Enhancing Transparency in The Coconut Supply Chain Through a Software Engineering Approach

Group Number

24 - 25J - 313

Project Proposal Report

K.D.R Manditha

B.Sc. (Hons) Degree in Information Technology specializing in Information Technology

Department of Information Technology

Sri Lanka Institute of Information Technology Sri Lanka

Automating Coconut Husk Grading System Using Image Processing and Computer Vision, IoT Automation System for Coco Peat Quality Assurance

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Declaration

I declare that this project proposal is my own work and has not been submitted previously for any academic qualification. All sources of information are acknowledged by references.

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Abstract

The focus of this project is on the development of an automated coconut husk grading system that integrates IoT for quality assurance using image processing techniques and computer vision. This gives the direction to the main research problem: Traditional image processing or computer vision, which is more appropriate for husk grading based on color as an indicator of quality? In this study, comparative analysis will be used to determine which of these technologies is best.

Additional project deliverables include the development of an IoT-based system capable of real-time monitoring of the coco peat quality considering the processing conditions are optimal, taking into account the integration with physical input mechanisms such as conveyor systems. The results shall drive the design for a strong and effective grading system to ensure uniformity in quality, enhanced accuracy, reduced labor cost, and a host of other benefits. This project is finalized by the proposition of an optimized solution for real-time grading of coconut husks and Coco Peat Quality monitoring which significantly
It leads to the automation of agricultural processing.

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Introduction

Grading of coconut husks in the industry is currently done through manual procedures: the workers sort the husks into three categories based on color. The greener the husk, the better the quality; dark brown is disqualified, and between green and brown, is accepted. This manual process is labor-intensive, time-consuming, and highly dependent on the expertise of the workers, hence inconsistencies and errors are likely to happen. There is pressure to cut down labor costs while maintaining product quality in the current economic climate. In addressing these, this project shall apply an automated system using image processing or computer vision technology in grading coconut husks and IoT systems to monitor the conditions of coco peat in real-time. This automation shall help increase efficiency, accuracy, and consistency in the coconut industry.

Background

Coconut Industry

The coconut industry has been one of the mainstay sectors for many tropical countries, providing immense value addition to their economies. Coconut husks are by-products of coconut processing and useful in many aspects, mainly on the production of coco peat. The latter becomes a by-product with huge demand for use as soil amendments or in horticulture. The quality assurance of coconut husk and coco peat concerns the maintenance of standards in end products.

Manual Grading Process

The grading of coconut husks is currently being carried out manually by the workers: each husk is visually inspected and then put into a specific category, based on its color. The process is subjective, hence leading to some human errors and may vary depending on the experience and knowledge of the workers. Manually grading requires a lot of time and causes bottlenecks in production.

Manual Monitoring of Coco Peat Conditions

Coco peat is a product processed by monitoring the EC and moisture levels during its washing and drying stages. Currently, this is done using manual methods whereby workers use sensors to check these levels and then record the data. Also, there should be the presence of a person in charge when the process is going on. This method is labor-intensive, inefficient, and full of errors that affect the consistency of the final products.

Literature Survey

Image Processing and Computer Vision

Results from previous studies on image processing and computer vision have shown their effectiveness in automating quality control for many industries. For example, the application of color analysis with machine learning algorithms has been successful in classifying agricultural products to a high degree of accuracy and reducing labor costs [1][2]. According to Zhang and Zheng, 2022, deep learning algorithms have been used massively in image processing, with crop yield estimation and detection of natural disaster instances. Similarly, Latha et al. indicated in their work in 2014 that image processing is able to detect weeds, making it suitable for optimizing agricultural practices.

IoT Systems in Agriculture

IoT systems have been widely adopted for real-time monitoring of environmental conditions in agriculture. The continuous data from the systems helps in maintaining optimum conditions against various processes, hence improving efficiency and reducing manual intervention.

Quality Assurance Automation

Research on the automation of quality assurance using industrial robots and image processing reveals improvements in consistency and throughput [3]. The approach lessens human error in measurement and thus enhances the reliability of the quality assurance process. For example, Watpade et al. explained in 2014 how automated visual inspection in manufacturing industries works in conjunction with image processing to detect faulty parts or missing components, thus ensuring increased accuracy in quality control [3].

