Design and Develop Automatic Light Vehicles (LV) Unit Number Identification by Image Recognition Using Computer Vision Artificial Intelligent

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Abstract*—This thesis presents the development of an AI-driven system to automate refueling data recording, improving accuracy, efficiency, and cost-effectiveness. The research aims to identify the LV unit and driver's name, verify custodianship cost centers, and record refueling volumes. A comprehensive and accessible refueling database is established for immediate data availability. The study employs the V model for Mechatronics System Design, utilizing the Raspberry Pi 4 model B 8 GB, a 5-inch HDMI screen, and a webcam for capturing LV unit numbers and ID badges. The EAST algorithm locates text, while OCR Tesseract extracts information. The data is stored in a SQLite database using Python. Error rate and OCR accuracy are analyzed, and system duration time is compared with the existing system. Results show that computer vision and AI effectively identify LV unit numbers and driver's names at fuel stations. The proposed system offers cost-effective, accurate refueling data, including date, time, LV number, custodian cost center, and driver. Implementation streamlines operations and provides comprehensive data for decision-making.

***Keywords*—EAST algorithm, tesseract OCR, computer vision, artificial intelligence, automated refueling**

I. Introduction

Fuel Station Minesite is one of the filling stations at PT. Kaltim Prima Coal (KPC), that serves Light Vehicles (LV) and the only filling station that offers gasoline to support the operation of the majority of non-mining LV. By the end of 2022, gasoline consumption had reached 905 kiloliters [1] and was projected to increase in 2023.

The fuel station is a self-service filling station with 1 (one) fuel dispenser equipped with pump and nozzle, 1 (one) flowmeter, and 1 (one) display to indicate the number of litres pumped. Unlike other self-service LV Fuel stations, gasoline Fuel Stations require the driver to manually record the unit number and total volume of fuel refuelled on the provided form. For back charge purposes, the manual refuelling data recorded on the refuelling form will be manually entered daily into an excel spreadsheet that already contains a lookup table that provides custodian information as the costing centre and information on the active period of the Fuel Authority Sticker.

Manual input from the driver, a double-handling process from the refuelling form to an Excel spreadsheet, and unclear written information have had an impact on the gasoline inventory reconciliation that reveals a shortage of more than 1 percent of total gasoline purchased. Equipping a gasoline fuel station with an existing auto ID system with a controller that uses RFID is costly. With only 0.1% of overall fuel consumption [2], this expensive equipment is considered improvidence.

This research aims to design and develop a new system that is more accurate, efficient, and cost-effective by using artificial intelligence to automate the recording of refuelling data, which includes identifying the LV unit and the driver's name, providing verified custodianship cost centers, and recording the volume of refuelling each time the process takes place. This research is also intended to provide and track a refuelling database that will be accessible immediately after the refuelling process is complete.

II. Previous Study

Numerous studies pertaining to image and character recognition have been carried out utilizing diverse techniques, hardware, and libraries. The majority of research investigations concentrate on the optimization of automatic license plate recognition in terms of efficacy and precision.

HSV Color Matching, Pattern Recognition, and Character Segmentation using Matlab under CPU Intel Core i3 2.2 Ghz 2 Gb RAM to recognize license plates were carried out in 2013 [3]. Image Edge Detection, Contour Finding, Cascade Classifier, and OCR Tesseract using OpenCV under the raspberry Pi 3 for text recognition were carried out in 2019 [4]. Image Thresholding, contour tracing, and OCR with the KNN Algorithm and OpenCV

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under the raspberry Pi 3 were carried out in 2020 [5]. AEG (Adaptive Embedding Gate) using pytorch and CUDA 8.0 under NVIDIA GTX-1080 TI 11 GB RAM for scene text detection was carried out in 2020 [6]. Deep Learning Text Extraction by Google Vision using Google Vision AI under personal computer for character recognition was carried out in 2022 [7-10].

