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Development of IoT Application for Lake Surface Cleaning Machine

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Abstract: This paper focuses on developing an Internet of Things (IoT) application for a lake surface-cleaning machine. The goal is to contribute to a cleaner environment by integrating IoT technology into the machine. Raspberry Pi is used as the microcontroller to control all the sensors and to run the OpenCV for the object detection algorithm. Meanwhile, an infrared sensor is used to detect the specific situation to trigger the alert system while the Euclidean Distance is used to calculate the shortest distance from the charging station. The findings have illustrated the successful achievement of the project objectives, showcasing the effectiveness of the object detection algorithm, designing an efficient alert system and achieving good energy conservation. By leveraging IoT technology, the machine can autonomously detect and remove garbage from the lake surface, saving time and energy for individuals involved in the cleaning process. The alert system ensures timely actions in response to full garbage tanks, low energy storage, and fully charged energy storage, enabling authorized personnel to take appropriate measures promptly. Moreover, the machine's energy conservation measures, such as calculating the shortest path to the charging station and triggering the conveyor when necessary, enhance operational efficiency and minimize energy consumption. Overall, the research outcomes highlight the significance of IoT applications in combating lake pollution and fostering a cleaner environment.

Keywords: Object Detection, Opencv, Iot

1. Introduction

Nowadays, there is a growing need for an automated solution to clean up the garbage on the surface of lakes. To address this issue effectively and efficiently, an automated lake surface cleaning device can be developed using Internet of Things (IoT) technology. By incorporating microcontrollers [1], sensors [2], software [3], and other technologies, IoT enables seamless communication and data exchange among all the components of the system. Drawing inspiration from these advancements, an IoT-based lake surface cleaning device can be developed to effectively remove garbage from the lake located in front of Block G3, Universiti Tun Hussein Onn Malaysia (UTHM). By implementing features like

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automatic waste detection and a position tracking system using IoT, this project aims to save people's time, energy, and money. The automated lake surface-cleaning device will require minimal human intervention, allowing individuals to focus on other important tasks while the device operates autonomously.

The first objective to archive in this project is to design a garbage detection algorithm for the lake surface cleaning machine. The second objective is to design an alert system for the energy depletion rate monitoring system and garbage tank storage monitoring system of the lake surface cleaning machine that can send notifications to authorized personnel. The third objective is to optimize the energy consumption of the lake surface cleaning machine in finding the shortest path to the on-land charging station.

According to the designing and optimization of an autonomous vacuum floor cleaning robot [4], Raspberry Pi 3 model B has been chosen to be installed in their machine. Raspberry Pi works as a central processing unit. Processing data and carrying out important activities are among Raspberry Pi's duties. All the machine's installed sensors, including the GPS module, LIDAR, motor-driven, and others, must be under Raspberry Pi's control [4].

From Intelligent Robot for Cleaning Garbage based on OpenCV [5], a technique to classify garbage has been introduced which is OpenCV. OpenCV, an open-source computer vision library, is widely utilized in real-time computer vision applications [6]. Developed by Intel, OpenCV emphasizes high computational efficiency and is specifically designed for real-time use [5].

Email notifications sent by Python coding method can be found in Designing a Thief Detection Prototype using Banana Pi M2+ Based Image Visual Capture Method and Email Notifications. When the stranger's face is detected in [7], the captured image will be sent to the owner's email for verification.

According to Human Movement Recognition using Euclidean Distance: A Tricky Approach [8], Euclidean Distance is used to calculate the distance of human movement. Euclidean distance uses the Pythagorean theorem to measure the shortest distance between them. According to Poster: Is Euclidean Distance the Best Distance Measurement for Adaptive Random Testing? [9], the Euclidean distance measure is effective when dealing with input domains that have a low number of dimensions.

2. Materials and Methods

2.1 Materials

Table 1 shows the list of hardware and software that was decided to be used in the project after the literature review.

