



## Review Article

# A Review on Potato Disease Detection and Classification by exploiting Deep Learning Techniques

Khalid Hamza<sup>1\*</sup>, Saba un Nisa<sup>2</sup>, Gulshan Irshad<sup>1</sup>

<sup>1</sup> Department of Plant Pathology, PMAS Arid Agriculture University Rawalpindi, Pakistan.

<sup>2</sup> University Institute of Information Technology, PMAS Arid Agriculture University Rawalpindi, Pakistan.

\*Correspondence: [khalidhamza7980@gmail.com](mailto:khalidhamza7980@gmail.com)

### Article History

Received: August 02, 2022

Accepted: September 09, 2022

Published: September 28, 2022

### Abstract

The edible potato comes in fifth for human consumption and fourth among main food crops. Since it is a crop that is vegetative grown, many pests and disease can be passed along from one generation to the next. Crop diseases, which have a negative impact on food security as well as economic losses, have a significant impact on the production and quality of yields from potato crops. Thus, the application of unique and precise deep learning-based algorithms for disease detection and classification is highly required. Identifying weaknesses in agricultural products, particularly potatoes requires the use of machine vision and image processing techniques. Deep learning and image processing have been used in agriculture to classify and number of disease and pests affecting potatoes has grown, and study in this area is still continuing. The use of artificial intelligence and image processing in agriculture for the classification and identification of potato pests and disease has grown, and work in this area is still ongoing. Different deep learning techniques, such as VGG19, VGG16, Google Net, Alex Net, and convolution neural network methods, can be used to address the disease problem in potatoes. These methods also examined multiple classes of potato diseases as: Healthy, Black Leg, Black Scurf, Pink Rot, Common Scab, etc. Food safety could be seriously threatened by the spread of potato disease. In this article, deep learning techniques for early detection of potato disease are discussed.

**Keywords:** Deep learning; Potato disease; Detection.

### Introduction

In developing country, the problem of food scarcity has gotten worse in recent years. Potato is a staple food throughout the year in many of these countries. After wheat and rice, potatoes are a crucial component of the global population's diet since they are one of the most strategically significant items in the world. Current shortages in potato output are attributable to a number of diseases like Late Blight and Early Blight, which greatly reduce the number of plants that can be harvested. Also, the national economy suffers a considerable loss as a result. One of the most destructive plant diseases in the world is the potato disease, which has a negative impact on both the agricultural industry and individual farmer while also reducing the production and quality of potato crops. (Thyagarajan and Kiruba Raji, 2019) Artificial intelligence technology advancements in



Copyright: © 2022 by the authors.  
Licensee Roots Press, Islamabad  
Pakistan.

This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

the early detection and classification of crop blight have enhanced the potential for improving and extending plant protection.

Agriculture's quality and quantity have significantly decreased as a result of the problem of plant and fruit diseases. Many diseases, such as late and early blight, have a significant impact on the quality and yield of potatoes, and manual analysis of these leaf diseases is time-consuming and labor-intensive. Even though it requires a high level of competence, efficient and automated diagnosis of these diseases during the emerging phase might assist improve potato crop output. To evaluate plant disease, plant pathologists now employ a time-consuming procedure that mainly relies on visual prediction. Manual methods take a lot of time and produce unreliable results. Early disease diagnosis is necessary for preventive intervention to reduce crop losses (Deshpande *et al.*, 2014).

A significant study area in the field of monitoring and surveillance of agricultural crops is automatic detection of plant and fruit diseases. This is due to the fact that millions of litres of hazardous solution are used annually to control weeds and plant pests in the fields. As soon as possible, disease symptoms start to show themselves on plant leaves. (Arivazhagan *et al.*, 2013). The consumption of these resources, which is bad for the environment, must be reduced while their use must be increased. (Thyagarajan and Raji, 2021) the use of image processing techniques in agriculture is rapidly rising, from simple field management to the detection of crop diseases.

There are several varieties of this agricultural crop. Identifying the type of potatoes that enter the warehouse is one of the challenges in preserving this crops (Arshaghi *et al.*, 2022). It is foreseeable that potatoes will need to be automatically classified in situations where this product is stored in quantity. As a result, a model has been developed to categories potatoes using the support vector machine algorithm and image processing techniques. Based on the potato's surface properties, this classification has been made. The results show that the model was generated with great accuracy. The two main categories of potato crop classification techniques are hardware and software. A software technique is suggested in this study to categories the potato crop.

