Indonesia International Institute for Life Sciences

# ENRICHMENT PROGRAM REPORT

## Student Activity and Capstone Project in Machine Learning Cohort of Bangkit Academy 2024

STUDY PROGRAM
**Bioinformatics**

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INDONESIA INTERNATIONAL INSTITUTE FOR LIFE SCIENCES (i3L)
2024

**INTERNSHIP REPORT**

# STUDENT ACTIVITY AND CAPSTONE PROJECT IN MACHINE LEARNING COHORT OF BANGKIT ACADEMY 2024

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i3L – Indonesia International Institute for Life Sciences
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Internship Project Supervisor: Muammar Sadrawi, B.S., M.S., Ph.D.

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## Certificate of Approval

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We hereby declare that this EP project is from the student's own work. The EP Report has been read and presented to i3L's Examination Committee. The EP has been found to be satisfactory and accepted as part of the requirements needed to obtain an i3L bachelor's degree.

Approved by,

EP Advisor

(Muammar Sadrawi)

Date: 17 January 2025

Assessor

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Date: 17 Jan 2025

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Submitted to
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I, Dhannyo Putta, do herewith declare that the material contained in my EP Report entitled:

"Student Activity and Capstone Project in Machine Learning Cohort of Bangkit Academy 2024"

Is original work performed by me under the guidance and advice of my EP advisor, Muammar Sadrawi, S.T., M.S., Ph.D, have read and do understand the definition and information on the use of source and citation style published by i3L. By signing this statement, I unequivocally assert that the aforementioned thesis conforms to published information.

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Date : 19 December 2024

# ABSTRACT

Bangkit Academy, part of the Study Independent MSIB program, ran from September 6 to December 31, 2024, offering a comprehensive learning path in machine learning as part of this internship. Over the course of four months, the program featured a variety of activities, including online courses on Dicoding and Coursera, Instructor-Led Training (ILT), and the completion of a capstone group project.

The machine learning courses covered intermediate to advanced topics, such as Python programming for operating systems, linear algebra for data science, supervised and unsupervised learning, TensorFlow for machine learning and deep learning, generative AI, and more. The ILT sessions were live online classes led by experts from leading companies, offering insights into the practical application of machine learning in the industry. The final capstone project encouraged collaboration between different learning paths to develop an app addressing real-world problems, integrating the knowledge and skills gained throughout the program.

**Keywords**: Machine Learning, Deep Learning, TensorFlow, Capstone Project.

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3. I want to thank my class mentor at MSIB Bangkit Academy, Juni Dio Kasandra. Most questions of internal administration and requirements were frequently discussed in each weekly consultation.

4. Finally, I also want to thank i3L for preparing and allowing me to join Bangkit Academy, one of the flagship MBKM programs with a tough selection process.

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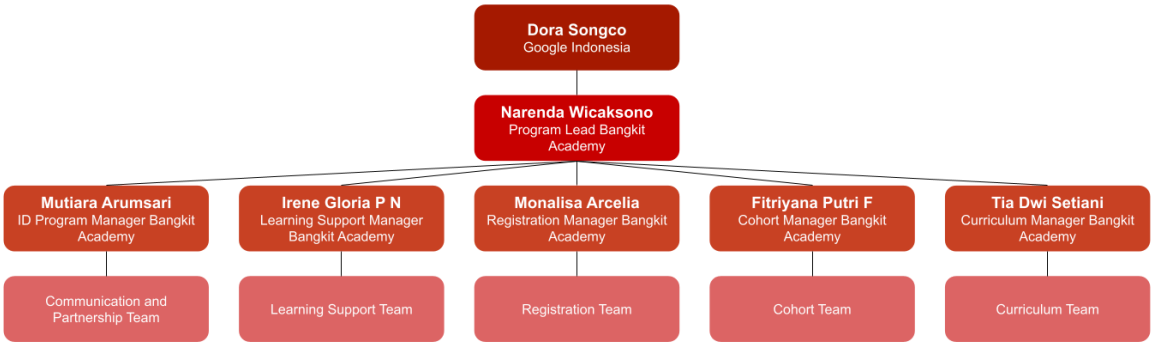
# INTRODUCTION

Bangkit Academy operates as a part of the Magang dan Studi Independen Bersertifikat (MSIB) program under Kampus Merdeka by Indonesian Ministry of Education. The official Bangkit Contributor Portal stated:

> Bangkit is a unique career readiness program led by Google and delivered with support from industry experts from GoTo and Traveloka. The program is designed to provide the participants with first-hand exposure to real-world practitioners and prepare them with relevant skills for a successful career in leading tech companies.

