ASSESSING THE POTENTIAL OF CONVOLUTIONAL NEURAL NETWORK(CNN) IN THE DETECTION OF DISEASES OF CUCURBITS

VASHTINE P. LIWANAGAN
IMMAN DIEVE R. YARCIA

An Undergraduate Thesis Manuscript Submitted to the Faculty of the Department Of Agricultural and Biosystems Engineering, College of Engineering, Central Luzon State University, Science city of Munoz, Nueva Ecija, Philippines in Partial Fulfillment of the Requirements for the Degree of

BACHELOR OF SCIENCE IN AGRICULTURAL AND BIOSYSTEMS ENGINEERING
(AB Machinery and Power Engineering)

JULY 2024

ACCEPTANCE SHEET

This undergraduate thesis entitled **"ASSESSING THE POTENTIAL OF CONVOLUTIONAL NEURAL NETWORK(CNN) IN THE DETECTION OF DISEASES OF CUCURBITS"**, prepared and submitted by **VASHTINE P. LIWANAGAN, and IMMAN DIEVE R. YARCIA**, in partial fulfillment of the requirements for the degree of **BACHELOR OF SCIENCE IN AGRICULTURAL AND BIOSYSTEMS ENGINEERING (AB Machinery and Power Engineering)**, is hereby accepted:

NICASIO C. SALVADOR, M.Sc.
Member, Advisory Committee

06-20-24
Date Signed

MARLON T. DELOS SANTOS, M.Sc.
Member, Advisory Committee

06-20-24
Date Signed

ELIZA E. CAMASO, M.Sc.
Chair, Advisory Committee

06-20-24
Date Signed

Accepted as partial fulfillment of the requirements for the degree of **BACHELOR OF SCIENCE IN AGRICULTURAL AND BIOSYSTEMS ENGINEERING (AB MACHINERY AND POWER ENGINEERING):**

JOHN PAULO C. SACDALAN, Ph.D.
Chair, Department of Agricultural and Biosystems Engineering

06-20-24
Date Signed

ROY SEARCA JOSE P. DELA CRUZ, Ph.D.
Dean, College of Engineering

06-20-24
Date Signed

BIOGRAPHICAL SKETCH

Vashtine P. Liwanagan was born on October 2, 2001, in Balanga City, Bataan. He grew up in a close-knit family with one older sister. His academic journey began at Tomas Pinpin Memorial Elementary School, where he excelled in his studies and showed a keen interest in Mathematics, Science, and Music.

Transitioning to Bataan National High School for his secondary education, Vashtine continued to demonstrate his commitment to learning, participating in the special program in the arts to improve his singing skills. Despite facing challenges along the way, Vashtine's perseverance and hard work paid off, and he moved up with honors in 20018.

Following high school, Vashtine pursued a Bachelor's degree in Agricultural and Biosystems Engineering at the Central Luzon State University, where he is currently studying in. During his time at university, he discovered his passion for coding and software development. He actively participated in coding competitions and interned at several tech companies, gaining valuable experience in the field.

Vashtine enjoys spending time with his family, working out, and volunteering to help the community. He is passionate about giving back to his community and hopes to make a positive impact in the world through his work while still enjoying living life as best as he can. The view of the future ahead of Vash is something that he is looking forward to; creating new experiences and endeavors and meeting people along the way is what keeps his life lively.

Vashtine P, Liwanagan

Imman Dieve R. Yarcia was born in San Felipe, Zambales on July 18, 2002. The third of four children were born to Mr. Deonie S. Yarcia and Mrs. Evelyn R. Yarcia, and he currently resides in Barangay Capirpiriwan, Cordon, Isabela.

He finished his grade school at Urdaneta I Central School, Urdaneta City, Pangasinan, in 2014; he then went on to pursue his secondary and senior high school studies at San Mateo National High School, graduating in 2018 and 2020, respectively. Imman is currently enrolled in the Bachelor of Science in Agricultural and Biosystems Engineering program at Central Luzon State University, majoring in AB Power and Machineries.

Imman Dieve R. Yarcia

Acknowledgment

The completion of this thesis is indebted to the steadfast backing and inspiration provided by numerous individuals and institutions. Their enduring support has served as the bedrock upon which this scholarly endeavor has been erected.

