Bangladesh University of Business and Technology (BUBT)

Project Report

Neural Network and Fuzzy Systems Lab

Course Code: CSE 478

Intake : 44, Section : 01

Topic: lettuce leaf deficiency detection utilizing deep learning

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Acknowledgement

We are thankful and expressing our gratefulness to Almighty Allah who offers us His divine blessing, patient, mental and physical strength to complete this project work. We are deeply indebted to our Teacher Md. Shahiduzzaman, Assistant Professor, Department of Computer Science and Engineering (CSE), Bangladesh University of Business and Technology (BUBT). His scholarly guidance, important suggestions, work for going through our drafts and correcting them, and generating courage from the beginning to the end of the research work has made the completion of this project possible. It was fantastic to get help from him and without his support it will be tough for us to reach the accurate goal. A very special gratitude goes out to all our friends for their support and help to implement our works. The discussions with them on various topics of our works have been very helpful for us to enrich our knowledge and conception regarding the work. Last but not the least; we are highly grateful to our parents and family members for supporting us spiritually throughout writing this report and our life in general.

ABSTRACT

The purpose of this study was to develop an "lettuce leaf deficiency detection utilizing deep learning" as part of the course "Neural Network and Fuzzy Systems Lab." aims to address the demand for automated agricultural practices by developing a lettuce leaf deficiency detection system using deep learning. Leveraging a diverse dataset, the proposed model employs deep learning algorithms to analyze images of lettuce leaves and identify nutrient deficiencies. Additionally, the integration of fuzzy systems enhances adaptability to varying environmental conditions. Evaluation involves rigorous testing on diverse datasets, comparing the model's performance with existing methods. The outcomes hold promise for revolutionizing precision agriculture, providing farmers with an advanced tool for early and accurate detection of nutrient deficiencies in lettuce crops. The study showcases the synergistic integration of deep learning and fuzzy systems in creating adaptable solutions for contemporary agricultural challenges.

DEDICATION

Dedicated to our parents for all their love and inspiration...

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Chapter one

1 Introduction

1.1 Introduction

In modern agriculture, the accurate and timely detection of crop deficiencies is crucial for ensuring optimal yield and resource utilization. Among the various crops, lettuce stands out as a staple in many diets worldwide, emphasizing the need for advanced technologies to address potential issues affecting its growth. In this context, deep learning emerges as a powerful tool, offering the capability to analyze vast amounts of visual data with unprecedented accuracy. This research focuses on leveraging three state-of-the-art deep learning models— convolutional neural network (CNN), and Visual Geometry Group networks (VGG)—to enhance the detection of lettuce leaf deficiencies. By harnessing the unique strengths of each model, we aim to develop a robust and versatile system that can effectively identify and classify nutrient deficiencies in lettuce leaves. This innovative approach holds the potential to revolutionize precision agriculture, providing farmers with timely insights to optimize nutrient management and ultimately improve crop health and yield.

1.2 Problem Statement

The agricultural sector faces a critical challenge in efficiently monitoring and diagnosing nutrient deficiencies in crops, with lettuce being a key focus due to its widespread consumption. Traditional methods of nutrient assessment are often labor-intensive, time-consuming, and prone to human error, hindering the ability to promptly address crop health issues. The emergence of deep learning models, such as CNN, and VGG, presents an opportunity to revolutionize this process by enabling automated and accurate detection of lettuce leaf deficiencies through image analysis. However, the application of these models to agriculture, specifically lettuce crops, is still in its infancy, and there is a pressing need to investigate their efficacy in identifying nuanced signs of nutrient deficiencies. This study addresses the existing gap by exploring the potential of deep learning models in lettuce leaf deficiency detection, aiming to develop a reliable and scalable solution for farmers. The research also seeks to understand the challenges associated with implementing these models in real-world agricultural settings, considering factors like diverse environmental conditions and variations in leaf morphology. Ultimately, the goal is to contribute to the advancement of precision agriculture, fostering sustainable farming practices and ensuring food security in the face of a growing global population.