Bangkit Academy has been running for four years since 2020, has trained more than 20,000 students from all universities in Indonesia, and is commonly praised as the "gold standard" of the Kampus Merdeka program. Bangkit Academy has admitted approximately 5000 students from all universities across Indonesia in the current batch. Bangkit Academy's vision is to be a transformative force in education, giving people second chances to be capable of driving change. Several missions of Bangkit Academy include equipping students with tech skills and soft skills required to excel in tech-based careers, fostering the spirit of collaboration and leadership among participants, and bridging the gap between industry needs and academic preparation.

The main activity of Bangkit Academy is its intensive learning programs, which are split into three learning paths: machine learning, cloud computing, and mobile development. These programs combine theoretical knowledge with practical applications through hands-on exercises and capstone projects. Bangkit Academy operates under the following organizational structure to support this learning approach.




The Program Manager is responsible for coordinating with stakeholders and ensuring that the program participants' learning process goes well. The Learning Support Manager is responsible for program planning and support budgeting and managing capstone, judges/judging process, and rewards disbursements. The Registration Manager is responsible for the overall program registration process, including planning, management, and execution, to ensure the acquisition of qualified cohorts. The Cohort Manager is responsible for managing and handling all students and ensuring the minimum graduation rate is the same as last year. The Curriculum Manager is responsible for maintaining and monitoring the curriculum for all tech and soft skill learning paths, providing student learning timelines and monitoring student learning progress.

As mentioned above, the available learning paths for Bangkit Academy 2024 are machine learning, cloud computing, and mobile development. Each student can only partake in one of these learning paths at a time. Students enrolled in Bangkit Academy are organized based on their chosen learning paths into classes consisting of 24 students, with one mentor to guide and monitor the student's progress.

# INTERNSHIP ACTIVITIES

Bangkit Academy is a mixed-modality program consisting of self-paced online learning as well as instructor-led training sessions (ILT). These activities aim to promote development of technical and non-technical soft skills. Each student will also participate in a mandatory small group capstone project by the second half of the program's duration.

## I. Self-paced Online Learning

The primary way of knowledge delivery is through self-paced online learning. I must enroll in Coursera and Dicoding classes to explore a wide range of subjects, from the basic building blocks of programming to specialized advanced courses in machine learning. A certificate is issued by the end of each course, with some also providing a professional certificate for completing a specialization. Below is the list of courses I have taken during my study at Bangkit Academy 2024 as a machine learning cohort.

Table 1. Courses Enrolled in Bangkit Academy

| Course name | Creator | Platform | Deadline |
|---|---|---|---|
| Google IT Automation with Python | Google | Coursera | Sep 29 |
| Data Analysis with Python | Dicoding | Dicoding | Oct 4 |
| Linear Algebra for Machine Learning and Data Science | DeepLearning.AI | Coursera | Oct 9 |
| Machine Learning Specialization | Stanford University, DeepLearning.AI | Coursera | Oct 23 |
| DeepLearning.AI TensorFlow Developer Professional Certificate | DeepLearning.AI | Coursera | Nov 10 |
| DeepLearning Specialization | DeepLearning.AI | Coursera | Nov 10 |
| TensorFlow: Data and Deployment Specialization | DeepLearning.AI | Coursera | Nov 17 |
| TensorFlow: Advanced Techniques | DeepLearning.AI | Coursera | Dec 5 |

| | | | |
|---|---|---|---|
| Specialization | | | |
| Generative AI for Everyone | DeepLearning.AI | Coursera | Dec 8 |
| Build Basic Generative Adversarial Networks | DeepLearning.AI | Coursera | Dec 22 |

# II. Instructor Led Training (ILT) Sessions

Another key method of learning delivery in Bangkit Academy is through Instructor-Led Training (ILT) sessions. Experts directly lead these live online meeting sessions from leading tech companies, offering participants valuable experience and insights into the concepts of machine learning and its industrial applications. Unlike the self-paced courses, ILT provides real-time interaction, enabling students to ask questions and engage with industry professionals. In addition to machine learning-related topics, Bangkit Academy also offers ILT sessions focused on soft skills development, which are crucial for managing workplace challenges and maintaining professional resilience. Below are ILT sessions conducted during my study at Bangkit Academy.