Table 1: List of hardware and software

Hardware	Software
Raspberry Pi 4 Model B *GPS NEO 6MV2* *Raspberry Pi Camera Module 2* *Infrared sensor E18-D80NK*	*Thonny IDE*

2.2 Methods

Figure 1 illustrates the phase 1 flowchart of the project which is regarding the object detection algorithm. When in the start mode, the machine will start to move forward for 5 seconds before making a 360-degree turn for garbage detection. When garbage is detected, the machine will move forward to trap it and continue to move if fails to detect garbage.

Figure 2 is the flowchart of phase 2 regarding both infrared sensors. When the infrared sensor installed in the garbage trap is triggered for 10 seconds, the conveyor will start to move the garbage to the garbage tank. The email for the fully occupied garbage tank will be sent when the infrared sensor installed in the garbage tank is triggered for 10 seconds.

Figure 3 shows the flowchart of phase 3 regarding the alert system. The emails with different subjects will also be sent in different conditions. For example, the email with the subject 'Your machine energy storage is running low' and 'Your machine energy storage is full' will be sent when the machine energy storage is low and full respectively.

Figure 4 illustrates the phase 4 flowchart of the project regarding the returning path of the machine. After the email is sent, the returning command is started, and the machine starts to calculate the shortest distance to the charging station by using the Euclidean Distance formula by comparing the longitude and latitude between the machine and the charging station. When the distance between the machine and the charging station is smaller than 1 meter, the machine will stop moving.

