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Trash to Treasure (3T) Transforming Waste into Valuable Resources

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Abstract: ***Bubble tea has become a popular drink, favored by many people in Indonesia. Many outlets have started offering bubble tea, including Chatime. From February 2022 to June 2023, the plastic waste generated by Chatime reached 1737 kilograms. To address this issue, this research developed a machine to manage plastic waste at Chatime outlets. This research, titled Trash to Treasure (3T), uses the You Only Look Once (YOLO) algorithm and ESP-32 CAM to identify and process Chatime cups. Additionally, a website was developed using Flask to support the machine's functionality. The machine is designed to accept Chatime cups and provide points that can be exchanged for attractive items or vouchers, as shown on the website. Evaluation results show that the object detection model works well, with F1-score values 94,9%. The implementation in the form of software was successful, developing a user-friendly interface for both admin and users. This research benefits not only Chatime but also supports the community in the circular economy by providing an innovative solution to manage plastic waste. Thus, this research is expected to contribute significantly to plastic waste management and support environmental sustainability.***

Keywords: Chatime, Plastic Waste, YOLO, ESP32-CAM, Flask, Circular Economy

1. Introduction

Bubble tea has become one of the most popular beverages favored by the general public. Its popularity in Indonesia surged around 2011, and since then, many restaurants in Indonesia have offered bubble tea as their main beverage [1]. Chatime, a Taiwanese franchise operating since 2006 and managed by PT. Beverage Food Indonesia [2], is a well-known business among many people. Data shows that in 2019 there were 275 Chatime outlets in Indonesia, which increased to 428 outlets in 2023 [2]. From February 2022 to June 2023, Chatime generated 1737 kilograms of plastic waste [3].

To address this issue, Chatime launched the "Sapu Plastik" movement, providing special bins for disposing of plastic waste at their outlets [3]. Despite this initiative, public participation has been low due to a lack of motivation to encourage people to participate in the movement. Several related works have focused on the management of plastic waste through innovative approaches. For instance, studies have investigated the effectiveness of reward-based recycling systems that utilize smart technologies to enhance user participation. In one study, a smart bin system using image recognition to sort recyclables and provide incentives showed promising results in increasing recycling rates [4]. Another research utilized RFID technology to track recycling habits and provide users with rewards, leading to significant improvements in waste management practices [5].

The solution offered in this research is to create a machine that accepts Chatime cups and provides points that can be redeemed for goods or attractive vouchers, as demonstrated on the website. This machine will utilize the YOLO (You Only Look Once) algorithm along with ESP32-CAM, ESP32, and servo motors to identify and process Chatime cups. The supporting website is developed using Flask, a Python-based web framework. The state of the art in this area includes various technologies for automated waste sorting and incentive-based recycling systems. However, a gap remains in the integration of these technologies specifically for managing waste from popular beverage outlets like Chatime. The novelty of this research lies in its application of YOLO algorithm and IoT devices to create an efficient, user-friendly recycling system tailored for Chatime outlets. This approach not only aims to increase public participation in waste management but also supports the circular economy by incentivizing recycling behaviors. This research hopes to benefit not only Chatime and the researchers but also the community and support the ongoing circular economy

2. Method

In implementing the machine, several key components were considered, including the machine itself, the algorithm, and the website. These elements work together to create an efficient and effective system. YOLO (You Only Look Once) is a deep learning algorithm used for real-time object detection, repurposing a classifier or localizer. This research utilizes YOLO v5 to develop a machine learning model for detecting "Chatime" products. Python was chosen for implementing the YOLO algorithm due to its extensive libraries, such as Ultralytics, which are well-suited for this application and efficient for project execution.