**Table 2.** ILT Sessions in Bangkit Academy

| ILT Session | Date |
|---|---|
| ILT Tech | |
| Understanding the Basics of Python Programming | Sep 24 |
| Exploring Python for Data Analysis | Oct 10 |
| Introduction to Supervised Learning: Concepts and Applications | Oct 25 |
| Exploring Unsupervised Learning & ANN: Techniques and Practical | Nov 5 |
| Going Beyond the Basics: Advanced Deep Learning Techniques with TensorFlow | Nov 18 |
| TensorFlow in the Real World: Deploying Models | Dec 4 |
| The New Era of AI: Practical Applications from Theory to Implementation Gen AI | Dec 12 |
| ILT Soft Skill | |
| Growth Mindset and The Power of Feedback | Sep 18 |
| Time and Energy Management | Sep 30 |
| Adaptability and Resilience | Oct 16 |
| Critical Thinking and Problem Solving | Oct 31 |
| Project Management | Nov 14 |
| Professional Branding and Interview Communication | Nov 25 |

# III. Weekly Consultation

Another important component of learning in Bangkit Academy is the weekly consultation session. This one-hour online meeting is held once a week, bringing together 24 students from the same class and their assigned mentor. Attendance is compulsory, and the mentor leads the session and facilitates discussions with each student. The focus is reviewing learning progress, addressing any challenges during the week, and guiding to overcome obstacles. These sessions ensure consistent support and foster a collaborative learning environment among peers.

# IV. Capstone Project

The capstone project serves as the culminating assignment for students in the Bangkit Academy and is a mandatory requirement for program completion. This final project allows students to apply the knowledge and skills gained throughout their journey in the real world. The primary objectives of the capstone project are to demonstrate problem-solving abilities, provide hands-on experience in teamwork, mentoring, and collaboration, and practice implementing the learned skills in real-world scenarios using technology-driven solutions. Students tackle significant problems through this project, showcasing their creativity, technical expertise, and ability to work collaboratively in diverse teams. There are seven available themes for capstone projects: healthcare, economy and welfare, improving education systems, tourism and travel, entertainment and media, agriculture and fishery, and environmental sustainability. Students need to collaborate to create a minimum viable product of their ideation. The capstone project timeline starts with submitting the project plan, development, presentation, and submission of final deliverables (demo videos and project brief). I joined a six-membered group of three machine learning students and three cloud computing students for my capstone project. My team focused on agriculture and successfully developed a prototype for the vegetable freshness analyzer we call VegiScan.

The learning activities from the courses and ILT sessions have provided materials from various fields of machine learning that were previously unfamiliar, significantly enhancing my technical skills. The ILT sessions, in particular, deepened my understanding of advanced topics and offered valuable opportunities to interact with experts. These interactions allowed me to ask questions and gain insights into the practical implementation of machine learning in daily industrial tasks. Additionally, the certifications earned from completed courses are a strong asset for personal branding. The capstone project taught me how to collaborate effectively on a tech-related project, working

alongside teams from different learning paths. This multidisciplinary teamwork was an invaluable experience in integrating diverse expertise to achieve a common goal.

Many courses offered by the i3L bioinformatics study program have introduced basic programming and data analysis skills. Courses such as calculus, probability, statistics, discrete math, and linear algebra have been taught, which serve as the basis for learning programming and data analysis. Additionally, courses on Linux operating systems have also been taught in i3L. Data analysis and basic machine learning approaches, such as supervised learning and essential neural networks, have also been taught in i3L but are primarily focused on the scope of bioinformatics. At Bangkit Academy, I gained a deeper understanding and developed more advanced skills. These included engineering practices, model structuring, understanding different machine learning approaches, Python code design, deployment, and more. I learned applications of machine learning in computer vision, convolutional neural networks, natural language processing, and time series analysis. This comprehensive learning experience has enabled me to apply machine learning to bioinformatics research and solve real-world problems across various domains.

