image for various operations like dimension reduction.

### 2.5. CNN algorithm

The weed detection is done using CNN algorithm. The layers of CNN like input, processing and output does the work of weed image identification. The image denitrification further leads to image classification. The massive developments in ultimating the distance among human and machine capabilities is achieved using the techniques of machine learning and artificial intelligence. The CNN results are amazing in the area of image processing and classification. The area of machine imaginative and prescient is certainly considered one among numerous such disciplines.

The aim of this area is to allow machines to look and understand the sector within side the identical manner that people do, and to apply that understanding for a number of responsibilities inclusive of image recognition. The image feature extraction, creation of value vector, clarification training testing etc are the major components comes with CNN algorithm. The image captured using high quality camera is a input for CNN, the weights are assigned to the various factors of the image with the help of extracted features and images are distinguished depending on the feature vector values.

### 2.6. Classification

In the classification section deep learning algorithm is used for actual classification on the basis of its features. The weed identification is based on the characteristics of weed i.e. set of values. The values decides the type of weed. The feature vector is used to identify weed using CNN algorithm. The phases of CNN like training, testing are used for actual classification of weed. The classification and identification of weed is the end result of this work. Figure 1 shows the block diagram of proposed system.

As shown in the Figure1 the image is captured using camera, the image is pre-processed, features are extracted and classification is done. The classification leads to the identification of image. The training of the image is again performed using three phases. Input image, image pre-processing, feature extraction are three stages used in the training phase. The pre-processing phase makes the image more clear all the borders are pixel values are extracted in this phase. The values identified in the pre-processing phase are used for training of the module.

The feature extraction phase mainly used for identification of key features of the of the images. On the basis of key features the training and testing of the images is enriched. The training phase stores data of all such weed images for the further identification of weed images. The more data records in the dataset increases accuracy of the training set. The training set is used as a input for the classification of weed images. The proposed module gives a accurate platform for weed detection as shown in the Figure1. The end result of this module is identification of weed.

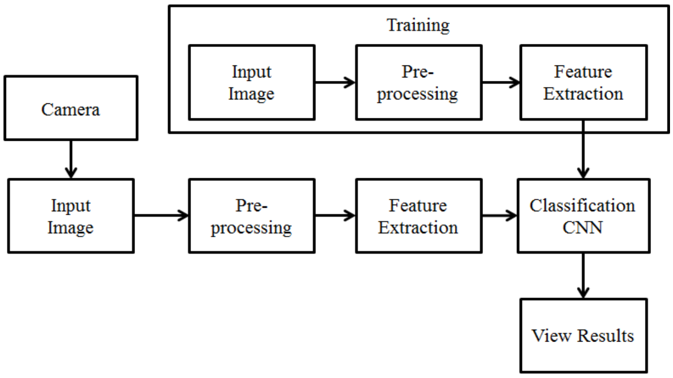



Figure 1. Block diagram of system

## 3. RESULTS AND DISCUSSION

This section discusses the results obtained from proposed system. The Figure 2 gives the System user interface of working module of weed detection software system. The Figure 2 is divided in six components. The details of each component is described in subsequent paragraphs. Figure 2(a), shows the home page of the system weed detection system. In the proposed system, the CNN algorithm is used for weed detection. In Figure 2(b), registration page of the weed detection is shown. For this registration, the user can enter the username, password, and password confirmation to register in the system. In Figure 2(c), the login page of the weed detection system is shown. For logging in to the system, the user will have to enter the username, and password. In Figure 2(d), the page of upload image for the detection of weed is shown. In this page, the user can choose the input image for detection of a weed in that image. In Figure 2(e), the result of weed detection is shown. By using the CNN classifier, the system can detect the weed accurately given in this Figure 2(e). This system predicts the result by using the CNN classifier. The weed is not detected in the given image. The system takes the image as an input and by using the CNN classifier algorithm, it detects whether the given image is a weed or not. The system refers the dataset to identify the weed. In Figure 2(e), it shows that the resulting image is not a weed. In Figure 2(f), the result of weed detection is shown. By using the CNN classifier, the system is able to accurately detect the weed in the figure. This system predicts the result by using the CNN classifier. The Figure 2(f), shows that the weed is detected.