In contrast, current research will utilize the EAST algorithm [11] in conjunction with non-maxima suppression (NMS) for detecting scenery text and the Tesseract OCR algorithm, including pattern matching for character recognition of the LV unit number and of the user's name situated on the ID badge. The system will be developed using Python, OpenCV, and a SQLite database on a Raspberry Pi 4b 8 GB.

III. METODOLOGY

A root cause analysis was conducted to ascertain the fundamental reasons behind the losses in gasoline inventory with a fishbone diagram. The categories of Equipment, Process, and People were given priority as they were deemed to be the most relevant factors:

- There is no automatic detection control to determine whether or not the Light Vehicles are authorized to refuel.
- The LV driver is responsible for recording their unit number and total volume after refueling, this has resulted in data errors regarding missed types, which can be intentional or unintentional.
- Repetitive data input to perform fuel Backcharge, Occasional typographical errors result in missed cost allocations.
- Fuel was taken by an unauthorized LV.
- The user's ignorance of their LV's fuel authority status and consequent continuation of refueling activities.

The V-model presented herein Fig. 1 outlines the conceptual design that is used as the main guideline in this research.

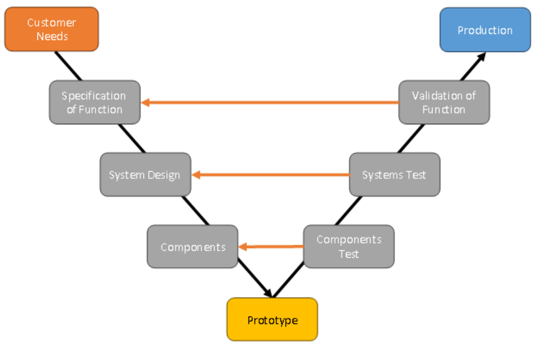

Fig. 1. V model design

Regarding customer needs and root cause analysis, this research will design and develop a new system that is more accurate, efficient, and cost-effective by using artificial intelligence to automate the recording of refueling data, which includes identifying the LV unit and the driver's ID Name, providing verified custodianship cost centers, and recording the volume of refueling each time the process takes place. The refueling data will be accessible immediately after the refueling process is complete, without the need for human intervention, and can be tracked for verification purposes.

A. Main Function Design

Fig. 2 below describes in detail the main functional design specification of this research, which consists of two sub function design, which are Automatic Unit Number Identification and User ID Identification.

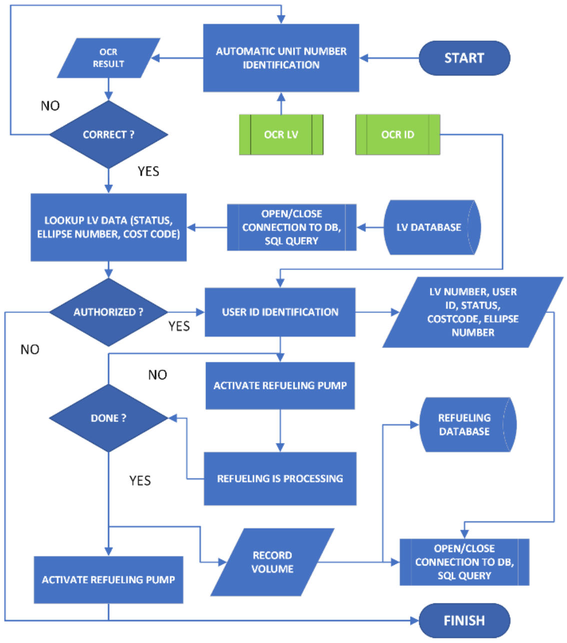

Fig. 2. Main functional design

B. Automatic Unit Number Identification (OCR LV)

The flow process of sub function automatic unit number identification will start with capturing the image of the unit number located at the front door booth left and right, followed by text extraction as LV number, as illustrated in Fig. 3 below:

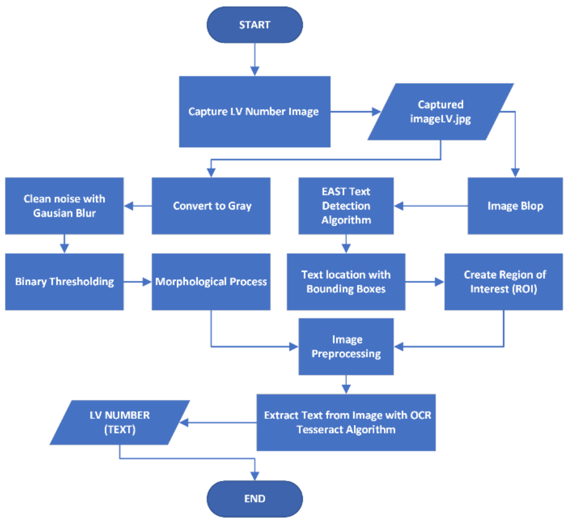

Fig. 3. LV number identification

C. User name identification

The flow process of sub function user name identification will start also with capturing the image of ID Badge where name of the user located on it to text extraction as Name of the user is illustrated at Fig. 4 below:

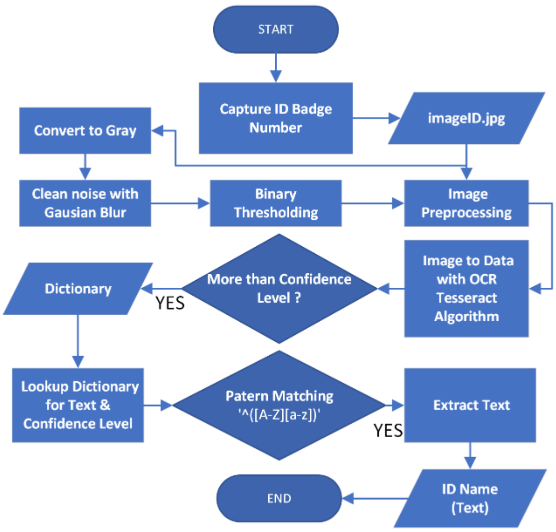

Fig. 4. User name identification

D. Block Diagram

The Raspberry Pi 4 functions as the central hub for executing algorithms pertaining to image recognition and character segmentation. In addition, the system incorporates a compact embedded database that serves as a reference for the recognized LV unit numbers, which will synchronize with the gasoline dispensing pump. During the process of refueling, the display screen will exhibit the gasoline refuel volume along with pertinent details such as the LV number, ID name, and custodianship. The connections can be depicted in accordance with Fig. 5 below:

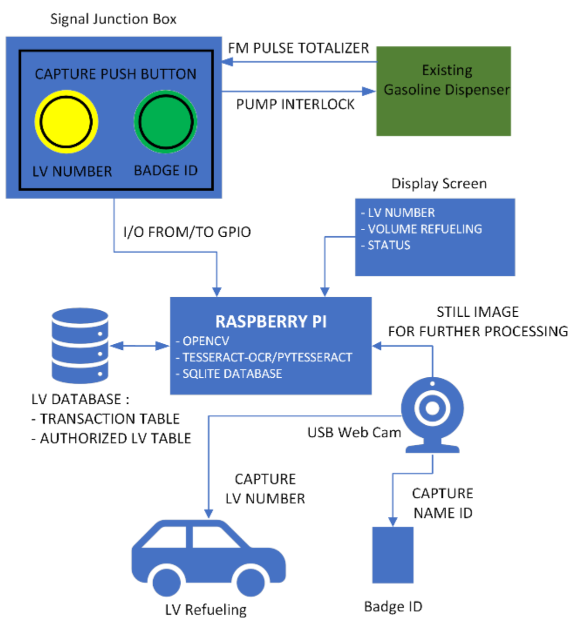

Fig. 5 Block diagram

E. Image Capture Method

In order to enhance the precision of the Optical Character Recognition (OCR) result, it is recommended that the image acquisition process involve proper alignment, whereby the camera is situated directly above and at a right angle or perpendicular to the OCR object. Fig. 6 and Fig. 7 show how the image is captured.