The fantastic opportunity provided by Bangkit Academy also poses its challenges. The materials provided in the courses ranged from intermediate to expert levels, requiring significant time investment to fully grasp the course content and complete quizzes, hands-on practices, and assignments. The deadline for completing each course is relatively short. The ILT sessions also consumed a whopping 2 hours per session and were usually accompanied by assignments with strict submission deadlines. These challenges are also aggravated during the capstone project due to the time allocated for research and development. Time management was a critical aspect of the Bangkit program to ensure that no sessions, courses, or assignments were missed or delayed. To address this, I dedicated approximately ten hours daily to completing all Bangkit activities, ensuring consistent

attendance and punctuality. Through effective time management and discipline, I successfully completed all sessions on time, significantly improving my skills along the way.

# PROJECT DESCRIPTION

## A. Introduction

Food waste and limited consumer knowledge regarding vegetable quality present significant challenges in the agricultural sector (Aschemann-Witzel et al., 2015). Many consumers struggle to differentiate between high and low-quality vegetables, increasing spoilage and waste (Mijares et al., 2021). This issue is exacerbated by a lack of understanding about properly selecting, storing, and preparing vegetables, which can result in unnecessary food loss (Conrad et al., 2018). Research indicates that a substantial amount of food is wasted at the consumer level, with estimates suggesting that U.S. consumers waste approximately 422 grams of food per person daily (Conrad et al., 2018). This waste is particularly pronounced in fruits and vegetables, which are health-promoting but require significant agricultural resources for production. Higher-quality diets, while beneficial for health, are paradoxically associated with more significant amounts of food waste due to the perishability of fresh produce (Jones-Gracia et al., 2022). Increasing consumer knowledge about vegetable quality is essential for mitigating food waste. Educational initiatives focusing on proper storage techniques and preparation methods can empower consumers to make better choices, ultimately reducing spoilage and waste (Collart et al., 2022).

Advancements in technology, particularly in computer vision, have demonstrated considerable potential in addressing visual analysis tasks. This ability offers promising solutions for addressing the challenges of limited consumer knowledge. Computer vision systems can analyze vegetable quality by assessing attributes such as color, size, structure, and texture from images. For instance, a deep learning-based approach has been proposed by Roul et al. (2023) that allows for the automatic evaluation of vegetable freshness using a single photograph. This system categorizes and scores vegetables based on visual characteristics, providing producers real-time

quality feedback throughout the supply chain. Such technologies enhance the ability to assess freshness and facilitate better decision-making regarding pricing and transportation conditions. By integrating computer vision into agricultural practices, stakeholders can improve the quality of produce available to consumers while reducing waste. Other studies have also shown the ability of computer vision models to assess the quality of fruits and vegetables by analyzing various parameters with varying model architectures (Mukhiddinov et al., 2022). Another prominent tool on the rise that can help solve this issue is generative AI based on LLMs. Razzaq et al., 2023 have utilized this approach to create a context-aware recipe recommender system. On the other hand, a study conducted by Papastratis et al., 2024, has utilized the power of generative AI for nutrition analysis and recommendation.

Following this direction, by leveraging computer vision built on convolutional neural networks (CNN) and prompting with generative AI, we aim to create a system that can analyze vegetable freshness and offer recipe recommendations based on available ingredients. This initiative aims to mitigate food waste by empowering consumers to make informed decisions about vegetable consumption. This comprehensive approach addresses food waste challenges and limited consumer knowledge, ultimately contributing to a more efficient and sustainable agricultural sector.

# B. Result and Discussion

This project relies heavily on the machine learning backbone to provide freshness analysis and recipe recommendations. The model will be deployed as a web application for public use.

## a. Data Wrangling and Preprocessing

To supply the data-driven nature of the freshness analysis model, the first step is acquiring quality data and ensuring they are specifically suitable for model training. Six datasets were

collected from varying online sources as listed below. Additionally, web scraping was also utilized to create a supplementary dataset.