To build the application's interface, Flask, a web framework written in Python, was used. Flask serves as the framework for the application's functionality and web interface. User account data and rewards are stored in a MySQL database, an open-source relational database management system, allowing for efficient data storage and management. The ESP32 CAM acts as the brain of the system, with its camera detecting the Chatime logo on the cups. Additionally, the

ESP32 enhances image processing and device control capabilities, strengthening the overall system's ability to detect and manage Chatime cups. The ESP32 CAM MB is a module supporting the camera. Servo motors are used for the mechanism that opens and closes the compartment where the cups are placed, providing precise control over specific angles.

Cardboard is used as the primary material for constructing the vending machine's frame, offering sufficient strength to support the components and overall structure of the machine. Hot glue is employed to assemble the cardboard parts and other components in the machine's construction. Jumper wires are used to connect electronic components to power sources or to link various parts of the machine to the necessary electrical connections. The flow of the machine's operation can be understood through the accompanying diagrams, which describe and analyze the designed system. These diagrams are essential for visualizing the process and ensuring that each component functions correctly within the system. By considering these elements and their integration, the resulting machine is designed to be efficient and effective in managing Chatime cups, ultimately supporting environmental sustainability through improved plastic waste management.

The use case diagram illustrates the interactions between the Admin and User within the system. The Admin can log into the system, add new vouchers, view transaction records, and monitor user activities. These actions help in managing and supervising the system effectively. The User, on the other hand, can create an account, log in, view available vouchers, and perform transactions such as redeeming vouchers. The diagram highlights the key functionalities available to both the Admin and the User, demonstrating the system's capabilities in voucher management and transaction processing.

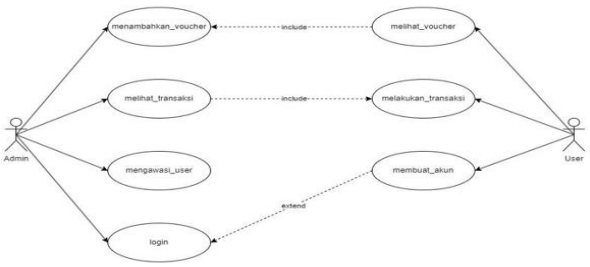

Figure 1: Use Case Diagram

The ERD (Entity-Relationship Diagram) showcases the relationships between different entities within the system, specifically focusing on Admins, Users, and Vouchers. The Admin entity includes attributes such as `id`, `username`, `name`, and `password`. Admins can perform actions like monitoring users and adding vouchers. The Voucher entity has attributes such as `points`, `description`, `exchange_date`, `number`, and `name`. Admins can add these vouchers to the system. The User entity includes attributes such as `id`, `username`, `password`, `name`, `phone_number`, and `points`. Users can view their transaction history, perform exchanges, and earn points. The relationships indicate that Admins can monitor multiple Users and add multiple Vouchers, while Users can redeem multiple Vouchers. This diagram effectively maps out the core functionalities and data interactions within the system.