Fig. 6. Taking LV image

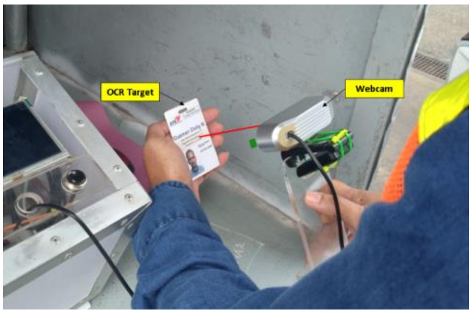

Fig. 7. Taking ID image

F. Evaluation Metric

In order to evaluate the performance of the OCR system, two metrics will be utilized which are:

- Character error rate that considers three different types of error, which are character insertions, character substitutions, and character deletions [12]. Fig. 8 below explains each type of error:

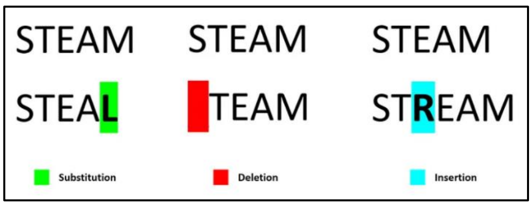

Fig 8. Error types

The formula for calculating the character error rate is shown on Equation (1):

$$CER = \frac{N_s + N_i + N_d}{N_s + N_i + N_d + N_c} \tag{1}$$

While the accuracy can be calculated as Equation (2) below:

$$ACC = 1 - CER \tag{2}$$

Where:

- *CER* : Character Error Rate
- *ACC* : Accuracy
- *Ns* : Number of Character Substitutions
- *Ni* : Number of Character Insertions
- *Nd* : Number of Character Deletions
- *Nc* : Number of Characters that correctly identified

- Segmentation and recognition duration. The OCR process duration will be calculated in second, which includes ROI and Character Identification duration. As baseline data, current method duration was recorded by monitoring CCTV located at the Fuel Station to calculate the duration of the user when writing down the LV information, which consists of the LV Number, ODO meter, ID Badge Number, and LV refueling volume.

IV. Result And Discussion

Multiple experiments were conducted to ascertain the optimal parameters for both algorithms in order to achieve the highest possible level of optical character recognition.

A. *System Simulation*

Configuration of self-contained system described at the following Fig. 9 below:

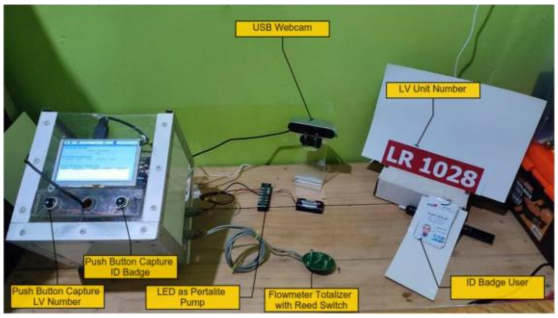

Fig. 9. Self-contained system simulation

- Capturing LV Number.
  The simulation process commences by acquiring the LV number through the activation of the corresponding push button. Upon completion of the process, the outcome will be displayed on the graphical user interface (GUI) and subsequently trigger the LED to function as a refueling pump, indicating that the interlock has been disengaged. Fig. 10 below shows the result:

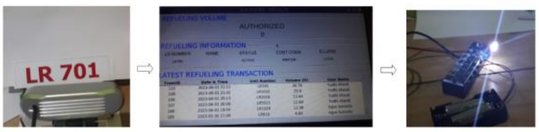

Fig. 10. Capturing LV number

- Capturing ID Badge
  The subsequent step in the simulation involves the acquisition of the ID badge to extract the username, which is achieved by activating a distinct pushbutton that differs from the previous pushbutton utilized for capturing the LV number. Fig. 11 below shows the result:

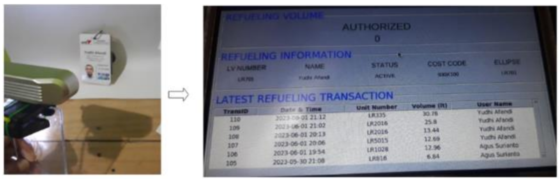

Fig. 11. Capturing ID badge

- Recorded Data.
  Complete refueling activity will be automatically put into the database. It can be accessed and downloaded for further purposes, such as backcharge and reconciliation. Fig. 12 below shows the recorded data:

Table: tbl_trans

	key	UnitNr	Volume	Start	UserID	CC
	Fi...	Filter	Filter	Filter	Filter	Filter
34	138	LR2016	7.5	2023-06-07 23:28	Yudhi Afandi	160S100
35	139	LR621	3.33	2023-06-07 23:34	Yudhi Afandi	230S407
36	140	LR803	4.56	2023-06-08 10:08	Yudhi Afandi	920X100
37	141	LR519	5.82	2023-06-08 10:22	Yudhi Afandi	210X100
38	142	LR3023	11.34	2023-06-08 10:26	Yudhi Afandi	650S100
39	143	LR702	10.44	2023-06-08 12:15	Alviar Rgmbe	930X100

Fig. 12. Recorded data

B. *System Performance*

- System Accuracy of LV Number Identification.
  According to the statistical findings, the LV identification system has an average accuracy of 95.81% across a sample of 80 LV unit numbers. The mean accuracy for the entire population is 95.81% ±1.21% as indicated by the standard error of 1.21%.

- System Accuracy of Username Identification.
  According to the statistical findings, the Username identification system has an average accuracy of 97.07% across a sample of 10 ID Badges. The mean accuracy for the entire population is 97.07% ±1.50% as indicated by the standard error of 1.50%.

- Duration of Identification.
  The average of the identification process, including web-cam position adjustment, LV Number and Name Identification, and preview of each capture result, is 14 seconds. While the average duration for the existing system is 21 seconds, it shows that there will be a 34% improvement in refueling duration time, especially in providing LV information and recording refueling volume.

C. *Identification Error reduction*

The character error rate shows character insertion, substitution, and deletion in the LV identification result.

Repetition of image capture for the same object with the same LV number and identity can improve the process. Users will see the identification process's results in a pop-up window to assess its accuracy. If the result is correct, the user can tell the machine to continue. If the result is inaccurate, the user can ask the system to take the LV number photo again to fix the identification, as shown in Fig. 13 below:

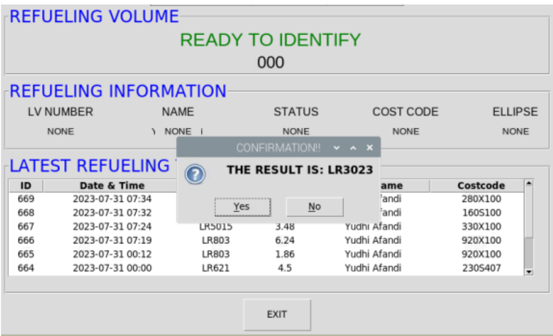

Fig. 13. Pop-Up confirmation

D. *Robustness Testing*

Based on the robustness testing result, the prototype demonstrates its functional capabilities through a cumulative uptime of 948 minutes, involving 198 instances of refuelling that involve the interaction of LV and user ID identification. Additionally, a total refuelling volume of 5,055 Liters is recorded.