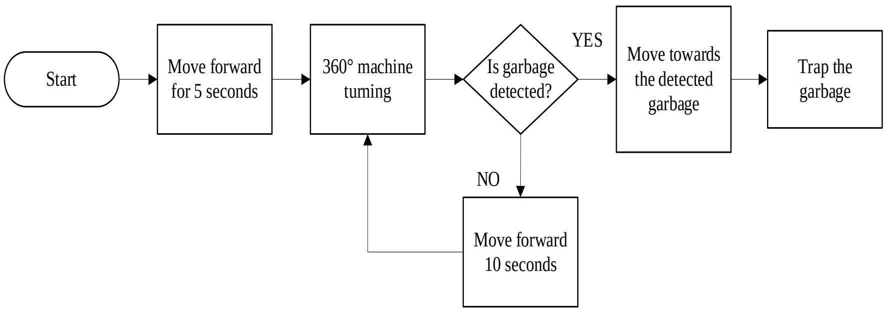

Figure 1: Flowchart of Phase 1

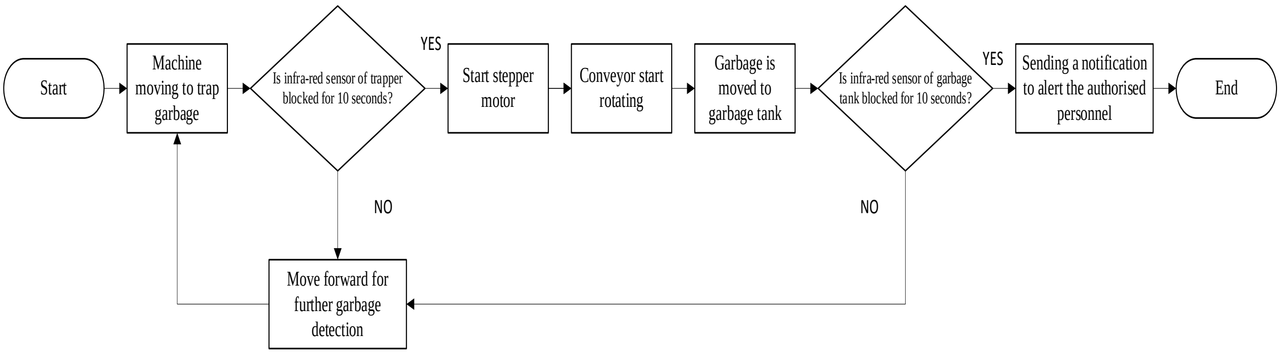

Figure 2: Flowchart of Phase 2

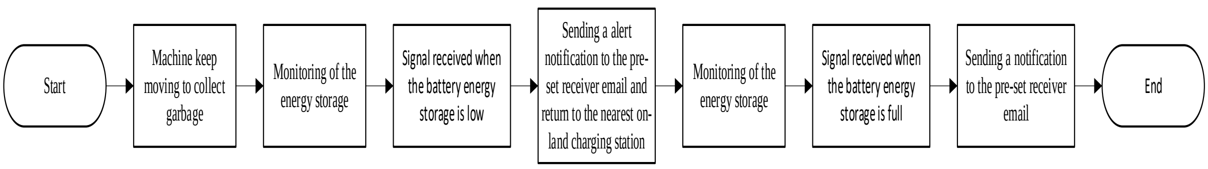

Figure 3: Flowchart of Phase 3

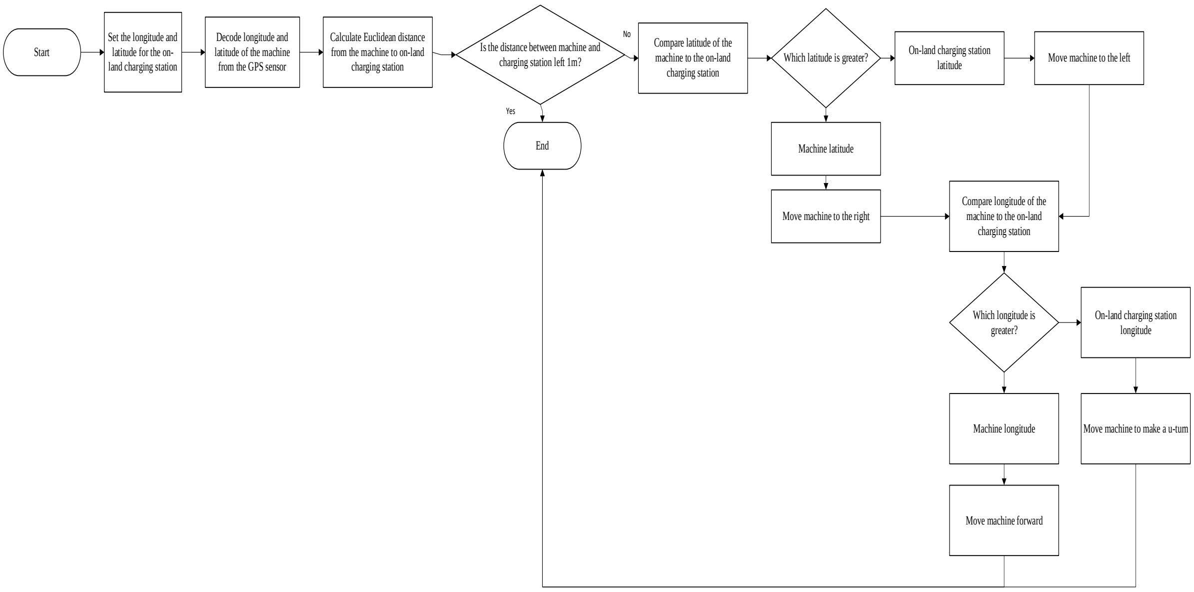

Figure 4: Flowchart of Phase 4

2.3 Equations

Eq1 shows the Euclidean Distance formulae which is represented by d while x_2 represents the longitude of the charging station and x_1 represents the longitude of the machine. y_2 represents the latitude of the charging station and y_1 represents the latitude of the machine.

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \qquad Eq.1$$

2.4 Schematic diagram

Figure 5 demonstrates the schematic diagram for the connection of the sensors to the Raspberry Pi. The GPS tracker, Arduino pins and infrared sensors will be connected to the GPIO of the Raspberry Pi for sending and receiving the signal as shown in Table 2. The camera module will be connected to the camera port of the Raspberry Pi.