**Table 3.** Dataset List

| Dataset | Source | Format | Size | Amounts | Label Categories |
|---|---|---|---|---|---|
| Fruit and Vegetable Disease (Healthy vs Rotten) | Kaggle | jpg, png, jpeg, other | 5.21 GB | 29.3k | Healthy, Rotten |
| Fruits and Vegetables Image Recognition Dataset | Kaggle | jpg, png, jpeg | 2.17 GB | 3.8k | Unspecified |
| Fresh and Stale Images of Fruits and Vegetables | Kaggle | png | 1.53 GB | 14.7k | Fresh, Rotten |
| Vegetable Image Dataset | Kaggle | jpg | 571 MB | 21k | Unspecified |
| Vegetables360 Dataset | Kaggle | jpg | 279 MB | 1.2k | Unspecified |
| VegNet: Vegetable Dataset with quality (Unripe, Ripe, Old, Dried and Damaged) - Mendeley Data | Mendeley Data | jpg | 121 MB | 6.85k | Fresh, Old, Dry, Rotten |

Images in each dataset were relabeled by moving them to a folder representing their category (e.g., fresh_bellpepper, rotten_potato) with the help of the Linux command available in Google Colab and the os package in Python. Manual inspection was done to remove images of poor quality and unsuitable for the intended use case. Following this step, each image undergoes the following preprocessing steps. Firstly, the images are modified uniformly into 3-channel RGB. Next, the images were resized to 224 x 224 resolution, fitting the input size of the model. Furthermore, the pixel values for each image were rescaled by dividing the values by 255. The datasets were then merged into one master set.

## b. Model Development

Model development was carried out in Google Colab using Tensorflow libraries. Several rounds of rigorous testing were performed across varying CNN architectures. EfficientNet B0 emerged victorious and consistently outperformed other models with relatively small parameter sizes in small datasets. These specifications are suitable for our target application and the given development budget for cloud services. Basing our model on EfficientNet B0, transfer learning and fine-tuning were utilized to create the CNN model for our project. Several layers were also added to the top of the layers from EfficientNet B0. Two output layers have been defined: the softmax layer for classification output and the custom layer to calculate the veggie freshness score. The complete model architecture is provided below.

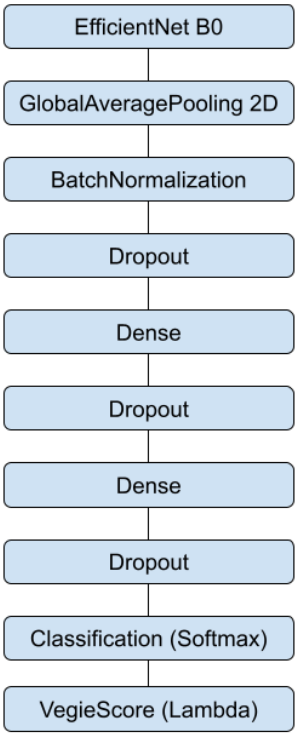



***Figure 1.*** *Model architecture*

The model was compiled regarding accuracy and val_accuracy, with the Adam optimizer, the learning rate 0.001, and the categorical cross-entropy loss function. The model was trained in a batch size of 32 for 50 epochs with a learning rate controller and early stopping callback to prevent performance degradation.