As shown in Figure 3, total of 1,280 images are used for testing the system, and the system was able to detect a weed in 1,260 of those images successfully. It means the accuracy of this system is more than 98%. The number in a green coloured box shows the number of correctly identified weed images. Where a faint red coloured box, shows the number of not identified images. Figure 4 shows the performance of proposed system. Figure 4(a), gives comparison of accuracy of existing system and proposed system. The existing systems uses weed detection techniques based on image processing only without the use of the CNN algorithm. The proposed system has better accuracy as compared to the existing system. The confusion matrix Class1, Class2 training modules are shown in the Figure 3. In Class1, the input photos are 909, and the system achieved an accuracy of 98.46 % and precision of 0.99 % while training the classifier with the supplied input database. Because the 909-classifier failed to classify 8 photos as an output form of a class1, recall is reduced to 0.99 %, and F1 score is also reduced to 0.99%. In Class2, the input photos are 391, and the system achieved an accuracy of 98.46 % and precision of 0.97 % while training the classifier as a train with the given input database. As a result of the 391-classifier failing to detect 12 photos as an output form of a Class 2, recall has been reduced to 0.98 %, and F1 score has been reduced to 0.97 %. It can be concluded that our system's performance is better with 98.46% after looking at the above performance parameters.

The Figure 4(b), shows performance of the system based on the parameters accuracy, precision, recall, and F1score. The Figure 4(a), shows that the overall performance of the system is 97% or above for both the classes. Figure 4(b) referees Class1 and Class 2 images mentioned in the Figure 3. The accuracy, precision, recall and F1 score measurements are calculated by the system of Class 1 and Class 2 respectively s shown in the Figure 4(b). Table 2 gives confidence of each of the images. The score shows the accuracy of weed detection of the system for a particular image.

In Figure 5, the confidence score of the images is shown with the help of a graph. The graph of confidence score against images is plotted for ten images. These ten random images were taken for testing, which were not used for training and this system was successful in identifying the weed from those images. The results show the ability of the system to capture low level features to improve the ability to detect small objects. Hence, the average confidence score of the system is more than 98%.