E. *Operational Advantages*

An OCR system's classification as substandard occurs when its precision level drops below 90% [13]. The OCR system proposed in this study exhibits a high level of accuracy, with a 95.81% ±1.21% rate for LV number identification and a 97.07% ±1.50% rate for username identification, thereby qualifying it as a proficient OCR system.

F. *Labour cost & Operational Saving*

The implementation of this approach, involving two cost-cutting strategies where capital and operational costs only took 1.13% and 4.67% compared to the existing RFID system, guarantees optimal cost savings for the company. Fig. 14 below shows the capital cost comparison, while Fig. 15 show the Operational cost comparison.

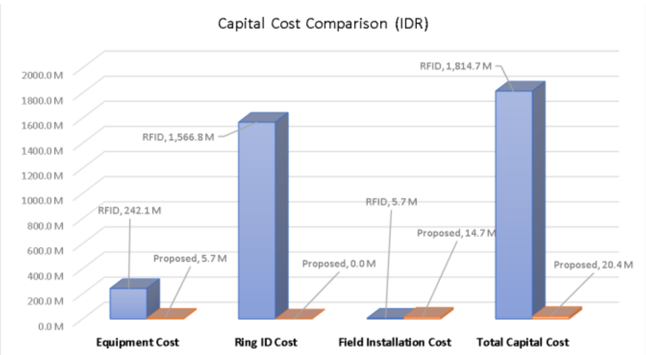

Fig. 14. Capital cost comparison

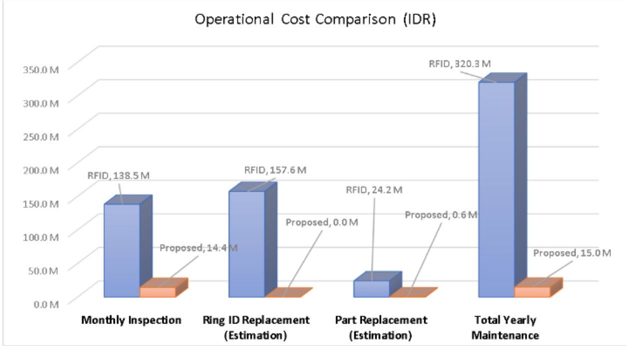

Fig. 15. Operational cost comparison

V. CONCLUSIONS AND RECOMENDATIONS

A. *Conclusions*

- Raspberry Pi 4 and OpenCV-based operating systems enable computer vision technology to capture, extract, and identify LV numbers and driver names during refueling activities at gasoline fuel stations.
- The proposed system, comparable to RFID, identifies LV unit numbers, records refueling volumes, and logs transactions, costing only 1.13% and 4.67% less in capital and operational expenses, demonstrating greater cost-effectiveness.
- LV number and username identification can be done without supplementary radio frequency devices, using existing LV numbers and ID badges for efficient identification.
- The proposed system prevents unauthorized refueling by obstructing access using artificial intelligence, collecting and processing data, eliminating redundant work, and utilizing an automatic flow totalizer for accurate refueling volume measurements.
- The system tracks refueling activity data, including event date, LV number, cost center, and driver, enabling efficient tracking for reconciliation and fuel usage reports.

B. *Recommendations*

- The proposed system should have web-server capabilities for real-time fuel consumption monitoring and cost optimization.
- To use the proposed system in real operation, consideration should be paid to such things as:
  - The Raspberry Pi requires a larger cooling system for excessive heat generation and enclosure.
  - Raspberry Pi lacks a real-time clock; a network or internet connection is required for accurate transaction timestamps.
  - High screen contrast is crucial for optimal visibility during refueling in bright outdoor conditions.

- Visible line markings improve fuel station image capture by directing Light Vehicles to designated locations.
- Distribute and communicate standard operating procedures to fuel station users.

- Utilize machine learning for enhanced system identification.

- Research suggests image recognition systems can enhance occupational health and safety in mining, identify vehicle violations, and implement automatic gate systems in restricted areas.

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