***Figure 2.*** *Model training and validation accuracy*

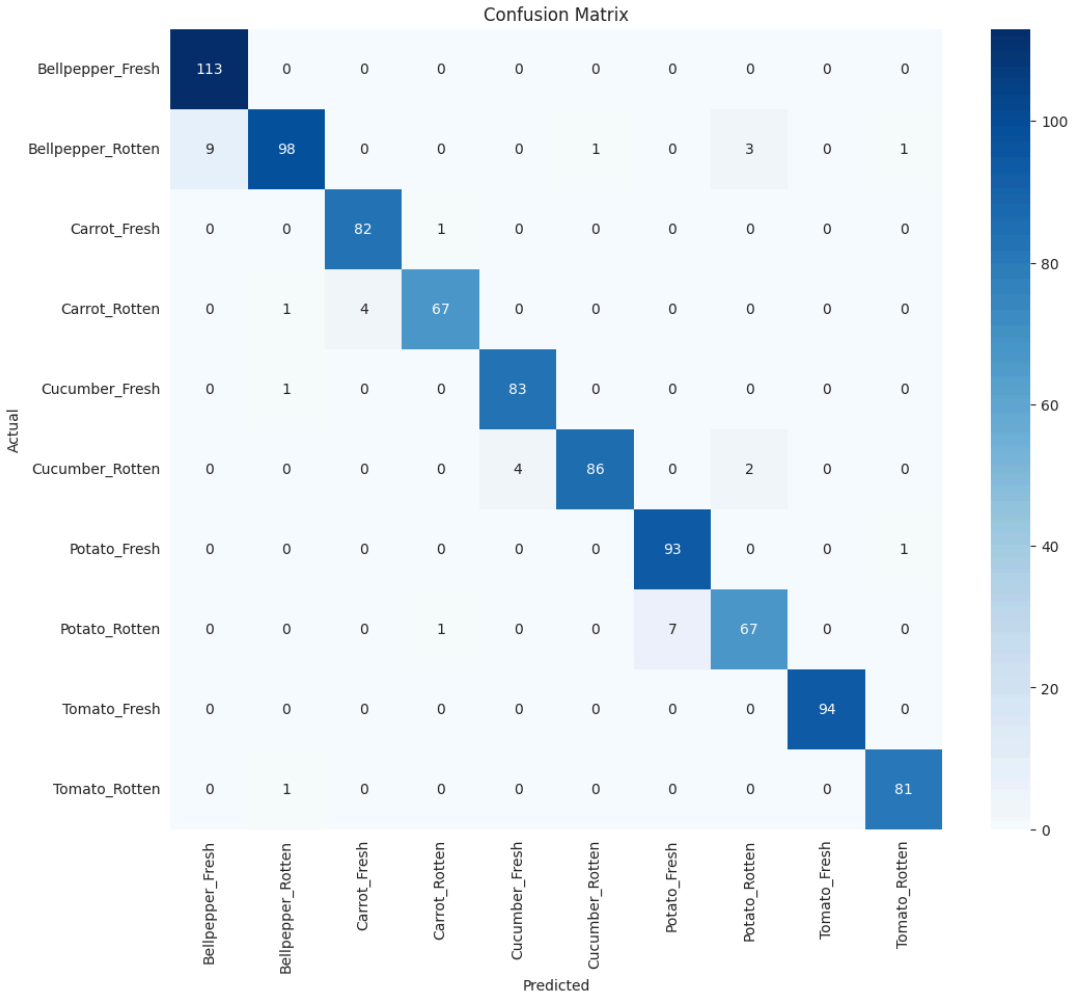



***Figure 3.*** *Confusion matrix generated with sklearn and seaborn*

**Table 4.** Classification report generated with sklearn and seaborn

| Class | Precision | Recall | F1-score | Support |
|---|---|---|---|---|
| Bellpepper_Fresh | 0.9262 | 1.0000 | 0.9617 | 113 |
| Bellpepper_Rotten | 0.9703 | 0.8750 | 0.9202 | 112 |
| Carrot_Fresh | 0.9535 | 0.9880 | 0.9704 | 83 |
| Carrot_Rotten | 0.9710 | 0.9306 | 0.9504 | 72 |
| Cucumber_Fresh | 0.9540 | 0.9881 | 0.9708 | 84 |

| | | | | |
|---|---|---|---|---|
| Cucumber_Rotten | 0.9885 | 0.9348 | 0.9609 | 92 |
| Potato_Fresh | 0.9300 | 0.9894 | 0.9588 | 94 |
| Potato_Rotten | 0.9306 | 0.8933 | 0.9116 | 75 |
| Tomato_Fresh | 1.0000 | 1.0000 | 1.0000 | 94 |
| Tomato_Rotten | 0.9759 | 0.9878 | 0.9818 | 82 |
| accuracy | | | 0.9589 | 901 |
| macro avg | 0.9600 | 0.9587 | 0.9586 | 901 |
| weighted avg | 0.9597 | 0.9589 | 0.9585 | 901 |

The model successfully achieved a viable training classification of 0.9783 and a validation accuracy of 0.9408. Model training is stopped at this point as no overfitting was observed, and further epochs start to give diminishing returns. From the confusion matrix, only a few misclassifications occurred, and the F1 score is within an acceptable range.

### c. Model Deployment

The model was saved into .keras format. Inferences were conducted by loading the saved model with Google Cloud Run. This endpoint will be used for communication with the frontend of the web application.

### d. Integration with Gemini API

A default prompt is engineered to be called from POST and GET requests each time a user image was successfully scanned. Gemini API was utilized to give general info regarding the identified vegetable as well as recipe recommendation suitable for the given condition. The users can also chat with the Gemini API to ask other questions related to vegetables, recipes, and other information.

### e. Deployed Application

The application was successfully deployed as a web application accessible from any browser. Users can easily navigate to the scan vegetable page to upload their vegetable of concern. The model will analyze the freshness of the vegetable and provide general information as well as recipe recommendations powered by Gemini API.