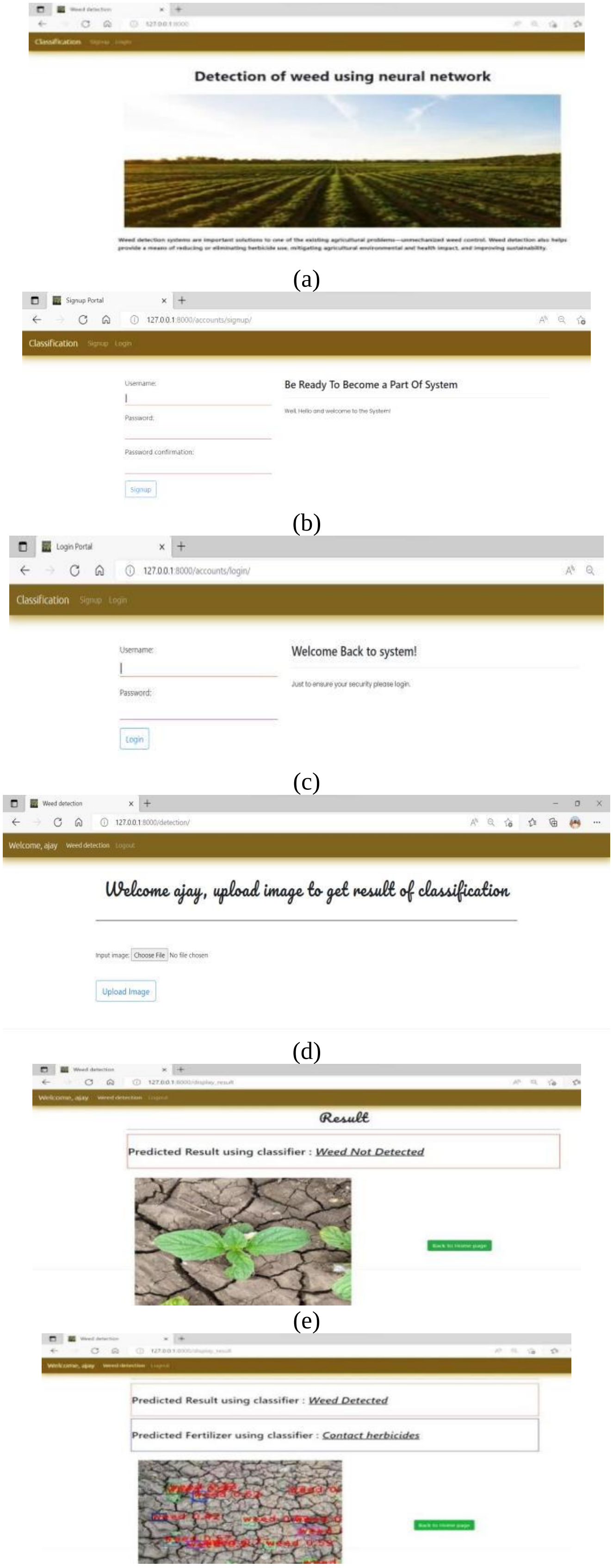



Figure 2. System user interface (a) home page, (b) registration page, (c)login page, (d) input image, (e) result weed not detected, and (f) result weed detection

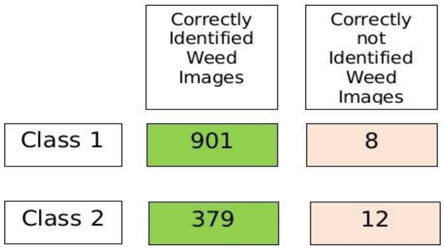
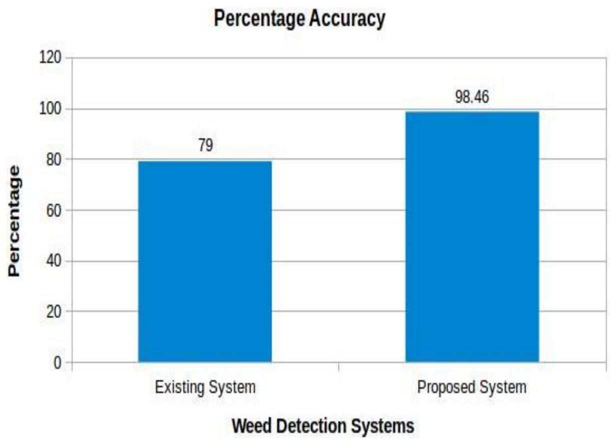
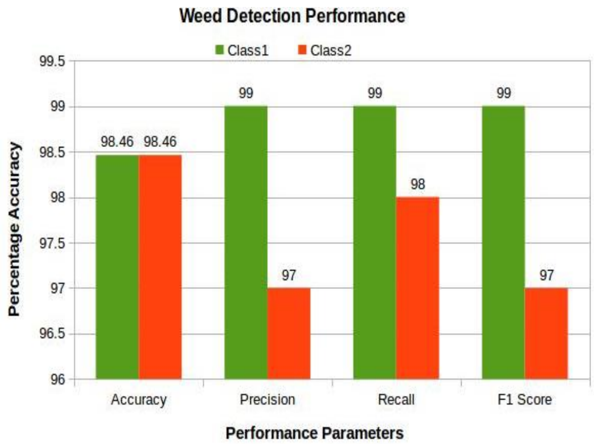



Figure 3. Dataset for testing the system




(a)




(b)

Figure 4. Performance of proposed system (a) accuracy comparison and (b) system performance

Table 2. Confidence score of weed images

| Weed images | Confidence score |
|---|---|
| Image 1 | 98.67 |
| Image 2 | 99.46 |
| Image 3 | 97.54 |
| Image 4 | 99.28 |
| Image 5 | 94.49 |
| Image 6 | 97.54 |
| Image 7 | 99.67 |
| Image 8 | 96.24 |
| Image 9 | 98.15 |
| Image 10 | 97.48 |