Gratitude to the Divine for His unwavering guidance and the fortitude, wisdom, and resilience granted to overcome every challenge encountered during the completion of this study.

Acknowledgment is also extended to our dear families, notably our parents, whose enduring support, both financial and emotional, has been the cornerstone of our academic journey. Their unwavering belief in our dreams has served as a beacon of inspiration, propelling us forward on our path to achievement.

With utmost respect and gratitude, we acknowledge the distinguished service of our former advisor, Dr. Theody B. Sayco, upon his retirement from the university. His dedicated guidance and steadfast support were instrumental in facilitating the completion of this study.

To our former panel member and now thesis advisor, Engr. Eliza E. Camaso, whose expertise and guidance have greatly influenced the direction of this thesis. Her patience and mentorship have helped refine our research skills and elevate the quality of our work to meet rigorous standards.

Gratitude is also extended to our panel members, Engr. Marlon T. Delos Santos and Engr. Nicasio C. Salvador, for their valuable input and feedback. Their guidance and constructive criticism have been invaluable in shaping our research journey, providing essential support and encouragement along the way.

We extend heartfelt gratitude to our classmates and friends, whose unwavering presence provided invaluable support throughout the highs and lows of this journey. Their companionship added depth to this experience, transforming challenges into opportunities for growth and celebrations into moments of shared joy.

This thesis stands as a tribute to the collaborative efforts of all individuals mentioned. We express sincere appreciation for Their integral role in this academic milestone.

TABLE OF CONTENTS

RESULTS AND DISCUSION

SUMMARY, CONCLUSION AND RECOMENDATION

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIX FIGURES

ABSTRACT

LIWANAGAN, VASHTINE P. AND YARCIA, IMMAN DIEVE R., Department of Agricultural and Biosystems Engineering, College of Engineering, Central Luzon State University, Science City of Muñoz, Nueva Ecija, Philippines, **JULY 2024, ASSESSING THE POTENTIAL OF CONVOLUTIONAL NEURAL NETWORK(CNN) IN THE DETECTION OF DISEASES OF CUCURBITS.**

Adviser: ELIZA E. CAMASO, M.Sc.

Cucurbits, including cucumbers, melons, pumpkins, squash, and gourds, are part of the Cucurbitaceae family with a millennia-long historical significance. They have been pivotal to civilizations globally, contributing to food security, economic growth, and cultural heritage. In modern agriculture, cucurbits remain indispensable, thriving in diverse climates, providing nutrition, and promoting sustainable farming practices.

This study utilizes computer vision and machine learning techniques to tackle challenges in cucurbit production, explicitly focusing on disease detection. The objective is to harness convolutional neural networks (CNN) for early disease identification in cucurbit crops, progressing through three phases: identifying common diseases, developing a CNN-based smart detection system, and evaluating system accuracy and reliability.

The methodology involves designing a conceptual framework to guide CNN model training for disease detection. Sample images collected from agricultural fields are standardized using an Image data generator. The CNN model is trained to extract relevant features from the images, enabling disease classification. Evaluation metrics, including precision, recall, and F1-score, are analyzed using a confusion matrix. Results show promising performance, with an overall accuracy of 73%. Additionally, the study demonstrates the model's improved performance with increasing training epochs, indicating its real-world application potential.

In conclusion, this research underscores the significance of computer vision in revolutionizing disease management strategies in cucurbit production. By integrating technology into agricultural practices, farmers can enhance disease detection, mitigate yield losses, and ensure the sustainability and productivity of cucurbit crops.

Keywords: Cucurbits, computer vision, machine learning, convolutional neural networks (CNN), disease detection.

LITERATURE CITED

Algren, M., (2021). Machine learning in life cycle assessment. In Elsevier eBooks (pp. 167–190). https://doi.org/10.1016/b978-0-12-817976-5.00009-7

Alpaydin, E. (2010). Introduction to machine learning (2nd ed.). Cambridge, MA: MIT Press.