Research Gap

There is an important research gap in determining which technology—image processing or computer vision—is best for integration with the physical input mechanisms in coconut husk grading systems. Much of the available literature discusses the algorithmic effectiveness of either technology over a spectrum of domains, seldom discussing their overall integration with real-world input mechanisms like conveyor belts necessary in most real-time, fully automated grading processes. Therefore, this gap calls for a comprehensive analysis and comparison of the technologies in optimizing them for practical, efficient, and accurate grading within an industrial setting and specific to the unique characteristics and requirements of coconut husks.

Research Problem

Grading coconut husks is still done manually in the agricultural industry, and the process is time-consuming, allowing inconsistencies. Potential solutions for automating this process are found in some technologies like image processing and computer vision. However, there is a lack of studies comparing these technologies in the context of coconut husk grading, particularly with respect to their integration with any physical input mechanism like a conveyor system.

The problem statement of the research entails the determination of which technology—image processing or computer vision—is more appropriate to develop an efficient, accurate, and real-time grading system for coconut husks in relation to their integration with existing input mechanisms.

Objectives

Main Objectives

- To automate the coconut husk selection process using image processing technology to ensure efficiency and consistency.
- To implement IoT systems for real-time monitoring of coco peat conditions during the washing and drying processes.

Specific Objectives

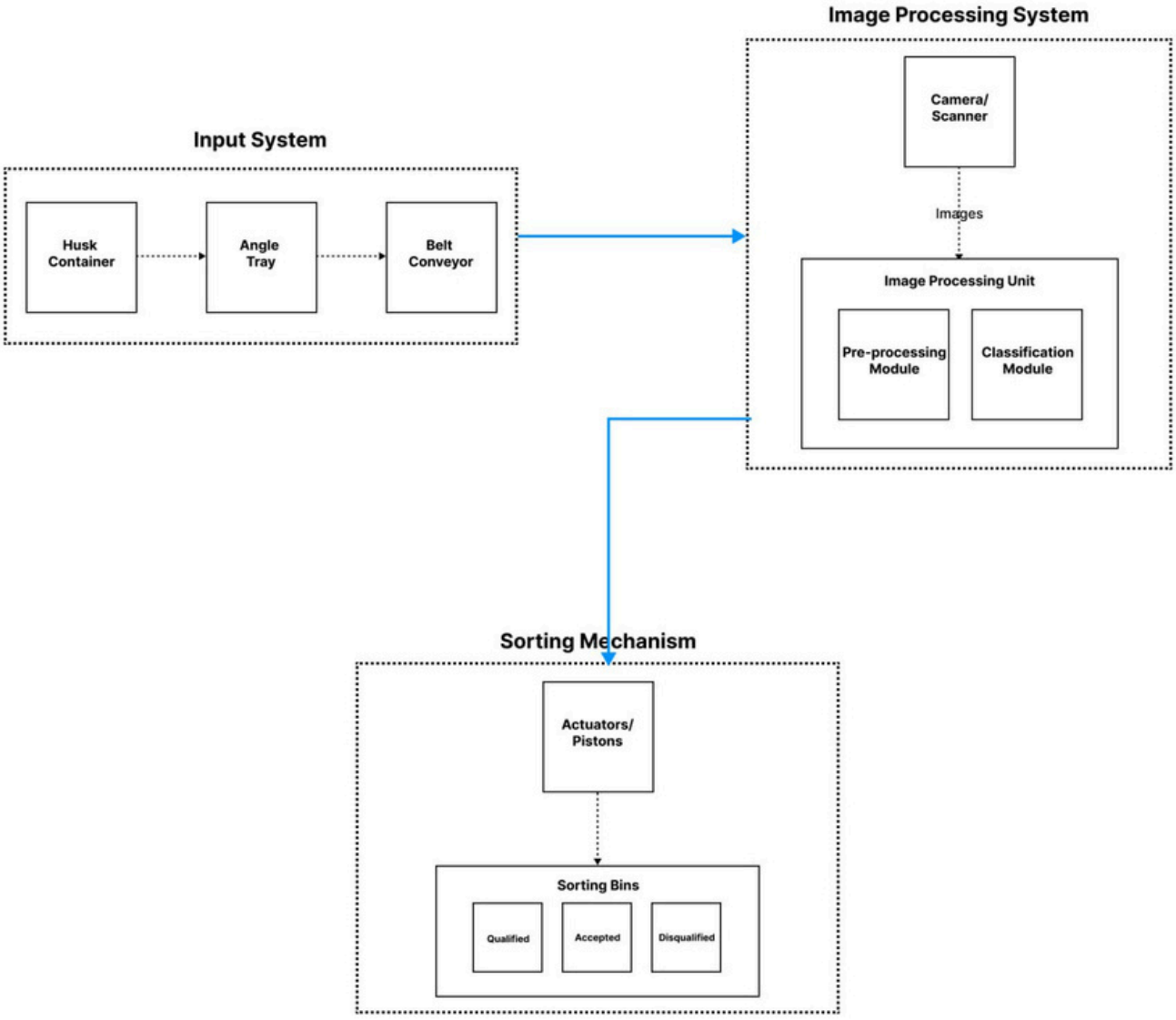
- Design a mechanism to transfer husks from the vehicle to the scanner.
- Develop and train data models for the image processing system.
- Design and implement an automated husk sorting mechanism.
- Deploy sensors for monitoring moisture and EC levels in coco peat.
- Create a web dashboard for real-time data visualization.