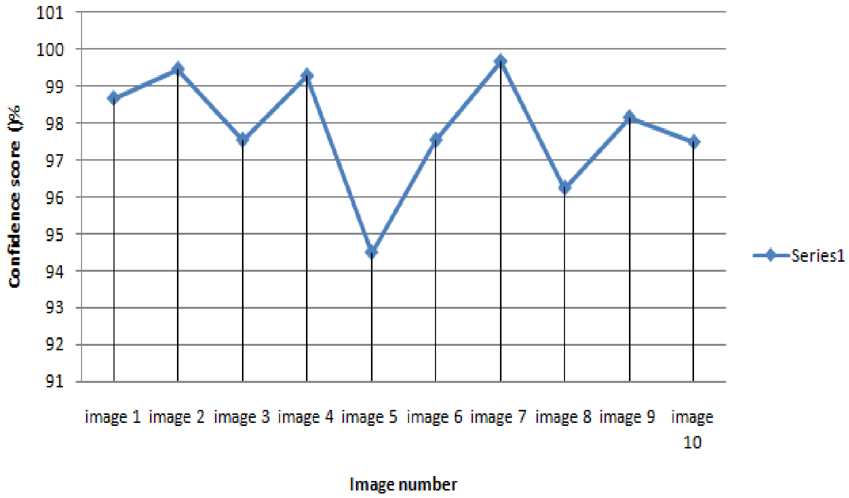



Figure 5. Confidence score of images

## 4. CONCLUSION

To improve production of farmers the weed removal plays vital role. There is a need to distinguish weed and crop. The proposed work uses CNN to extract key features of weed images. The image processing and feature extraction using CNN is a base of the proposed work for identification of weed. Deep learning approach is used to process captured image, assign the values to key attributes as per its features extracted. On the basis of various valued attributes of image the weed images are distinguished and identified. The proposed system uses CNN based approach for image characterization so the accuracy of the the system is more. The future work of includes automation in the process of weed removal from the crop.

## APPENDIX

Table 1. Summary of literature survey

| Sr. No. | Paper title | Author | Publication | Remark |
|---|---|---|---|---|
| 1. | Weed detection in perennial ryegrass with deep learning convolutional neural network | Yu *et al.* | 2019 | CNN techniques are used in the paper for detection of a certain type of weed. |
| 2. | A deep learning approach for weed detection in lettuce crops using multispectral | Osorio *et al.* | 2020 | Three methods based on deep learning are suggested for weed identification. |
| 3. | An experimental set up for utilizing convolutional neural network in automated weed detection | Tiwari *et al*. | 2019 | In association with CNN drone technology and deep learning us used. |
| 4. | Weed detection in farm crops using parallel image processing | Umamaheswari *et al.* | 2018 | IoT systems are used for agriculture work |
| 5. | Real-time weed detection using machine learning and stereo-vision | Badhan *et al*. | 2021 | A motion based technique is used to create 3-D factor. |
| 6. | Performance comparison of weed detection algorithms | Sarvini *et al*. | 2019 | AI based techniques are for the weed detection. |
| 7. | Weed detection in soybean crops using convnets | Ferreira *et al.* | 2017 | A weed identification from soyabin crop is done using CNN. The images of soyabin crop is used as a base. |
| 8. | Weed detection in canola fields using maximum likelihood classification and deep convolutional neural network | Asad and Bais | 2019 | The technique of pixel labeling with human help is used in this work. This process is carried in two parts. |
| 9. | Weed detection for selective spraying: a review" published online | Liu and Bruch | 2020 | The work means to reduce use of herbicides by identifying the weed accurately. The health, environment , sustainability parameters are also considered. |
| 10. | Detecting weeds from crops under complex field environments based on faster RCNN | Le *et al.* | 2021 | Photo dataset is changed into an accrued through a digital brought on a compact streetcar below common-sense discipline situations from an enterprise. |

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## REFERENCES

[1] J. Yu, A. W. Schumann, Z. Cao, S. M. Sharpe, and N. S. Boyd, "Weed detection in perennial ryegrass with deep learning convolutional neural network," *Frontiers in Plant Science*, vol. 10, Oct. 2019, doi: 10.3389/fpls.2019.01422.