### Deep Learning and Potatoes Disease Detection

The detection of potato pathogens has been reported using a number of image processing-based techniques. Dimas employed aspects of diffuse reflection to find potato surface defects (Al Riza *et al.*, 2017). Loddo *et al.* (2021) wrote a paper in which, a structure of CNN is proposed. For the purpose of identifying their families or species, the new CNN SeedNet has been proposed. For both of the examined datasets, the results are displayed in seed classification; the accuracy scores are 95.65% for the first dataset and 97.47% for the second. In comparison to other networks tested ( ResNet18, ResNet101, ResNet50, VGG16, Google Net, ShuffleNet, MobileNetV2, AlexNet, SqueezeNet, InceptionV3, SeedNet), the SeedNet classifier for the data set used in the paper has better accuracy than kNN, Random Forest, Naive Bayes, and SVM classifiers. Additionally, training time is shorter than that of other networks. (Loddo *et al.*, 2021). Potato leaf diseases detection using deep learning is proposed in (Tiwari *et al.*, 2020). In this study, a model is proposed for extracting the essential features from the dataset via fine-tuning (transfer learning) using pre-trained models like VGG19. According to the results, logistic regression has a 97.8% accuracy rate on the test dataset.

Automated early blight identification could encourage a significant decrease in plant protection agent consumption and the resulting production losses. To distinguish between impacted and unaffected pixels, spectral classifiers including partial least squares discriminant analysis (PLS-DA) and support vector machines (SVM) based on PCA scores were tried. With accuracies above 0.92, both spectral classifiers worked well at the pixel level. Gené-Mola *et al.* (2020), A deep learning strategy is suggested for categorizing potato leaf diseases. One of the most destructive plant diseases in the world, potato leaf blight reduces the yield and quality of potato crops and has a negative impact on both individual farmers and the agricultural sector. Three types of potato leaf categories can be found in the training dataset: healthy leaves, early blight leaves, and late blight leaves. The overall mean testing accuracy for the suggested architecture was 98%. Deep learning is increasingly employed in picture classification, object recognition, semantic segmentation, and image retrieval.

Hasan *et al.* (2021) an epidemic of the potato disease poses a serious risk to food safety. In this study, deep learning techniques are used to describe early detection of potato disease. Using 1574 photos of various diseases, a dataset is created. By using scaling and rotation, the data augmentation technique increases this dataset to 7870 images. The data are split into training and testing categories in an experiment at a ratio of 8:2. AlexNet, ResNet, and GoogleNet are three examples of the deep convolutional neural network designs that are used. The ResNet performs the best for this particular application when the results are compared based on accuracy, precision, recall, and F1 score. Table 1 lists some of the studies that went into classifying potato diseases based on images.

Table 1. State-of-art on potatoes disease.

Product	Method	Accuracy	Year	Author
Potato Leaves	Deep Learning, Transfer Learning	94.94%	2020	(Dasgupta <i>et al.</i> , 2020)
Potato	R-CNN	90.8% - 93.0%	2020	(Lee and Shin, 2020)
Potato Leaves	SVM and PLS-DA	92%	2022	(Arshaghi <i>et al.</i> , 2022)
Potato	CNN	86.6%	2020	(Su <i>et al.</i> , 2020)
Potato	ABC, BUZO, PSO, DT, SVM	88.83%	2020	(Arshaghi <i>et al.</i> , 2022)
Potato	LS - SVM	90.70%	2019	(Zhang <i>et al.</i> , 2019)
Potato	GA PLS-	97.6%	2017	(Al Riza <i>et al.</i> , 2017)
Potato	Fussy C-mean	95%	2016	(Brar and Singh, 2016)
Potato	LS-SVM(LeastSquare)	90%	2016	(Gao <i>et al.</i> , 2016)
Potato	Fussy Logic, GA	88.10%	2014	(Moallem <i>et al.</i> , 2014)
Potato	MLP, SVM, RBF	95% , 96%, 86%	2011	(Razmjoooy and Daviran, 2011)

### Deep learning classification

Image acquisition is the first step in computer vision-based systems. Next, different image-processing tasks, such as scaling, filtering, selection, segmentation, and feature extraction, are performed. Finally, machine learning and deep learning-based algorithms are used for recognition and classification. The whole process followed by the majority of deep learning-based approaches to identify and categories potato disease is shown in Figure 1.