Methodology

Coconut Husk Grading System

System Description:

The Coconut Husk Grading System is envisioned to automate the sorting of coconut husks in terms of their quality through image processing. It comprises the following three primary subsystems:



- **Input System:** These will be the husk container, angle tray, and belt conveyor, all working together to move the husks into the image processing system.

- **Image Processing System:** This system captures the image of coconut husks through a camera or scanner. The images would then be processed by a pre-processing module, succeeded by the classification module, which subsequently classifies them into qualified, accepted, or disqualified categories.

- **Sorting Mechanism:** The results are then fed to actuators/pistons, which categorically sort the husks into appropriate bins according to quality as determined by the image processing system.

Technology Stack:

- **Camera/Scanner:** High-resolution industrial camera (e.g., Basler Ace) for capturing husk images.
- **Image Processing Framework:** OpenCV for image processing tasks.
- **Computer Vision:** TensorFlow or PyTorch to build a CNN model.
- **Classification:** Image processing techniques (e.g., color space conversion, thresholding, pixel counting) implemented using OpenCV.
- **Programming Language:** Python for implementing the image processing and machine learning algorithms.
- **Hardware:** Raspberry Pi or NVIDIA Jetson Nano for running the image processing algorithms locally.
- **Actuators/Pistons:** Pneumatic pistons controlled via GPIO for sorting the husks.

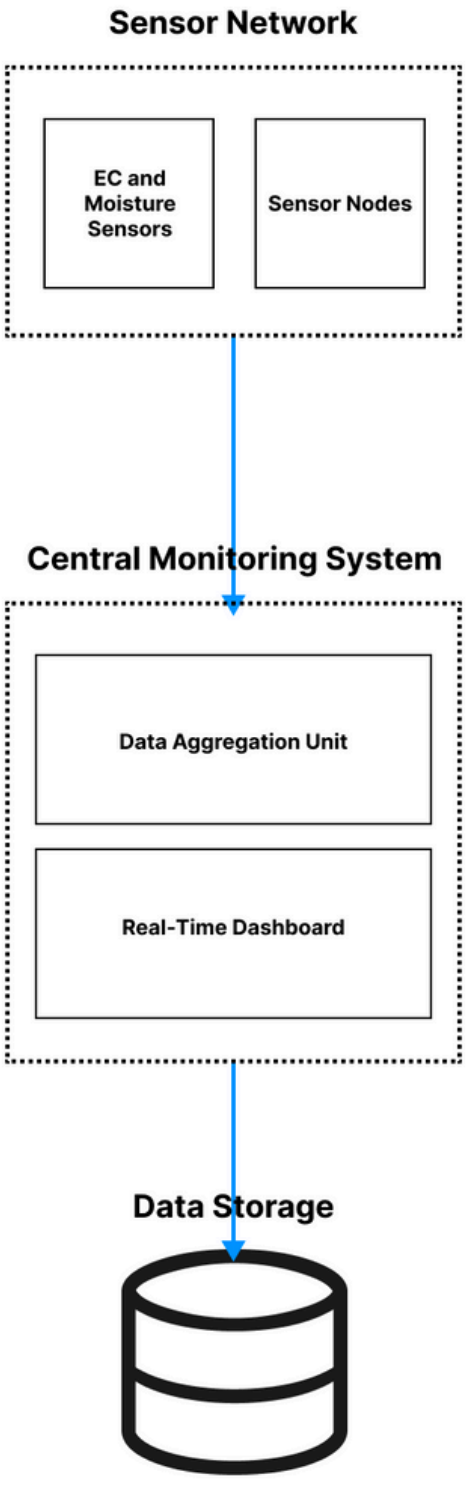
Implementation Steps:

- **Data Collection:** Capture a large dataset of coconut husk images covering all possible variations in color and quality.
- **Pre-processing:** Design and implement OpenCV-based pre-processing of images, including color normalization and noise reduction, before feature extraction, followed by classification.
- **Color-Based Classification:** Convert images into the HSV color space and perform thresholding to sort husks, based on their quality, into three different categories: high quality (green), medium quality (brown), and low quality (dark brown), by counting the pixels.
- **Integration:** Integrate the image processing system with the camera/scanner and implement real-time image processing to classify husks on the fly.
- **Sorting Mechanism:** Implement actuator control logic to activate the appropriate piston and then sort the respective husks into their class bins, again according to the result of the classification.
- **Testing:** Test the integrity of the whole system in a controlled environment, ensuring efficiency and accuracy, and make the necessary adjustments with the findings.

Coco Peat Condition Monitoring System using IoT

System Description:

The Coco Peat Condition Monitoring System automates the following: monitoring the quality of the coco peat by tracking some critical parameters like electrical conductivity and moisture levels during washing and drying.



- **Sensor Network:** Includes EC and moisture sensors connected to sensor nodes that collect data in real-time.
- **Central Monitoring System:** Aggregates the data and visualizes it through a real-time dashboard.
- **Data Storage:** Stores historical data for trend analysis and decision-making.

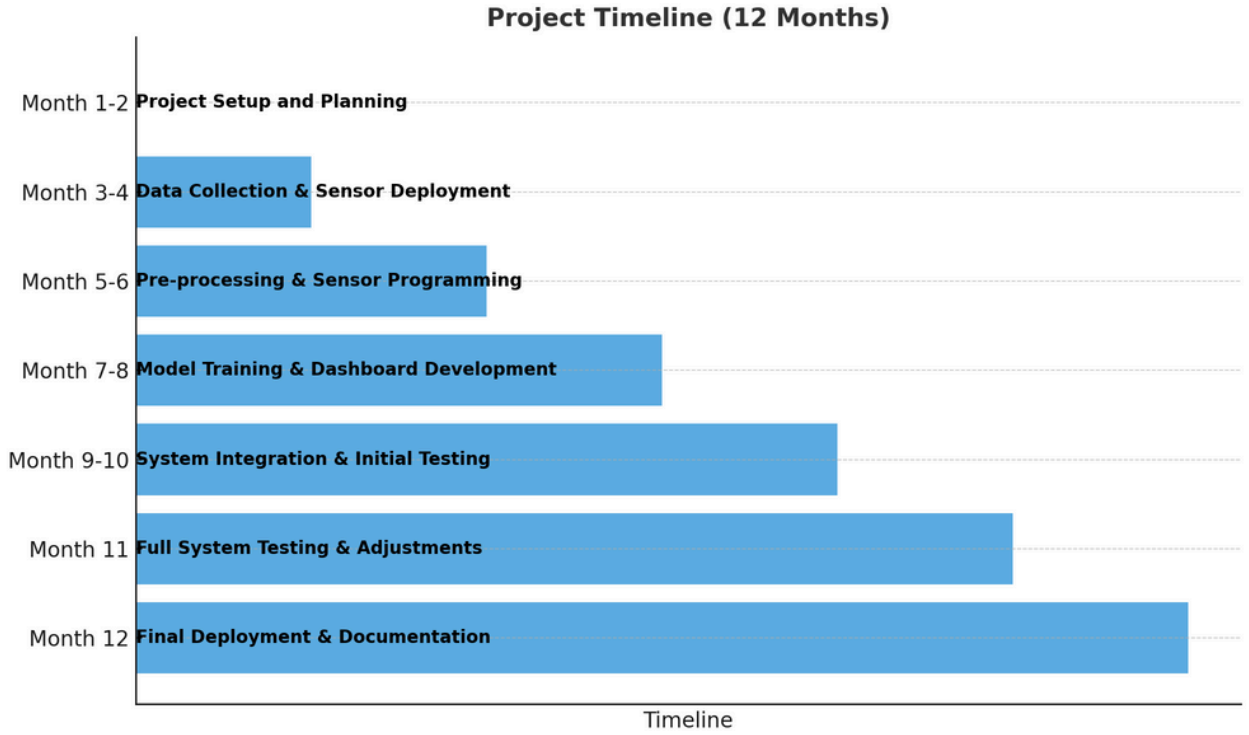
Technology Stack:

- **Sensors:** DHT22 (for moisture) and EC sensor (for conductivity).
- **Microcontroller:** Arduino or ESP8266/ESP32 for collecting sensor data.
- **Wireless Communication:** WiFi module (e.g., ESP8266) for transmitting data from sensors to the central monitoring system.
- **Data Aggregation and Visualization:** Node-RED for aggregating sensor data and displaying it on a real-time dashboard.
- **Data Storage:** InfluxDB for storing historical data.
- **Programming Language:** Python or C++ for microcontroller programming.
- **Real-Time Dashboard:** Grafana integrated with Node-RED for visualizing the data.

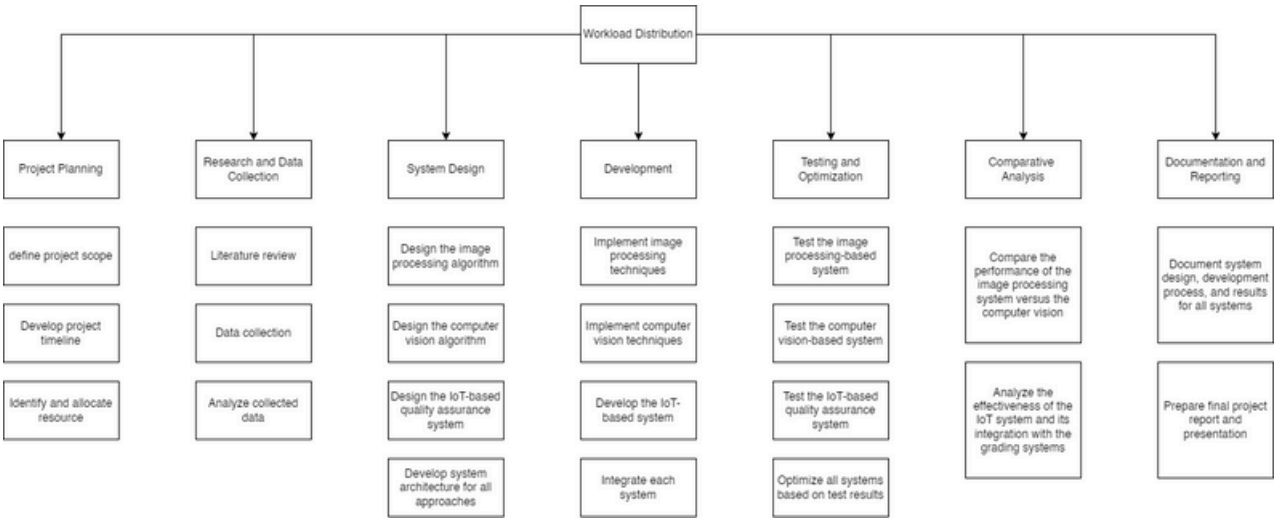
Implementation Steps:

- **Sensor Deployment:** Install EC and moisture sensors within key points in washing and drying areas, recording real-time data.
- **Microcontroller Programming:** Program the microcontroller—for example, Arduino or ESP32—to read data from the sensors in a block and transmit it over WiFi to a central monitoring system.
- **Data Aggregation:** Set up a Node-RED either on a local server or the cloud, and it consolidates the sensor data before further relaying it to InfluxDB or Firebase for storage.
- **Dashboard Development:** Develop a real-time dashboard using Grafana, integrated with Node-RED, to visualize the data, showing current readings and historical trends.
- **Alerts and Notifications:** Add a logic in Node-RED that triggers an alert by SMS/email if sensor readings go outside acceptable thresholds.
- **Testing:** Conduct an extensive test of the sensor network and dashboard for accuracy, reliability, and responsiveness. Be prepared to adjust the system after any results from testing.