[2] K. Osorio, A. Puerto, C. Pedraza, D. Jamaica, and L. Rodríguez, "A deep learning approach for weed detection in lettuce crops using multispectral," *AgriEngineering*, vol. 2, no. 3, pp. 471–488, Aug. 2020, doi: 10.3390/agriengineering2030032.

[3] O. Tiwari, V. Goyal, P. Kumar, and S. Vij, "An experimental set up for utilizing convolutional neural network in automated weed detection," in *2019 4th International Conference on Internet of Things: Smart Innovation and Usages (IoT-SIU)*, Apr. 2019, pp. 1–6, doi: 10.1109/IoT-SIU.2019.8777646.

[4] S. Umamaheswari, R. Arjun, and D. Meganathan, "Weed detection in farm crops using parallel image processing," in *2018 Conference on Information and Communication Technology (CICT)*, Oct. 2018, pp. 1–4, doi: 10.1109/INFOCOMTECH.2018.8722369.

[5] S. Badhan, K. Desai, M. Dsilva, R. Sonkusare, and S. Weakey, "Real-time weed detection using machine learning and stereo-vision," in *2021 6th International Conference for Convergence in Technology (I2CT)*, Apr. 2021, pp. 1–5, doi: 10.1109/I2CT51068.2021.9417989.

[6] T. Sarvini, T. Sneha, G. G. S. Sukanya, S. Sushmitha, and R. Kumaraswamy, "Performance comparison of weed detection algorithms," in *2019 International Conference on Communication and Signal Processing (ICCSP)*, Apr. 2019, pp. 0843–0847, doi: 10.1109/ICCSP.2019.8698094.

[7] X. Jin, J. Che, and Y. Chen, "Weed identification using deep learning and image processing in vegetable plantation," *IEEE Access*, vol. 9, pp. 10940–10950, 2021, doi: 10.1109/ACCESS.2021.3050296.

[8] M. H. Asad and A. Bais, "Weed detection in canola fields using maximum likelihood classification and deep convolutional neural network," *Information Processing in Agriculture*, vol. 7, no. 4, pp. 535–545, Dec. 2020, doi: 10.1016/j.inpa.2019.12.002.

[9] B. Liu and R. Bruch, "Weed detection for selective spraying: a review," *Current Robotics Reports*, vol. 1, no. 1, pp. 19–26, Mar. 2020, doi: 10.1007/s43154-020-00001-w.

[10] V. N. T. Le, G. Truong, and K. Alameh, "Detecting weeds from crops under complex field environments based on faster RCNN," in *2020 IEEE Eighth International Conference on Communications and Electronics (ICCE)*, Jan. 2021, pp. 350–355, doi: 10.1109/ICCE48956.2021.9352073.

[11] B. Alipanahi, A. Delong, M. T. Weirauch, and B. J. Frey, "Predicting the sequence specificities of DNA- and RNA-binding proteins by deep learning," *Nature Biotechnology*, vol. 33, no. 8, pp. 831–838, Aug. 2015, doi: 10.1038/nbt.3300.

[12] A. Bordes, S. Chopra, and J. Weston, "Question answering with subgraph embeddings," Jun. 2014, [Online]. Available: http://arxiv.org/abs/1406.3676.

[13] P. Busey, "Cultural management of weeds in turfgrass," *Crop Science*, vol. 43, no. 6, pp. 1899–1911, Nov. 2003, doi: 10.2135/cropsci2003.1899.

[14] Q. Chen, J. Xu, and V. Koltun, "Fast image processing with fully-convolutional networks," in *2017 IEEE International Conference on Computer Vision (ICCV)*, Oct. 2017, pp. 2516–2525, doi: 10.1109/ICCV.2017.273.

[15] R. Collobert and J. Weston, "A unified architecture for natural language processing," in *Proceedings of the 25th international conference on Machine learning - ICML '08*, 2008, pp. 160–167, doi: 10.1145/1390156.1390177.

[16] R. Collobert, J. Weston, L. Bottou, M. Karlen, K. Kavukcuoglu, and P. Kuksa, "Natural language processing (Almost) from scratch," *The Journal of Machine Learning Research*, vol. 12, pp. 2493–2537, 2011.