An Intelligent Plant Dissease Detection System for Smart Hydroponic Using Convolutional Neural Network. (2021, December 1). IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/abstract/document/9691971

Awati, R. (2023). convolutional neural network (CNN). Enterprise AI. https://www.techtarget.com/searchenterpriseai/definition/convolutional-neural-network

Baloglu, M. C. (2018). Genomics of Cucurbits. In Elsevier eBooks (pp. 413–432). https://doi.org/10.1016/b978-0-12-810439-2.00017-9

Beklemysheva, A. (n.d.). Why Use Python for AI and Machine Learning? Steelkiwi. https://steelkiwi.com/blog/python-for-ai-and-machine-learning/

Benos, L. (2021). Machine Learning in Agriculture: A Comprehensive Updated Review. Sensors, 21(11), 3758. https://doi.org/10.3390/s21113758

Borines, L., Gamit, R., & Balangcod, K. (2019). Production Practices of Cucurbit Crops Among Selected Farmers in Benguet, Philippines. Philippine Journal of Crop Science, 44(2), 1-14.

Bournet, P., & Rojano, F. (2022). Advances of Computational Fluid Dynamics (CFD) applications in agricultural building modelling: Research, applications and challenges. Computers and Electronics in Agriculture, 201, 107277. https://doi.org/10.1016/j.compag.2022.107277

Brownlee, J. (2016) Feature Selection for Machine Learning in Python. - References - Scientific Research Publishing. (n.d.). https://www.scirp.org/(S(351jmbntvnsjt1aadkposzje))/reference/ReferencesPapers.aspx?ReferenceID=2143688

Caro, A.C. (2019). Effect of Bacillus subtilis and Trichoderma harzianum on powdery mildew in cucumber (Cucumis sativus L.). Journal of Agricultural Science, 11(8): 96-102.

Chomicki, G., Schaefer, H., & Renner, S. S. (2020). Origin and domestication of Cucurbitaceae crops: insights from phylogenies, genomics and archaeology. New Phytologist, 226(5), 1240–1255. https://doi.org/10.1111/nph.16015

Cruz-Ramírez, A., Bautista-Bautista, N., Moreno-Cadenas, R., & Gómez-González, E. (2021). Artificial neural network approach to predict growth in plants. Journal of Environmental Management, 295, 113023.

Cucumber disease detection using artificial neural network. (2016, August 1). IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/abstract/document/7830151/authors#authors

Dalida, M. L. P., & Navasero, M. V. (2016). Diseases of cucurbits and their management strategies in the Philippines. Philippine Journal of Crop Science, 41(1), 1-9.

Deep Learning Based Plant Disease Detection for Smart Agriculture. (2019, December 1). IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/abstract/document/9024439

Department of Agriculture - Regional Field Office No. 7. (n.d.). Cucurbits. Retrieved from https://rfu07.da.gov.ph/index.php/crops-2/cucurbits

Department of Agriculture. (2021). Crops statistics. Retrieved from https://www.da.gov.ph/data-statistics/crops-statistics/

Deshapande, A. S., Giraddi, S., Karibasappa, K. G., & Desai, S. D. (2019). Fungal Disease Detection in Maize Leaves Using Haar Wavelet Features. In Smart innovation, systems and technologies (pp. 275–286). Springer Nature. https://doi.org/10.1007/978-981-13-1742-2_27

Ebert, A. D. (2014). Potential of Underutilized Traditional Vegetables and Legume Crops to Contribute to Food and Nutritional Security, Income and More Sustainable Production Systems. Sustainability, 6(1), 319–335. https://doi.org/10.3390/su6010319

FINAL RESULTS Volume of Livestock Production in Central Luzon January to December 2022 | Philippine Statistics Authority RSSO 03. (n.d.). https://rsso03.psa.gov.ph/article/final-results-volume-livestock-production-central-luzon-january-december-2022

Fernandez, F. L., & Aguda, R. M. (2015). Integrated pest management for cucurbits in the Philippines. Journal of Pest Science, 88(4), 683-691.

Gao, G., Xiao, K., & Chen, M. (2019). An intelligent IoT-based control and traceability system to forecast and maintain water quality in freshwater fish farms. Computers and Electronics in Agriculture, 166, 105013. https://doi.org/10.1016/j.compag.2019.105013

Gartner. (2021). Gartner Says Python Is Now One of the Most Popular Programming Languages. Retrieved from https://www.gartner.com/en/newsroom/press-releases/2021-07-19-gartner-says-python-is-now-one-of-the-most-popular-programming-languages

Géron, A. (2019). Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow: Concepts, tools, and techniques to build intelligent systems (2nd ed.). Sebastopol, CA: O'Reilly Media.

Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep learning. Cambridge, MA: MIT Press.