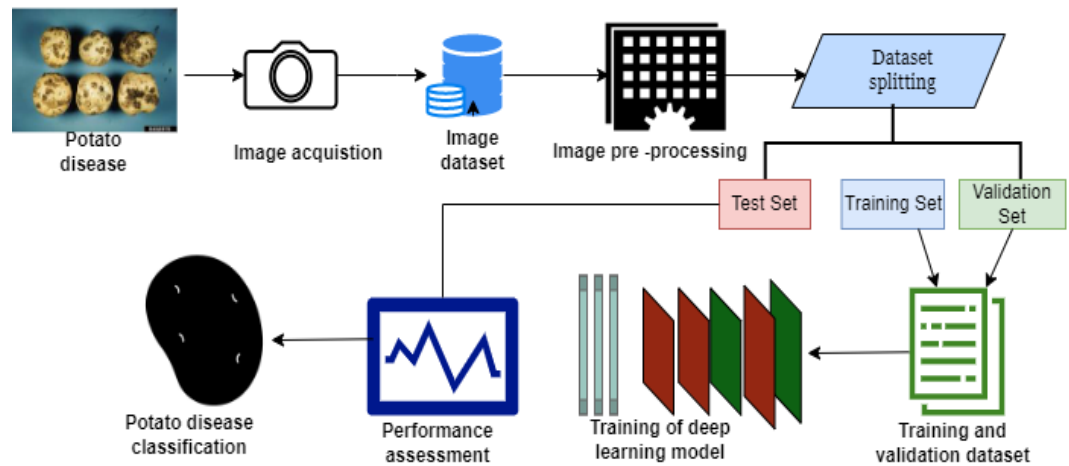


Figure 1. Flow of the potato disease detection and classification.

A total of about 5000 potato photos were used for image acquisition. The images were either captured in real time from potato fields in Ardebil, Iran, or they were taken from databases maintained by the CFIA (Bietlot and Kolakowski, 2012), USDA (Act, 2017), plant villages, and machine learning repositories. Images from the dataset included each of the main potato pathogens. In the first stage of programming, all photos were resized to the same size. Typically, two class labels—healthy and effective—are employed in many papers. Most of papers classified potato photos into five categories: healthy, black scurf, black leg, common scab, and pink rot. Figure 2 displays disease dataset visuals. If data sets were gathered, learned, and then applied to networks, classification accuracy would improve. Increasing the required data set for use in processing is one way to improve classification. By expanding the data set, you can rotate an image 90, 180, or 270 degrees, crop it in the middle, and convert it to grayscale. The size of photos is reduced to 128 x 128 for preprocessing. The feature extraction process requires this work. Deep learning networks automatically extract features.

An efficient deep learning technique is the convolutional neural network (CNN). Many diverse image collections are used to train CNNs. From these substantial databases, CNNs may learn detailed feature representations for a range of images. These feature representations frequently outperform than manually produced features like HOG, LBP, or SURF. Using a pre-trained CNN as a feature extractor is a simple approach to take advantage of CNN power without spending time and effort on training. The network's design makes it easier to extract features, which boosts this kind of disease classification. Some researchers used the ResNetA, AlexNet, and VGG architectures, while others employed the CNN with PCA (Chen *et al.*, 2014), SVM (Douarre, Schielein, Frindel, Gerth, & Rousseau, 2016), macroscopic cellular automata (Song *et al.*, 2016), linear regression (Chen *et al.*, 2017), large margin classifiers (LMC), (Xinshao and Cheng, 2015). To gain an edge, several researchers blend CNN models. (Pan and Yang, 2010) such as (Lee *et al.*, 2015; Reyes *et al.*, 2015; Sa *et al.*, 2016; Steen *et al.*, 2016; Bargoti and Underwood, 2017; Mohanty *et al.*, 2016), for the VGG16, Google Net and AlexNet architectures.



Figure 2. Different types of potato disease.

Configuring the CNN structure is one of the main contributions of the majority of researchers. By looking at articles and studies on CNN on potato classification. Using deep learning-based methods like VGG19, VGG16, Google Net and Alex Net, to compare the findings on the various disease classes with prior research. Table 2 contains this comparison.