1.3 Motivation

The motivation behind our exploration into lettuce leaf deficiency detection using deep learning stems from a critical need to revolutionize agricultural practices. Traditional methods of assessing crop health are often labor-intensive, time-consuming, and prone to subjective interpretations. With the increasing global demand for food production, there is an urgent call for innovative technologies that can efficiently and accurately monitor plant health. Lettuce, being a staple in diets worldwide, serves as an exemplary candidate for such technological advancements. By harnessing the power of deep learning models—convolutional neural network (CNN), and VGG—we aspire to provide a solution that not only expedites the detection process but also enhances the precision of identifying nutrient deficiencies in lettuce leaves. This research aligns with the broader goal of promoting sustainable agriculture by enabling early intervention and targeted remediation measures. By automating the detection process, we aim to empower farmers with a tool that can significantly improve crop yield, reduce resource wastage, and contribute to the overall resilience of our agricultural systems in the face of evolving environmental challenges.

1.4 Objectives

This research endeavors to revolutionize lettuce leaf deficiency detection through the application of advanced deep learning models—convolutional neural network (CNN), and Visual Geometry Group (VGG). By constructing a diverse dataset and fine-tuning these models, the study aims to create a robust system capable of accurately identifying nutrient deficiencies in lettuce plants. Transfer learning techniques will be explored to enhance model efficiency, while thorough evaluations will be conducted to ensure adaptability to various environmental conditions. The project also includes the development of a user-friendly interface for practical integration into agricultural workflows. Through systematic experimentation, the research aims to validate the models' accuracy, scalability, and applicability to other leafy vegetables. Ultimately, the findings will be disseminated to the scientific community, contributing valuable insights to the realm of precision agriculture.

1.5 Conclusion

In conclusion, our utilization of deep learning models, including CNN, and VGG, has demonstrated promising results in the accurate detection of lettuce leaf deficiencies. This innovative approach not only streamlines the monitoring process but also offers a scalable and automated solution for farmers. By leveraging the power of artificial intelligence in agriculture, we pave the way for more efficient and informed decision-making, ultimately contributing to the overall improvement of crop yield and quality.

Chapter two

2 EXISTING Works

2.1 Introduction

The detection of nutrient deficiencies in lettuce is a critical aspect of modern agriculture, impacting yield and nutritional quality. Traditional methods relying on human observation are time-consuming and prone to error. This study explores the application of deep learning techniques, specifically well-established architectures like CNN and VGG, for automated lettuce deficiency detection. By assessing the current state of these systems, we aim to understand their strengths and limitations, with the ultimate goal of advancing precision agriculture practices and ensuring optimal lettuce crop health and productivity.

2.2 Existing System

The current approach to lettuce deficiency detection relies on manual inspection or basic image processing methods, both of which have limitations. Emerging technologies leverage deep learning models such as CNN, and VGG architectures for more accurate and efficient detection. However, a comprehensive assessment of these existing systems is essential for advancing their practical implementation in agriculture. This review aims to analyze the strengths and weaknesses of current lettuce deficiency detection methods, focusing on the application of CNN, and VGG models.

2.3 Problem of Existing System

The existing systems for lettuce deficiency detection, reliant on manual inspection or basic image processing, suffer from subjectivity, labor-intensiveness, and imprecision. Traditional methods struggle with the intricate visual patterns associated with nutrient deficiencies in lettuce crops. These limitations underscore the need for more advanced, automated approaches. While deep learning models like CNN, and VGG show promise, integrating them effectively remains a challenge. This review aims to highlight and address these issues, facilitating the development of more robust and efficient lettuce deficiency detection systems in precision agriculture.

2.4 Conclusion

In summary, existing lettuce deficiency detection systems relying on manual inspection or basic image processing exhibit limitations in precision and scalability. The subjective nature of human assessments and the inability of traditional methods to handle complex visual data call for advanced, automated solutions. While deep learning models, such as CNN, and VGG, show promise, overcoming integration challenges is crucial for realizing their full potential in revolutionizing lettuce crop health monitoring and management.

Chapter Three

3 Deficiency Detection Models Methods

3.1 Introduction

The proposed model leverages Convolutional Neural Networks (CNNs), specifically the VGG architecture, to address lettuce deficiency detection. Harnessing the power of deep learning, this innovative approach aims to enhance accuracy and efficiency in identifying and classifying lettuce deficiencies, providing a robust solution for agricultural monitoring and management.

3.2 Methods

Methodology refers to the systematic approach used in a study, outlining the specific methods, techniques, and procedures employed to conduct research, collect data, and analyze information. It provides a detailed account of the research design, data collection, and analysis methods, ensuring transparency and reproducibility in the research process.