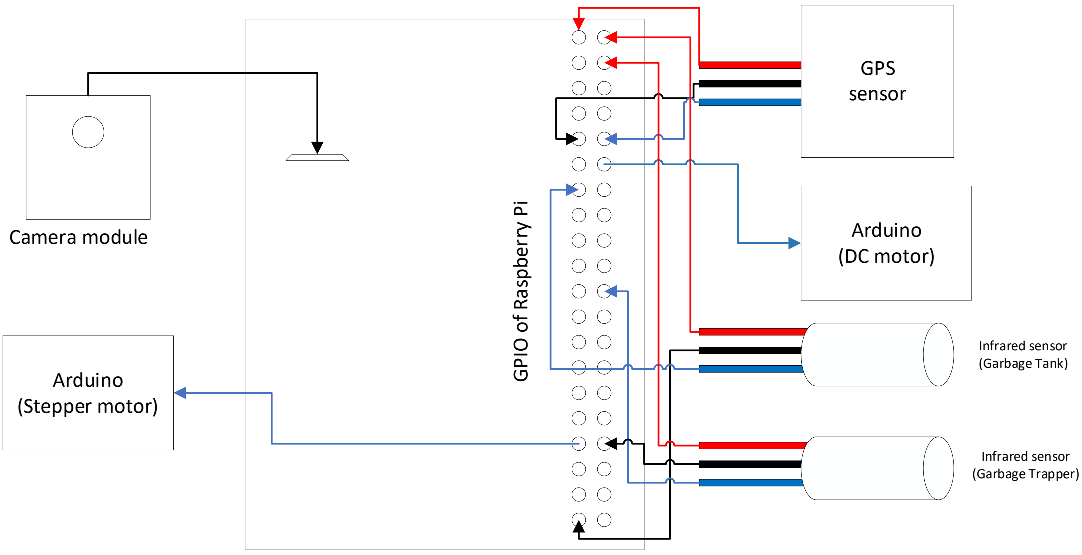

Figure 5: Schematic diagram for the connection of the sensors to Raspberry Pi

Table 2: The components and its connection

Sensor	Positive pin	GPIO Signal pin	Negative pin
GPS sensor	3.3V	GPIO15	GND
Arduino (DC motor)	To motor driver	GPIO18	GND
Infrared (Garbage tank)	5V	GPIO27	GND
Infrared (Garbage trapper)	5V	GPIO25	GND
Arduino (Stepper motor)	To motor driver	GPIO13	GND

3. Results and Discussion

3.1 Results

Figure 6 shows the output of object detection. A green box surrounding the detected object is shown in the figure, and the type of the object and the detection accuracy are shown in the green box.

Figure 6: Object detection output

Table 3 shows the detection result comparison for the distance from 30cm to 100cm. The accuracy decreases when the distance gets further. A false detection occurs when the distance is 90cm and increases accuracy. The detection accuracy also depends on the size of the object. The bigger object will have higher accuracy compared to the smaller object.

Table 3: Detection result comparison for distances from 30cm to 100cm

Distance (cm)	Size	Detected ?	Accuracy (%)
30	Small	Yes	66.02
40	Small	Yes	63.84
50	Small	Yes	60.46
60	Small	Yes	54.64
70	Small	Yes	49.80
80	Small	Yes	47.59
	Bigger	Yes	63.24
90	Small	False detection	56.26
	Bigger	Yes	55.54
100	Small	No	-
	Bigger	No	-

Figures 7, 8 and 9 show the results of the alert system to the authorized personnel when a specific condition is triggering.

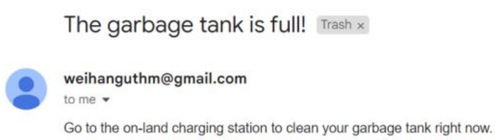

Figure 7: Email sent by Raspberry Pi when the machine garbage tank is full

Figure 8: Email sent by Raspberry Pi when the machine energy storage is left 30%

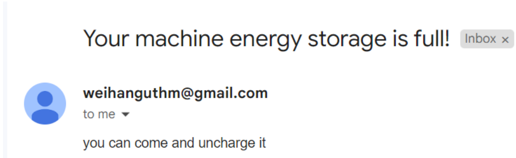

Figure 9: Email sent by Raspberry Pi when the machine energy storage is full

Figure 10 shows the latitude and longitude of the machine detected by the GPS and the distance to the targeted location which is the location of the charging station calculated by the Euclidean Distance.