### Conclusion

Image acquisition is the first step in computer vision-based systems. Next, different image processing tasks, such as scaling, filtering, selection, segmentation, and feature extraction, are performed. Finally, machine learning and deep learning-based algorithms are used for recognition and classification. Many Potato diseases, such as late and early blight, have a significant impact on the quality and yield of potatoes, and manual analysis of these leaf diseases is time-consuming and labor-intensive. Overall, the CNNs and deep learning frameworks utilised in these studies correctly identified the various stages of the early blight disease. By precisely recognizing the early blight-infected plants, site-specific fungicide administration has a high potential to reduce the usage of agrochemicals, increase the profitability of potato growers, and reduce environmental dangers (runoff of fungicides to water bodies). We have also examined a number of recent papers that identified and examined plant diseases using machine learning or deep learning-based techniques. When it comes to image classification tasks, deep learning models outperform machine learning-based methods. The majority of research in the literature have employed laboratory-conditioned image datasets like the Plant Village dataset and UCI machine learning repository. The performance of deep learning models significantly depends on the training of the underlying model used for classification purposes.

Table 2. State-of-art comparison between Deep learning methods.

Deep Model	Accuracy				
	Healthy	Black Scurf	Black Leg	Pink Rot	Common Scab
VGG19	75.1	87.9	26.1	17.4	18.9
Alex Net	91.7	27.7	25.2	74.9	55.2
VGG16	29.3	97	11.5	20.3	17.9
Google Net	95.9	28.4	20.7	15.4	42.4
CNN	100	98	99	100	100

A model that has been trained on a dataset of laboratory-conditioned images typically does not perform well when applied to real-field images. Researchers should first gather a large enough sample of real-conditioned images for the model's training and testing in order to achieve greater generalization on real-conditioned images of potatoes disease. There are five different categories of potato diseases: healthy, black scurf, common scab, black leg, and pink rot. The majority of earlier studies on potato disease used the conventional approach to diagnose two different diseases. The accuracy of deep learning is higher than that of standard techniques, and CNN can achieve 100% and 99% accuracy in several classes. We can further apply onto the six to nine disease of the potatoes by using the deep learning models.

### Conflict of Interest

The authors have not declared any conflict of interest.

### Authors Contributions

All the authors have contributed equally to the research and compiling the data as well as editing the manuscript.

### References

- Al Riza, D. F., T. Suzuki, Y. Ogawa and N. Kondo. 2017. Diffuse reflectance characteristic of potato surface for external defects discrimination. *Postharvest Biology and Technology*, 133: 12-19.
- Arivazhagan, S., R. N. Shebiah, S. Ananthi and S. V. Varthini. 2013. Detection of unhealthy region of plant leaves and classification of plant leaf diseases using texture features. *Agricultural Engineering International: CIGR Journal*, 15: 211-17.
- Arshaghi, A., M. Ashourian and L. Ghabeli. 2022. Potato diseases detection and classification using deep learning methods. *Multimedia Tools and Applications*: 1-18.
- Bargoti, S. and J. Underwood. 2017. Deep fruit detection in orchards. 2017 IEEE international conference on robotics and automation (ICRA).
- Bietlot, H. P. and B. Kolakowski. 2012. Risk assessment and risk management at the Canadian Food Inspection Agency (CFIA): A perspective on the monitoring of foods for chemical residues. *Drug Testing and Analysis*, 4: 50-58.
- Brar, E. A. S. and K. Singh. 2016. Potato defect detection using fuzzy c-mean clustering based segmentation. *Indian Journal of Science and Technology*, 9: 1-6.
- Chen, S. W., S. S. Shivakumar, S. Dcunha, J. Das, E. Okon, C. Qu, C. J. Taylor and V.