Project timeline (12 months):



Workload distribution



Anticipate conclusion

1. Results

Coconut Husk Grading System:

- **Increased Efficiency:** automated coconut husk grading, will dramatically reduce the time needed for sorting coconut husks, increasing the output and reducing manual labor.

- **Enhanced Accuracy:** The use of image processing and machine learning ensures consistent and reliable husk classification, reducing errors and improving the overall quality of the graded husks.

- **Labor Cost Reduction:** One such feature that has come with automation is the minimal involvement of manpower. In this regard, operational costs are decreased, and human resources are saved for the execution of other tasks.

Coco Peat Condition Monitoring System:

- **Real-time Monitoring:** During all phases of coco peat processing, continuous monitoring of the moisture and electrical conductivity levels will ensure the right conditions for a more homogeneous and higher-quality final product.

- **Improved Decision Making:** Real-time dashboard with actionable insights and alerts enabling timely interventions that prevent quality degradation.

- **Data-Driven Operations:** historical data storage, coupled with its analysis, enables optimization of processes over time for further efficiency gains.

2. Applications

Agricultural Industry:

- These systems can, with minor modifications, be applied to all other areas of the agrarian sector for sorting, grading, and quality monitoring of several products, including fruits, vegetables, and cereals.

- It is of modular nature and can, therefore, be adapted to be applied to any crop and to different stages of processing.

Manufacturing and Quality Control:

- The developed image-processing system for coconut husk grading can be used to a large extent in other manufacturing processes where visual inspection-based quality control is required.

- IoT-based monitoring systems can be further extended to a number of industrial applications wherein real-time data collection and analysis are most crucial for the maintenance of product quality.

Supply Chain Management:

- This project will integrate IoT and real-time data dashboards to ensure more transparency and traceability in the supply chain. Improved traceability and transparency within the supply chain guarantee efficient management of resources and waste reduction.

3. Real world use

- **Higher Product Quality:** They use coconut husks for further processing into other products or coco peat for agricultural use, which would have increased quality standards from consistent grading and precise checking, leading to more customer satisfaction and increased market value.

- **Sustainability:** These systems optimize processes, reduce the manual labor involved, and contribute toward more sustainable practices for the coconut industry through energy and waste reduction.

- **Scalability:** Tt can be applicable to small, medium, or large operations, so a broad range of businesses in the agriculture sector is a potential candidate.

- **Economic Impact:** For producers, this could mean savings through lower labor, higher throughput, and better product quality—thereby ensuring better market profitability and competitive advantage.

Project Requirements

Functional Requirements

- Accurate classification of coconut husks based on color.
- Real-time monitoring of moisture and EC levels.
- User-friendly web dashboard for data visualization.

Non - Functional Requirements

- High system reliability and uptime.
- Low latency in data transmission.
- Scalability to accommodate varying production volumes.

Expected Test Cases

- Test the accuracy of the husk classification system.
- Verify the real-time data transmission from sensors to the dashboard.
- Ensure the web dashboard displays accurate and up-to-date information.

Budget and Budget Justification

Resources	Estimated Budget (LKR)
Hardware equipments	25,000.00
Internet	5,000.00
Total	**30,000.00**

References

1. Zhang, Y., & Zheng, X. (2022). Development of Image Processing Based on Deep Learning Algorithm. IEEE Asia-Pacific Conference on Image Processing, Electronics and Computers (IPEC), 1226-1228.
2. Latha, M., Poojith, A., Reddy, B. V. A., & Kumar, G. V. (2014). Image Processing in Agriculture. International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering, 2(6), 1562-1565.
3. Watpade, A. B., Amrutkar, M. S., Bagrecha, N. Y., & Vaidya, A. S. (2014). QCUIP: Quality Control Using Image Processing. International Journal of Engineering Research and Applications, 4(3), 15-18.
4. G. S. Chiu and T. L. Fong, "Fruit Classification Using Image Processing," Procedia Computer Science, vol. 133, pp. 150-156, 2018.
5. R. K. Gupta and A. S. Anjum, "Detection of Fire Using Image Processing Techniques with LUV Color Space," Materials Today: Proceedings, vol. 5, no. 1, pp. 12777-12783, 2018.
6. N. R. Pavithra, D. M. Bhalerao, and D. K. Verma, "Beef Quality Identification Using Color Analysis and K-Nearest Neighbor Classification," Journal of Food Processing and Preservation, vol. 44, no. 11, e14800, 2020.