Grimalt, S., & Dehouck, P. (2016). Review of analytical methods for the determination of pesticide residues in grapes. Journal of Chromatography a/Journal of Chromatography, 1433, 1–23. https://doi.org/10.1016/j.chroma.2015.12.076

Hasanuzzaman, M., (2020). Phytotoxicity, environmental and health hazards of herbicides: challenges and ways forward. In Elsevier eBooks (pp. 55–99). https://doi.org/10.1016/b978-0-08-103017-2.00003-9

Hayward, Shaw, Dillon, Grumet, R., McCreight, J. D., McGregor, C., Weng, Y., Mazourek, M., Reitsma, K. R., Labate, J. A., Davis, A., & Fei, Z. (2021). Genetic Resources and Vulnerabilities of Major Cucurbit Crops. Genes, 12(8), 1222. https://doi.org/10.3390/genes12081222

Hernández-Pérez, G., Lutz, R., & Gavilán, R. (2021). Prediction of atmospheric pollutants concentration using support vector regression and artificial neural networks. Atmospheric Pollution Research, 12(2), 251-259.

Hong, Y. K., Lee, H. S., Choi, G. S., Jung, J. S., & Hong, S. K. (2018). Development of Real-time Loop-Mediated Isothermal Amplification Assay for Rapid and Quantitative Detection of Downy Mildew Pathogen Peronospora destructor in Onion. The Plant Pathology Journal, 34(3), 188-196.

Islam, M. N., (2022). IoT-Based Serious Gaming Platform for Improving Cognitive Skills of Children with Special Needs. Journal of Educational Computing Research, 60(6), 1588–1611. https://doi.org/10.1177/07356331211067725

IoT based Soil Nutrition and Plant Disease Detection System for Smart Agriculture. (2021, June 18). IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/abstract/document/9509719

Iqbal, S., Kiah, L. M., Dhaghighi, B., Hussain, M., Khan, S., Khan, M. S., & Choo, K. R. (2016). On cloud security attacks: A taxonomy and intrusion detection and prevention as a service. Journal of Network and Computer Applications, 74, 98–120. https://doi.org/10.1016/j.jnca.2016.08.016

Janse, J. D., (2018). Bacterial plant pathogens and their detection in seeds. Applied and Environmental Microbiology, 84(16), e00829-18. doi: 10.1128/AEM.00829-18

Kumar, A., & Rani, M. (2021). Artificial neural networks: A review of basic concepts and applications. International Journal of Information Management, 57, 102324.

Kwon, J., (2014). Simultaneous multiplex PCR detection of seven cucurbit-infecting viruses. Journal of Virological Methods, 206, 133–139. https://doi.org/10.1016/j.jviromet.2014.06.009

Liang, J. (2022, December 12). Confusion Matrix: Machine Learning. https://pac.pogil.org/index.php/pac/article/view/304

Lim, T. K. (2017). Cucurbits. In Edible Medicinal And Non-Medicinal Plants (pp. 241-317). Springer, Dordrecht.

Lumbanraja, J., (2018). Effectiveness of selected fungicides and cultural practices in controlling downy mildew of muskmelon (Cucumis melo L.). International Journal of Agriculture and Biology, 20(1): 71-76.

Mishra, S., Sachan, R., & Rajpal, D. (2020). Deep Convolutional Neural Network based Detection System for Real-time Corn Plant Disease Recognition. Procedia Computer Science, 167, 2003–2010. https://doi.org/10.1016/j.procs.2020.03.236

Neoh, Z. Y., (2023). Genetic Diversity and Geographic Distribution of Cucurbit-Infecting Begomoviruses in the Philippines. Plants, 12(2), 272. https://doi.org/10.3390/plants12020272

O'Shea, K. (2015, November 26). An Introduction to Convolutional Neural Networks. arXiv.org. https://arxiv.org/abs/1511.08458

Ojiambo, P. S., Holmes, G. J., Britton, W. J., Babadoost, M., Bost, S. C., Boyles, R., Brooks, M. L., Damicone, J., Draper, M. A., Egel, D. S., Everts, K. L., Ferrin, D. M., Gevens, A. J., Gugino, B. K., Hausbeck, M. K., Ingram, D. R., Isakeit, T., Keinath, A. P., Koike, S. T., . . . Zhang, S. (2011). Cucurbit Downy Mildew ipmPIPE: A Next Generation Web-based Interactive Tool for Disease Management and Extension Outreach. Plant Health Progress, 12(1). https://doi.org/10.1094/php-2011-0411-01-rv

Ompod, J. L. D., (2018). Climate variability and cucurbit productivity in the Philippines. Journal of Environmental Science and Management, 21(2), 37-51.