- Kumar. 2017. Counting apples and oranges with deep learning: A data-driven approach. *IEEE Robotics and Automation Letters*, 2: 781-88.
- Chen, Y., Z. Lin, X. Zhao, G. Wang and Y. Gu. 2014. Deep learning-based classification of hyperspectral data. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, 7: 2094-107.
- Dasgupta, S. R., S. Rakshit, D. Mondal and D. K. Kole. 2020. Detection of diseases in potato leaves using transfer learning. *Computational Intelligence in Pattern Recognition: Proceedings of CIPR 2019*.
- Deshpande, T., S. Sengupta and K. Raghuvanshi. 2014. Grading & identification of disease in pomegranate leaf and fruit. *International Journal of Computer Science and Information Technologies*, 5: 4638-45.
- Gao, Y., J. Geng, X. Rao and Y. Ying. 2016. CCD-Based skinning injury recognition on potato tubers (*Solanum tuberosum* L.): A comparison between visible and biospeckle imaging. *Sensors*, 16: 1734.
- Gené-Mola, J., R. Sanz-Cortiella, J. R. Rosell-Polo, J.-R. Morros, J. Ruiz-Hidalgo, V. Vilaplana and E. Gregorio. 2020. Fruit detection and 3D location using instance segmentation neural networks and structure-from-motion photogrammetry. *Computers and Electronics in Agriculture*, 169: 105165.
- Hasan, M. Z., N. Zahan, N. Zeba, A. Khatun and M. R. Haque. 2021. A deep learning-based approach for potato disease classification. *Computer Vision and Machine Learning in Agriculture*: 113-26.
- Lee, H.-S. and B.-S. Shin. 2020. Potato detection and segmentation based on mask R-CNN. *Journal of Biosystems Engineering*, 45: 233-38.
- Lee, S. H., C. S. Chan, P. Wilkin and P. Remagnino. 2015. Deep-plant: Plant identification with convolutional neural networks. 2015 IEEE international conference on image processing (ICIP).
- Loddo, A., M. Loddo and C. Di Ruberto. 2021. A novel deep learning based approach for seed image classification and retrieval. *Computers and Electronics in Agriculture*, 187: 106269.
- Moallem, P., N. Razmjoooy and B. S. Mousavi. 2014. Robust potato color image segmentation using adaptive fuzzy inference system. *Iranian Journal of Fuzzy Systems*, 11: 47-65.
- Mohanty, S. P., D. P. Hughes and M. Salathé. 2016. Using deep learning for image-based plant disease detection. *Frontiers in Plant Science*, 7: 1419.
- Pan, S. J. and Q. Yang. 2010. A survey on transfer learning. *IEEE Transactions on Knowledge and Data Engineering*, 22: 1345-59.
- Razmjoooy, N. and R. Daviran. 2011. Potato defect detection using computer vision and neural networks. *Correlatio*, 1: 1-9.
- Reyes, A. K., J. C. Caicedo and J. E. Camargo. 2015. Fine-tuning Deep Convolutional Networks for Plant Recognition. *CLEF (Working Notes)*, 1391: 467-75.
- Sa, I., Z. Ge, F. Dayoub, B. Upcroft, T. Perez and C. McCool. 2016. Deepfruits: A fruit detection system using deep neural networks. *Sensors*, 16: 1222.
- Song, X., G. Zhang, F. Liu, D. Li, Y. Zhao and J. Yang. 2016. Modeling spatio-temporal distribution of soil moisture by deep learning-based cellular automata model.

- Journal of Arid Land, 8: 734-48.
- Steen, K. A., P. Christiansen, H. Karstoft and R. N. Jørgensen. 2016. Using deep learning to challenge safety standard for highly autonomous machines in agriculture. *Journal of Imaging*, 2: 6.
- Su, Q., N. Kondo, D. F. Al Riza and H. Habaragamuwa. 2020. Potato quality grading based on depth imaging and convolutional neural network. *Journal of Food Quality*, 2020: 1-9.
- Thyagarajan, K. and I. Kiruba Raji. 2019. A review of visual descriptors and classification techniques used in leaf species identification. *Archives of Computational Methods in Engineering*, 26: 933-60.
- Thyagarajan, K. and I. K. Raji. 2021. Diagnosis of neem leaf disease using Fuzzy-HOBINM and ANFIS Algorithms. *CMC-Comput Mater Continua*, 69: 2061-76.
- Tiwari, D., M. Ashish, N. Gangwar, A. Sharma, S. Patel and S. Bhardwaj. 2020. Potato leaf diseases detection using deep learning. 2020 4th International Conference on Intelligent Computing and Control Systems (ICICCS).
- Xinshao, W. and C. Cheng. 2015. Weed seeds classification based on PCANet deep learning baseline. 2015 Asia-Pacific Signal and Information Processing Association Annual Summit and Conference (APSIPA).
- Zhang, W., Q. Zhu, M. Huang, Y. Guo and J. Qin. 2019. Detection and classification of potato defects using multispectral imaging system based on single shot method. *Food Analytical Methods*, 12: 2920-29.