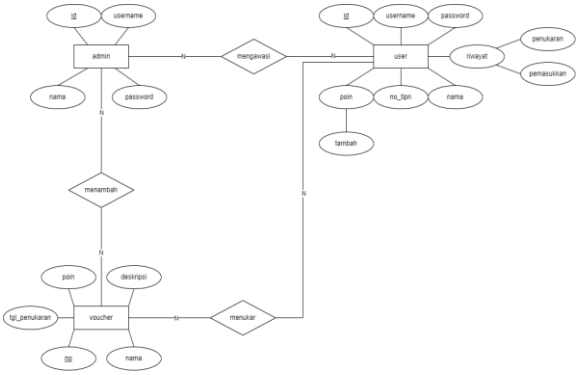

Figure 2: Entity Relationship Diagram

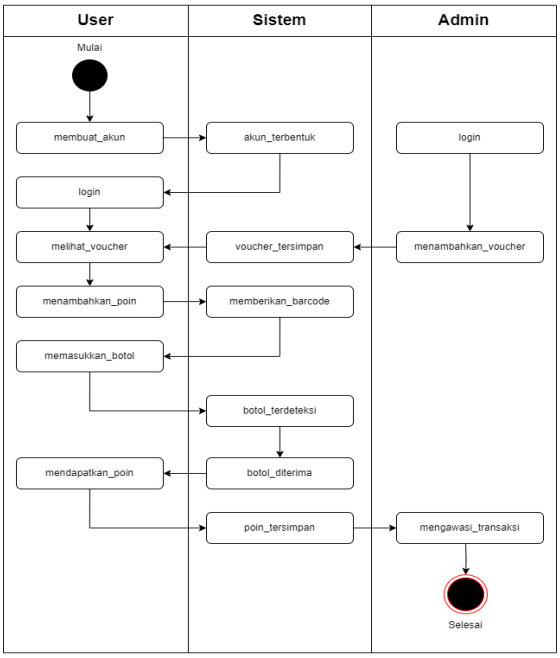

Figure 3: Activity Diagram for Creating an Account and Adding Points

The activity diagram illustrates the interactions between the User, System, and Admin in managing vouchers and points. The User begins by creating an account, which the System confirms. The User then logs in to view available vouchers and adds points by inserting a bottle. The System detects and processes the bottle, awarding points to the User's account. The Admin logs in to the system, adds new vouchers, and monitors transactions to ensure everything runs smoothly. This diagram effectively captures the workflow from account creation and voucher management to bottle detection and points allocation.

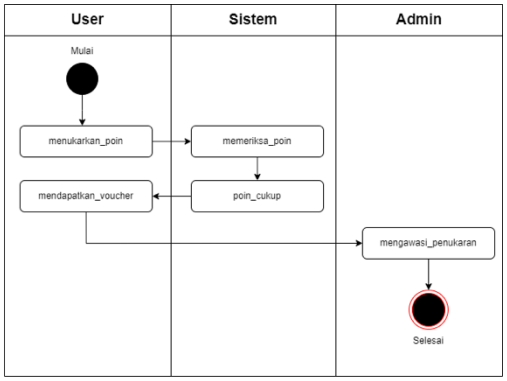

Figure 4: Activity Diagram for Redeeming Points

The activity diagram illustrates the process of redeeming points for a voucher. The User initiates the process by selecting the option to redeem points. The System then checks the User's points to ensure they have sufficient points for the voucher. If the points are sufficient, the System issues the voucher to the User. Meanwhile, the Admin oversees the redemption process to ensure its proper execution. This workflow ensures that the User can seamlessly exchange their points for a voucher, with the System handling the validation and issuance, and the Admin supervising the overall process.

A mockup is a model or design draft of a product created as a reference before it is realized [6]. A mockup serves as a visualization of a design concept, providing a realistic depiction of the product to be created [7]. In other words, a mockup is a model that facilitates the execution of the product design and offers a realistic overview of how the final product will look. In the development of the Trash To Treasure tool, creating a mockup is essential to provide a tangible visualization of the tool. The mockup is created using two tools: Figma and Tinkercad. Figma is used for 2D mockups, while Tinkercad is used for 3D mockups. Below are the mockup results using Figma.

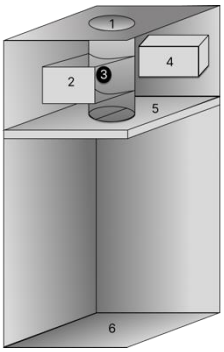

Figure 5: Internal View of the Tool

Figure 5 shows the internal view of the tool, which consists of several components: a slot for inserting Chatime bottles or cups, a camera holder, a designated position for logo scanning, a compartment for the machine and cables, a divider between the machine and the bottle container, and a container for collecting all bottles.

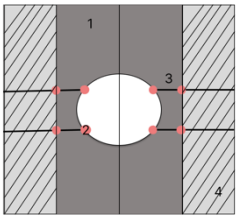

Figure 6: Divider Between the Scanning Section and the Bottle Container

Figure 6 shows the divider between the scanning section and the bottle container, consisting of several components: 1) the divider, 2) cable hooks, 3) cables, and 4) empty space. In addition to using Figma, the mockup was also created with Tinkercad. The tool measures 30cm x 30cm x 79cm, with the scanning section measuring 30cm x 30cm x 15cm, the divider section measuring 30cm x 30cm x 4cm, and the bottle container section measuring 30cm x 30cm x 60cm.