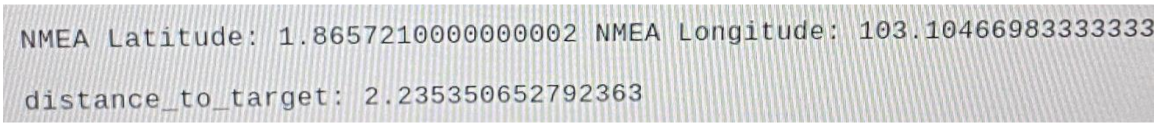

Figure 10: Latitude and longitude generated by GPS module and distance to the charging station

Table 4 shows the result of the infrared detection distance. The maximum distance that the infrared can detect is 40cm.

Table 4: Result of the infrared detection distance

Distance (cm)	Detection
10	Yes
20	Yes
30	Yes
40	Yes
50	No

4. Conclusion

In a nutshell, the successful implementation of the object detection algorithm by OpenCV can help to improve the machine's efficiency, allowing the machine to move autonomously. Detection accuracy can be affected by the size and the distance of the object from the machine. The alert system can help to prevent the disruption to the machine’s operation caused by low energy levels or a fully occupied garbage tank as the authorized personnel can take prompt action when alert notification is received. The machine's longitude and latitude are compared continuously to the charging station's longitude and latitude help to optimize the energy consumption of the machine.

Acknowledgement

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References

[1] H. K. Patel, T. Mody and A. Goyal, "Arduino Based Smart Energy Meter using GSM,," in 4th International Conference on Internet of Things: Smart Innovation and Usages (IoT-SIU),, Ghaziabad, India, 2019.

[2] J. Kumar and P. R. Ramesh, "Low Cost Energy Efficient Smart Security System with Information Stamping for IoT Networks," in 3rd International Conference On Internet of Things: Smart Innovation and Usages (IoT-SIU), india, 2018.

[3] M. Nagabushanam, S. Jeevanandham, S. Ramalingam, K. Baskaran and A. Maheshwari, "AI based E-ATM Security and Surveillance System using BLYNK-loT Server," in 3rd International Conference on Communication, Computing and Industry 4.0 (C2I4, India, 2022.

[4] H. A. S. H. Prayash, M. R. Shaharear, M. F. Islam, S. Islam, N. Hossain and S. Datta, "Designing and Optimization of An Autonomous Vacuum Floor Cleaning Robot," in IEEE International Conference on Robotics, Automation, Artificial-intelligence, 2019.

[5] S. Pan, Z. Xie, X. Yang, G. Lin and Y. Jiang, "Intelligent Robot for Cleaning Garbage Based on OpenCV," in IEEE 2nd International Conference on Pattern Recognition and Machine Learning (PRML), China, 2021.

[6] Gary Bradski and Adrian Kaehler, Learning OpenCV, USA: O'Reilly Media, 2008.

[7] L. M. Silalahi, M. Ikhsan, S. Budiyanto, I. U. Vistalina Simanjuntak, G. Osman and A.D. Rochendi, "Designing a Thief Detection Prototype using Banana Pi M2+ Based Image Visual Capture Method and Email Notifications," in 5th International Conference of Computer and Informatics Engineering (IC2IE), 2022.

[8] J. Javed, H. Yasin and S. F. Ali, "Human movement Recognition using Euclidean Distance: A tricky approach," in 3rd International Congress on Image and Signal Processing, 2010.

[9] R. Huang, C. Cui, W. Sun and D. Towey, "Poster: Is Euclidean Distance the best Distance Measurement for Adaptive Random Testing?," in IEEE 13th International Conference on Software Testing, Validation and Verification (ICST), Porto, Portugal, 2020.