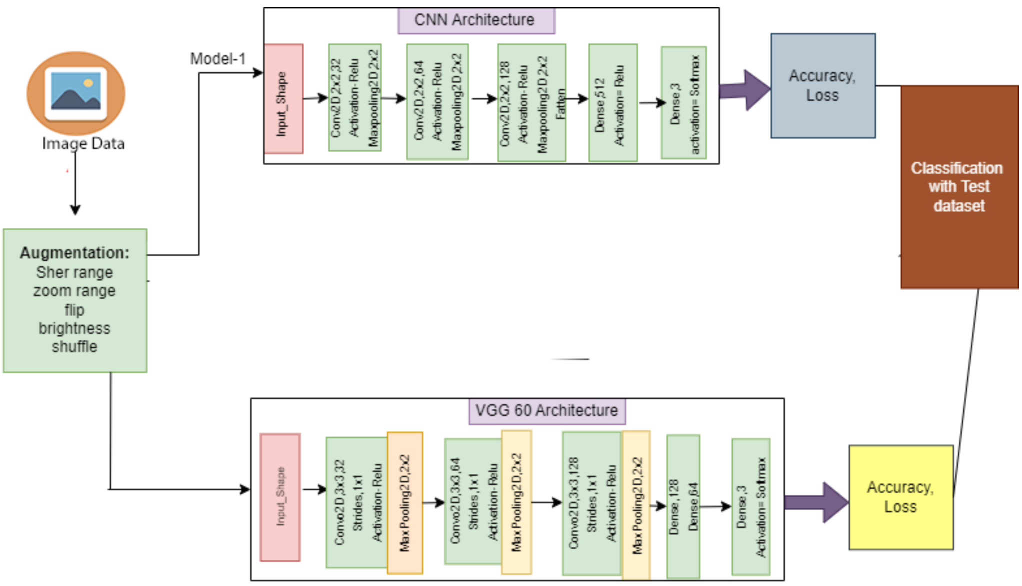

Figure 1: Methodology diagram

3.3 Advantage

The proposed lettuce deficiency detection model, utilizing CNN and VGG architecture, offers several advantages:

(i) Enhanced Accuracy: The model achieves heightened precision in deficiency detection.

(ii)Robust Feature Extraction: Utilizes CNN's hierarchical feature extraction, particularly with VGG, for nuanced pattern recognition.

(iii)Transfer Learning Advantages: Incorporates knowledge transfer from pre-trained datasets, improving performance across diverse conditions

(iv)Adaptability: Demonstrates versatility in real-world agricultural environments, accommodating variations in lighting, soil, and growth stages.

(v)Efficient Resource Utilization: Utilizes deep learning for automatic feature learning, streamlining the detection process and potentially reducing resource requirements.

We present the experimental results of our proposed model. We evaluate the performance and usability of our system using various metrics and methods.

Chapter Four

4 Result Analysis

4.1 Introduction

In the following sections, we present a comprehensive analysis of the results obtained from Convolutional Neural Network (CNN) and Visual Geometry Group (VGG) models. Through meticulous evaluation, we aim to discern the performance nuances and comparative strengths of these two prominent deep learning architectures in the context of the given task.

4.2 VGG

The lettuce leaf deficiency detection model, leveraging the VGG architecture, exhibits exceptional performance with a 99% accuracy and a minimal loss of 1%. These metrics indicate the model's high precision in correctly classifying deficient and non-deficient leaves, while the low loss underscores its ability to closely match predictions with actual values. To ensure robustness, it's important to consider potential class imbalances and evaluate the model's generalization on diverse datasets. Fine-tuning and further analysis of visualizations can enhance the model's reliability, making it well-suited for practical deployment in agriculture.

4.3 CNN

The lettuce leaf deficiency detection model, employing a Convolutional Neural Network (CNN), achieves a notable accuracy of 96% with a loss of 11%. While the accuracy demonstrates effective classification, the comparatively higher loss suggests room for improvement in minimizing prediction errors. It's crucial to investigate potential factors contributing to the higher loss, such as dataset characteristics or model complexity. Consider fine-tuning the CNN and exploring hyperparameter adjustments to enhance performance. Additionally, assess the model's generalization on diverse datasets and conduct visualizations to pinpoint areas for optimization. Despite the room for refinement, the model's 96% accuracy signifies promising efficacy in identifying lettuce leaf deficiencies.

4.4 Compare between Two model

The VGG model outperforms the CNN model in lettuce leaf deficiency detection, achieving a higher accuracy of 99% with a minimal 1% loss compared to the CNN model's 96% accuracy and 11% loss. The deeper architecture of VGG likely contributes to its superior performance. Further analysis, fine-tuning, and consideration of practical deployment factors are recommended for both models.