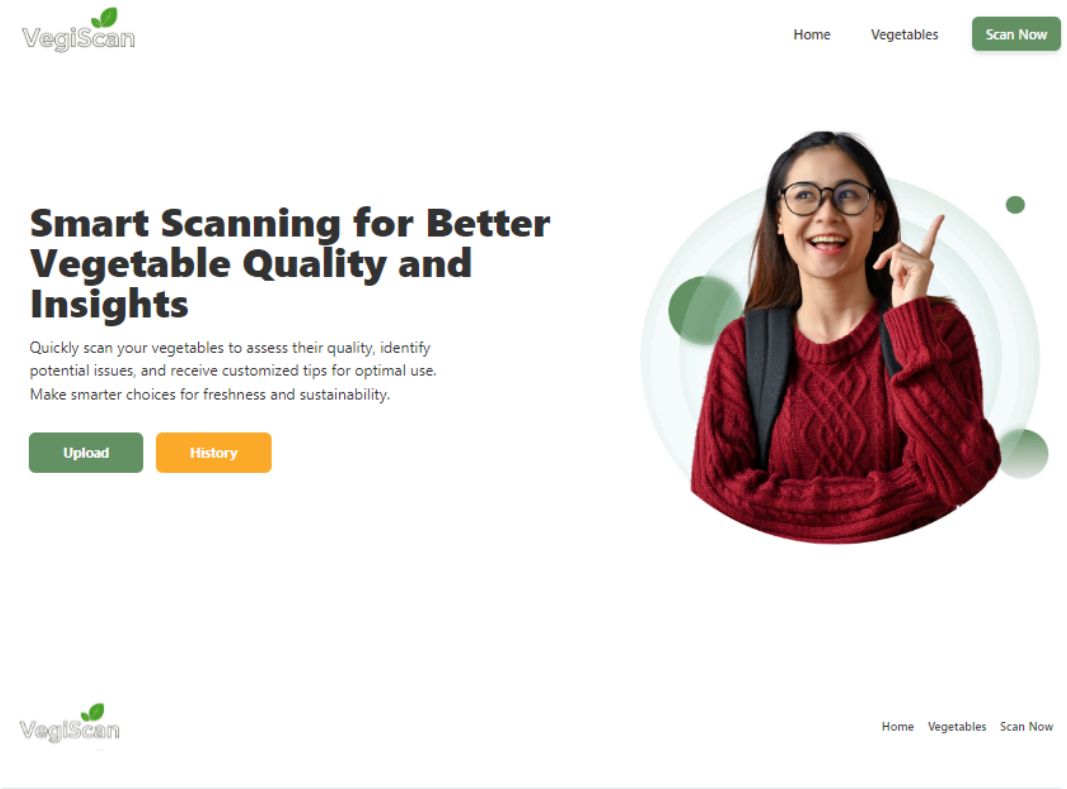



***Figure 4.*** *Scan page of the deployed web application*

## C. Conclusion and Recommendation

The minimum viable product for VegiScan has been reached showing a working product that involved machine learning and cloud computing students. This app can analyze the freshness of the vegetables as well as provide recipe recommendations suitable with the detected vegetables. As a result, personal food waste can be minimized and consumer concerns of freshness

uncertainty can be alleviated. However, this project is currently only limited to a very small category of vegetables due to time limitations. This project is still far from perfect and requires a lot of improvement for better performance especially in user experience. Additional features such as authorization and monetization can be considered in the future.

# SELF REFLECTION

Participating in the MSIB Bangkit Academy has been a transformative experience, offering me a significant opportunity to enhance my technical skills, particularly in machine learning. The program's courses covered machine learning topics comprehensively, including mathematical concepts, computer vision, supervised and unsupervised learning, neural networks, TensorFlow, generative AI, data pipelines, and more. These skills and the certifications earned have equipped me with a strong foundation to pursue a career in machine learning after graduation.

One of the program's greatest strengths lies in its structured learning environment, which combines high-quality courses with certifications and hands-on group work for the capstone project. These elements deepened my technical expertise and allowed me to collaborate with individuals outside my campus, including my mentor, capstone teammates, and industry experts, thus expanding my professional network. While the program was immensely beneficial, I identified a minor area for improvement: better time scheduling for future cohorts. The program's demanding schedule was one of the biggest challenges I faced. However, the fast-paced and immersive environment helped me develop adaptability and resilience, enabling me to manage my responsibilities effectively.