3. Result and Discussion

The following section presents the implementation in the form of software for the website, showcasing several screenshots of the website's interface for the admin, user, and machine sections.

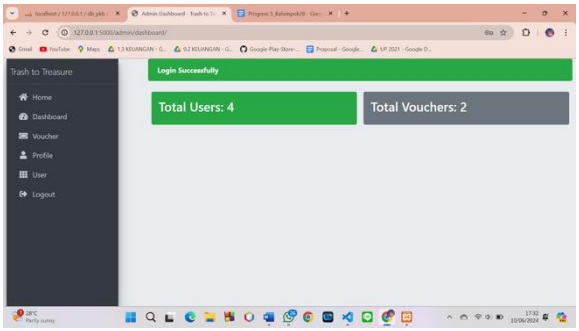

Figure 7: Add Voucher Admin

If there is no existing account, user can click on the user registration option, which will display a screen as shown below. Then, fill in the required data, including name, email, phone number, and password. The email will serve as the username when logging back into the account. After completing the data entry, press the signup button. Subsequently, a prompt will appear to log in using the registered credentials. If the correct email and password, as entered during signup, are provided, the login button should be pressed. If the email or password is incorrect, a notification will indicate that the email or password is incorrect. Upon successful login, the main page will be displayed as illustrated below. The navigation bar includes five options: Home, Dashboard, Voucher, Profile, and Logout.

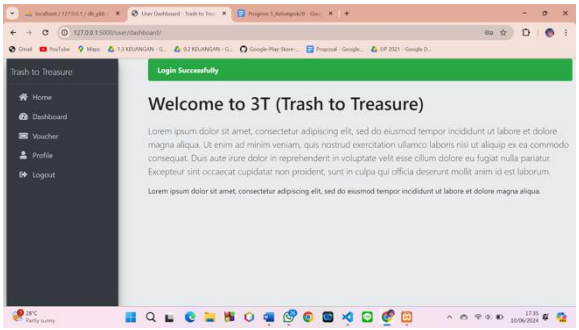

Figure 8: User Dashboard

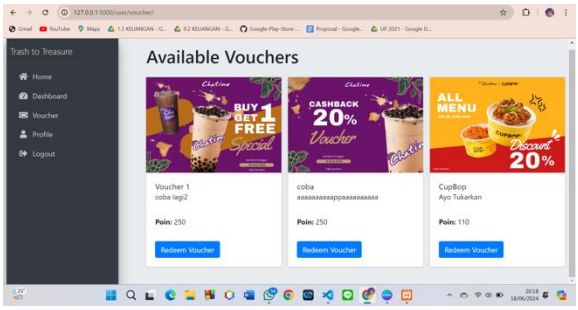

Figure 9: User Voucher

The following are the hardware or the framework of the device.

Figure 10: Side View of The Hardware

Figure 10 depicts the side view of the hardware, featuring a small door at the bottom for attendants to retrieve exchanged Chatime bottles. The hardware measures 39.5cm x 26.5cm x 89cm. The top of the hardware is covered with a lid measuring 38.8 cm x 25.8 cm, with a hole diameter of 12.5 cm. The hole is necessary to facilitate users in placing Chatime bottles. The lower section functions as a bottle compartment, while the middle part features a divider support and a scanning area.

Figure 11 depicts the camera support area, designed to maintain the camera in a stable position for optimal image capture, positioned 6 cm above the divider and 23 cm from the bottle compartment. Additionally, a tube is provided for holding bottles during the scanning process.

Figure 12 shows the partition or door that opens and closes with the help of a servo motor. Thus, if it is indeed a Chatime bottle, the partition will open 90 degrees, allowing the bottle to enter. If it is not a Chatime bottle, the partition will remain closed. This section measures 14cm x 14cm.