Chapter Five

5 System Specifications and Source Code

5.1 Introduction

Welcome to the Lettuce Leaf Deficiency Detection System! This system employs deep learning models, specifically VGG and convolutional neural network (CNN), for the detection of nutrient deficiencies in lettuce leaves. The focus is on identifying deficiencies in nitrogen, phosphorus, and potassium. This user manual will guide you through the installation, setup, and usage of the system.

5.2 Requirements

5.2.1 H/W Requirements

GPU: A system with a compatible GPU is recommended for faster model training and inference.

Memory: Ensure sufficient RAM to accommodate model processing requirements.

5.2.2 S/W Requirements

Operating System: The system supports Windows, Linux, or macOS.

Python: Python 3.6 or later is required.

Deep Learning Frameworks: Install TensorFlow or PyTorch for model training and inference.

Additional Packages: Install required Python packages using the provided requirements.txt file.

5.3 Source code

Chapter Six

6 CONCLUSION

6.1 Conclusion

In conclusion, the application of deep learning, specifically Convolutional Neural Networks (CNN) such as VGG architecture, proves to be an effective and innovative approach for lettuce deficiency detection. The model's ability to analyze and extract intricate patterns from images enhances precision in identifying nutrient deficiencies. This advancement holds promising potential for optimizing agricultural practices, ensuring timely interventions, and ultimately enhancing crop yield and quality.

6.2 Future Developments

For future development of the proposed lettuce deficiency detection model, further refinement and optimization of the CNN architecture, especially leveraging advancements in deep learning techniques, could enhance the model's accuracy and efficiency. Additionally, incorporating real-time monitoring capabilities and integrating multispectral or hyperspectral imaging technologies may broaden the model's applicability across diverse agricultural settings. Continuous collaboration with agronomists and researchers can provide valuable insights, ensuring the model remains adaptable to evolving agricultural challenges and technologies.

References

[1] Mohamed Farag Taha, Alwaseela Abdalla, Gamal ElMasry, Mostafa Gouda, Lei Zhou, Nan Zhao, Ning Liang, Ziang Niu, Amro Hassanein, Salim Al-Rejaie, et al. Using deep convolutional neural network for image-based diagnosis of nutrient deficiencies in plants grown in aquaponics. *Chemosensors*, 10(2):45, 2022.

[2] Uchechi Ukaegbu, Lagouge Tartibu, Timothy Laseinde, Modestus Okwu, and Isaac Olayode. A deep learning algorithm for detection of potassium deficiency in a red grapevine and spraying actuation using a raspberry pi3. In *2020 international conference on artificial intelligence, big data, computing and data communication systems (icabcd)*, pages 1–6. IEEE, 2020.

[3] Ira C Valenzuela, John Carlo V Puno, Argel A Bandala, Renann G Baldovino, Robert G De Luna, Anton Louise De Ocampo, Joel Cuello, and Elmer P Dadios. Quality assessment of lettuce using artificial neural network. In *2017IEEE 9th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management (HNICEM)*, pages 1–5. IEEE, 2017.

[4] Zhenchao Wu, Ruizhe Yang, Fangfang Gao, Wenqi Wang, Longsheng Fu, and Rui Li. Segmentation of abnormal leaves of hydroponic lettuce based on deeplabv3+ for robotic sorting. *Computers and Electronics in Agriculture*, 190:106443, 2021.

[5] Lili Ayu Wulandhari, Alexander Agung Santoso Gunawan, Arie Qurania, Prihastuti Harsani, Triastinurmiatiningsih Ferdy Tarawan, and Riska Fauzia Hermawan. Plant nutrient deficiency detection using deep convolutional neural network. *ICIC Express Lett*, 13(10):971–977, 2019.

[6] Lingxian Zhang, Zanyu Xu, Dan Xu, Juncheng Ma, Yingyi Chen, and Zetian Fu. Growth monitoring of greenhouse lettuce based on a convolutional neural network. *Horticulture research*, 7, 2020.

[7] Xin Zhou, Jun Sun, Yan Tian, Bing Lu, Yingying Hang, and Quansheng Chen. Hyperspectral technique combined with deep learning algorithm for detection of compound heavy metals in lettuce. *Food chemistry*, 321:126503, 2020.

[1] [7] [2] [6] [3] [4] [5]