My prior experience at i3L also played a key role in my success during Bangkit. Previous semesters in the bioinformatics study program introduced foundational topics in machine learning and programming, which proved crucial in tackling the advanced materials in Bangkit. Additionally, the BRIGHT sessions at i3L fostered self-awareness and accountability, essential skills I applied during the program. These soft skills were particularly valuable in managing the intense workload, ensuring I fulfilled all responsibilities during the capstone project and other activities in Bangkit. This blend of technical training and personal development has prepared me for the challenges of a future career in machine learning and beyond.

# CONCLUSION & RECOMMENDATION

Participating in the MSIB program at Bangkit Academy as part of my internship experience has been an invaluable opportunity to enhance my technical skills and gain hands-on experience in machine learning and technology development. The program's primary goals, such as learning, practical work, and team collaboration, were realized through comprehensive courses, certifications, and group-based projects. Completing these courses and earning industry-recognized certifications has significantly strengthened my professional profile and prepared me for a career in the competitive field of machine learning.

The skills I gained during Bangkit are instrumental for a successful future in technology. From mastering core machine learning concepts to applying them in real-world projects, this program provided a strong foundation in one of the most crucial areas of the modern tech industry. The collaborative environment also fostered teamwork and networking, enabling me to work closely with diverse individuals, including mentors, peers from different institutions, and industry professionals.

Machine learning is a rapidly evolving and complex field requiring continuous learning and practical application to stay ahead. I recommend that future participants seek similar opportunities to build their expertise through internships or similar programs. Additionally, it is vital to stay motivated and manage time well to thrive in such programs, as most are centered around self-paced learning.

# REFERENCES

Aschemann-Witzel, J., de Hooge, I., Amani, P., Bech-Larsen, T., & Oostindjer, M. (2015). Consumer-Related Food Waste: Causes and Potential for Action. *Sustainability*, *7*(6), 6457–6477. https://doi.org/10.3390/su7066457

Collart, A. J., Interis, M. G., Henson, C., & Maples, J. (2022). The Impacts of Food Waste Information on Consumer Preferences for Blemished Produce and Implications for Food Retailers. *Journal of Agricultural and Applied Economics*, *54*(3), 440–460. https://doi.org/10.1017/aae.2022.21

Conrad, Z., Niles, M. T., Neher, D. A., Roy, E. D., Tichenor, N. E., & Jahns, L. (2018). Relationship between food waste, diet quality, and environmental sustainability. *PLoS One*, *13*(4), e0195405. https://doi.org/10.1371/journal.pone.0195405

Jones-Garcia, E., Bakalis, S., & Flintham, M. (2022). Consumer Behaviour and Food Waste: Understanding and Mitigating Waste with a Technology Probe. *Foods*, *11*(14), 2048. https://doi.org/10.3390/foods11142048

Mijares, V., Alcivar, J., & Palacios, C. (2021). Food Waste and Its Association with Diet Quality of Foods Purchased in South Florida. *Nutrients*, *13*(8), 2535. https://doi.org/10.3390/nu13082535

Mukhiddinov, M., Muminov, A., & Cho, J. (2022). Improved Classification Approach for Fruits and Vegetables Freshness Based on Deep Learning. *Sensors*, *22*(21), 8192. https://doi.org/10.3390/s22218192

Papastratis, I., Konstantinidis, D., Daras, P., & Dimitropoulos, K. (2024). AI nutrition recommendation using a deep generative model and ChatGPT. *Scientific Reports*, *14*(1). https://doi.org/10.1038/s41598-024-65438-x

Razzaq, M. S., Maqbool, F., Ilyas, M., & Jabeen, H. (2023). EvoRecipes: A Generative Approach for Evolving Context-Aware Recipes. *IEEE Access*, 1–1. https://doi.org/10.1109/access.2023.3296144

Roul, A., Padhy, S., Parhi, M., & Pati, A. (2023). VeggieFreshAI: An intelligent system to detect vegetable quality using deep computational analysis. *AIP Conference Proceedings*. https://doi.org/10.1063/5.0137009

# APPENDICES

## External Links

VegiScan Deployed App
Model Development Colab
Datasets
**Certificates**