Figure 11: Bottle Container Divider and Scan Bin

Figure 12: Partition Display

The evaluation of the model's prediction results is based on the alignment of the "Chatime" class detection boxes with the label boxes in the dataset and the confidence value of a detection box within the range of zero to one. The evaluation methods used are the confusion matrix and the F1-score. A confusion matrix is a matrix where the order value is the number of classes that the model will predict. Each box represents the number of detections in certain conditions. The position of a box in a column represents the number of predictions where the actual presence of the class associated with that column is found. The position of a box in a row represents the number of predictions where the presence of a class associated with that row is found.

All classes receive the same order in the rows and columns of the matrix. Therefore, the evaluation is done by observing if detections more frequently occur on the diagonal of the matrix, which indicates that the prediction of a class happens when the actual presence of that class is there, and the detection frequency is minimal in the boxes outside the

diagonal. For instance, the model is evaluated as good if, in the row of the Chatime class representing the prediction of the presence of the Chatime class, there is a high density of values in the Chatime column, which indicates the actual presence of the Chatime class.

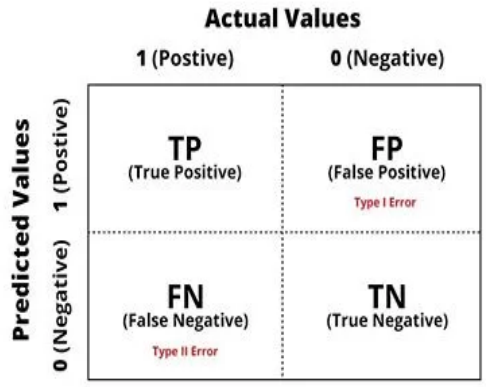

Figure 13: Confusion matrix

The F1-score is a metric used to measure the performance of a model in handling imbalanced classification tasks, where one class has more examples in the dataset than others. The F1-score addresses this imbalance by considering both precision and recall of the model. Precision is the proportion of true positive predictions for a class compared to the total number of true predictions for that class. Recall is the proportion of true positive predictions for a class compared to the total number of actual instances of that class. The formula for the F1-score is:

$$F1 - Score = 2 * \frac{(Precision * Recall)}{(Precision + Recall)} \quad (1)$$

Thus, the model evaluation is considered good if the F1-score is close to one, which is perfect. For example, an F1-score of 94.9% indicates high performance. The F1-confidence curve shows the relationship between the F1-score and the model's confidence in its predictions. A higher confidence score means the model is more certain about its predictions. The evaluation method is deemed good if the curve slopes upwards, indicating that the model performs well at higher confidence levels.

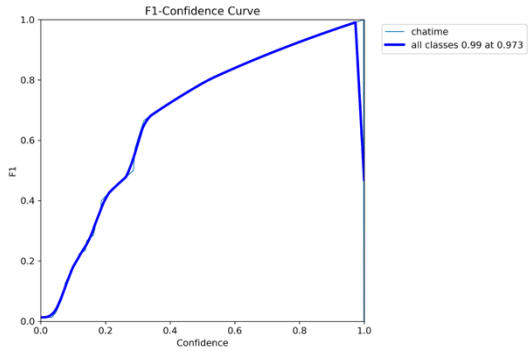

Figure 8: F1-confidence curve

4. Conclusion

This study successfully developed a machine, website, and hardware capable of identifying and processing Chatime cups using the YOLO v5 algorithm and ESP32-CAM. This machine offers an innovative solution for managing plastic waste at Chatime outlets by providing points that can be exchanged for attractive vouchers. The evaluation results indicate that the detection model performs well, with an F1-score of 94.9% and a positive F1-confidence curve. The software implementation was successful, resulting in a user-friendly interface for both administrators and users. This research is beneficial not only for Chatime but also for the community by supporting the circular economy.

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