[17] J. Deng, W. Dong, R. Socher, L.-J. Li, K. Li, and L. Fei-Fei, "ImageNet: a large-scale hierarchical image database," in *2009 IEEE Conference on Computer Vision and Pattern Recognition*, Jun. 2009, pp. 248–255, doi: 10.1109/CVPR.2009.5206848.

[18] A. S. Ferreira, D. M. Freitas, G. G. da Silva, H. Pistori, and M. T. Folhes, "Weed detection in soybean crops using ConvNets," *Computers and Electronics in Agriculture*, vol. 143, pp. 314–324, Dec. 2017, doi: 10.1016/j.compag.2017.10.027.

[19] S. A. Fennimore, D. C. Slaughter, M. C. Siemens, R. G. Leon, and M. N. Saber, "Technology for automation of weed control in specialty crops," *Weed Technology*, vol. 30, no. 4, pp. 823–837, Dec. 2016, doi: 10.1614/WT-D-16-00070.1.

[20] E. Gawehn, J. A. Hiss, and G. Schneider, "Deep learning in drug discovery," *Molecular Informatics*, vol. 35, no. 1, pp. 3–14, Jan. 2016, doi: 10.1002/minf.201501008.

[21] A. Geiger, P. Lenz, C. Stiller, and R. Urtasun, "Vision meets robotics: The KITTI dataset," *The International Journal of Robotics Research*, vol. 32, no. 11, pp. 1231–1237, Sep. 2013, doi: 10.1177/0278364913491297.

[22] S. Ghosal, D. Blystone, A. K. Singh, B. Ganapathysubramanian, A. Singh, and S. Sarkar, "An explainable deep machine vision framework for plant stress phenotyping," *Proceedings of the National Academy of Sciences*, vol. 115, no. 18, pp. 4613–4618, May 2018, doi: 10.1073/pnas.1716999115.

[23] G. L. Grinblat, L. C. Uzal, M. G. Larese, and P. M. Granitto, "Deep learning for plant identification using vein morphological patterns," *Computers and Electronics in Agriculture*, vol. 127, pp. 418–424, Sep. 2016, doi: 10.1016/j.compag.2016.07.003.

[24] J. Gu *et al.*, "Recent advances in convolutional neural networks," *Pattern Recognition*, vol. 77, pp. 354–377, May 2018, doi: 10.1016/j.patcog.2017.10.013.

[25] M. Havaei *et al.*, "Brain tumor segmentation with deep neural networks," *Medical Image Analysis*, vol. 35, pp. 18–31, Jan. 2017, doi: 10.1016/j.media.2016.05.004.

[26] K. He, X. Zhang, S. Ren, and J. Sun, "Deep residual learning for image recognition," in *2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, Jun. 2016, pp. 770–778, doi: 10.1109/CVPR.2016.90.

[27] G. Hinton *et al.*, "Deep neural networks for acoustic modeling in speech recognition: the shared views of four research groups," *IEEE Signal Processing Magazine*, vol. 29, no. 6, pp. 82–97, Nov. 2012, doi: 10.1109/MSP.2012.2205597.

[28] D. Hoiem, Y. Chodpathumwan, and Q. Dai, "Diagnosing error in object detectors," in *Computer Vision – ECCV 2012. ECCV 2012. Lecture Notes in Computer Science*, Berlin: Springer, 2012, pp. 340–353.

[29] Y. Jia *et al.*, "Caffe: convolutional architecture for fast feature embedding," in *Proceedings of the 22nd ACM international conference on Multimedia*, Nov. 2014, pp. 675–678, doi: 10.1145/2647868.2654889.

[30] C. R. Johnston, J. Yu, and P. E. McCullough, "Creeping bentgrass, perennial ryegrass, and tall fescue tolerance to topramezone during establishment," *Weed Technology*, vol. 30, no. 1, pp. 36–44, Mar. 2016, doi: 10.1614/WT-D-15-00072.1.
[31] M. I. Jordan and T. M. Mitchell, "Machine learning: trends, perspectives, and prospects," *Science*, vol. 349, no. 6245, pp. 255–260, Jul. 2015, doi: 10.1126/science.aaa8415.

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