Paris, H. R. & Schaffer, A., (2003). MELONS, SQUASHES, AND GOURDS. In Elsevier eBooks (pp. 3817–3826). https://doi.org/10.1016/b0-12-227055-x/00760-4

Raghavendar, K., Batra, I., & Malik, A. (2023). A robust resource allocation model for optimizing data skew and consumption rate in cloud-based IoT environments. Decision Analytics Journal, 7, 100200. https://doi.org/10.1016/j.dajour.2023.100200

Ranger, S. (2022). What is cloud computing? Everything you need to know about the cloud explained. ZDNET. https://www.zdnet.com/article/what-is-cloud-computing-everything-you-need-to-know-about-the-cloud/

Rizzo, D. M., (2021). Plant health and its effects on food safety and security in a One Health framework: four case studies. One Health Outlook, 3(1). https://doi.org/10.1186/s42522-021-00038-7

Sarker, I. H. (2021). Machine Learning: Algorithms, Real-World Applications and Research Directions. SN Computer Science, 2(3). https://doi.org/10.1007/s42979-021-00592-x

Savory, E. A., (2021). The cucurbit downy mildew pathogen Pseudoperonospora cubensis. Molecular Plant Pathology, 12(3), 217–226. https://doi.org/10.1111/j.1364-3703.2010.00670.x

Shoaib, M., (2023). An advanced deep learning models-based plant disease detection: A review of recent research. Frontiers in Plant Science, 14. https://doi.org/10.3389/fpls.2023.1158933

Siddiqua, A., 2022). Evaluating Plant Disease Detection Mobile Applications: Quality and Limitations. Agronomy, 12(8), 1869. https://doi.org/10.3390/agronomy12081869

Singh, R., Kumar, A., Singh, R., Chaudhary, P., & Kaur, J. (2020). Fungal diseases of cucurbitaceous crops: a review. Vegetos, 33(1), 125-136.

Sladojevic, S., (2016). Deep Neural Networks Based Recognition of Plant Diseases by Leaf Image Classification. Computational Intelligence and Neuroscience, 2016, 1–11. https://doi.org/10.1155/2016/3289801

Srivastava, T. (2024, January 8). 12 Important model evaluation Metrics for Machine Learning Everyone should know (Updated 2023). Analytics Vidhya. https://www.analyticsvidhya.com/blog/2019/08/11-important-model-evaluation-error-metrics/

Statista. (2023, May 5). Number of smartphone users in the Philippines 2019-2028. https://www.statista.com/statistics/467186/forecast-of-smartphone-users-in-the-philippines/

Sun, Z., Yu, S., Hu, Y., & Yanchen, W. (2022). Biological Control of the Cucumber Downy Mildew Pathogen Pseudoperonospora cubensis. Horticulturae, 8(5), 410. https://doi.org/10.3390/horticulturae8050410

TIOBE Index. (2023). TIOBE Index for April 2023. Retrieved from https://www.tiobe.com/tiobe-index/

Voulodimos, A., Doulamis, A., & Protopapadakis, E. (2018a). Deep Learning for Computer Vision: A Brief Review. Computational Intelligence and Neuroscience, 2018, 1–13. https://doi.org/10.1155/2018/7068349

Voulodimos, A., Doulamis, A., & Protopapadakis, E. (2018b, February 1). Deep Learning for Computer Vision: A Brief Review. Computational Intelligence and Neuroscience. http://downloads.hindawi.com/journals/cin/2018/7068349.pdf

Wang, Z., Zuo, J., (2019). Development of a multiplex PCR assay for the simultaneous and rapid detection of six pathogenic bacteria in poultry. AMB Express, 9(1). https://doi.org/10.1186/s13568-019-0908-0 What is Computer Vision? | IBM. (n.d.). https://www.ibm.com/topics/computer-vision

Yann L., (2015). Deep learning. Nature, 521(7553), 436–444. https://doi.org/10.1038/nature14539