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Sidewalk Violators Detection Innovation Using Raspberry Pi

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ABSTRACT: *Although the ETLE (Electronic Traffic Law Enforcement) system has been implemented in the electronic traffic violation handling system, monitoring of sidewalk users is still not optimal due to the lack of monitoring coverage from CCTV, so there are still many motorcycle users crossing the sidewalk. Based on this, an innovation was made to minimize violations of the use of the sidewalk function which is mostly done by motorcycle users, using Bluetooth Low Energy technology supported by Beacon devices as broadcasters, Raspberry Pi as detectors. Based on signal strength (RSSI), every violator crossing the sidewalk will be detected by sensors and ID identification is carried out via beacons and violators are detected, as evidence of whether the driver is really violating or not which is processed using computer vision with the YOLO algorithm. Once the owner of the vehicle is detected and the driver is verified as violating, the data will be sent to the server of the authorities. The result of this study is the display of beacon device data consisting of Mac Address, RSSI, time and date of detection of beacon devices displayed on the database server. In this system, the Raspberry Pi has the ability to detect 2 beacons or 2 motorcycles crossing the sidewalk.*

KEYWORDS -*Sidewalk function, beacon, rasbberry Pi, RSSI, violator detection.*

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I. INTRODUCTION

Currently, Indonesia has a fairly large percentage of motorized vehicle users. The development of the number of motorized vehicles by type in 2020 for the Number of Passenger Cars 15,909,838 units, Load Cars 5,108.051 units, Bus Cars 224,605 units and Motorcycles 111,647,266 [1]. The total number of motorcycles in Indonesia is seven times greater than that of cars. Based on land transportation statistics, the Indonesian Central Statistics Agency, the development of the number of motorized types of motorcycles per year from 2016-2020 has increased by 5.03% [2]. With the increase in the volume of motorized vehicle users, the percentage of traffic violations is also likely to increase. One of them is the misuse of the function of the sidewalk, where the sidewalk is only intended for pedestrian traffic [3]. It is also explained in the Law of the Republic of Indonesia number 22 of 2009 in article 131 paragraph 1 that pedestrians have the right to the availability of supporting facilities in the form of sidewalks, crossings, and other facilities [4]. However, there are still some motorcyclists who cross it, thus disturbing the comfort and safety of pedestrians.

Currently, there are frequent traffic violations that can lead to accidents. Most of the causes are due to negligent drivers [22].Along with the development of technology, in dealing with traffic violations, the government has created an electronic traffic violation handling system called ETLE (Electronic Traffic Law Enforcement) or known to the public as an electronic ticket. The system helps the police to conduct electronic ticketing against traffic violators, through CCTV monitoring. The provisions for this electronic ticket have been stated in Ministerial Regulation number 37 of 2018 in chapter 7 article 13, for the prosecution of this violation is contained in chapter 5 article 10 [5]. However, even though the ETLE system has been implemented, monitoring of sidewalk users is still not optimal due to the lack of monitoring range from CCTV, so there are still many motorcycle users crossing the sidewalk.

Based on this, it has led to innovations to minimize violations of the use of sidewalk functions which are mostly carried out by motorcycle users, using Bluetooth Low Energy (BLE) technology supported by Beacon devices, as well as Computer Vision techniques for violator detection. Based on the Received Signal Strength Indicator (RSSI) or signal strength, every violator who crosses the sidewalk will be detected by a Raspberry Pi 3 installed on the edge of the sidewalk and then violators will be detected, as evidence of whether the driver really violated or not which was processed using computer vision. After the vehicle owner is detected and the driver is verified as violating the data, the data will be stored in the database server, namely the server of the authorities. Raspberry Pi is an education oriented, inexpensive, and hackable pocket size single board computer (SBC) [16]. In this research Raspberry Pi is used as a sensor node to detect and process the RSSI values from BLE Beacon devices. The results of this research are in the form of hardware design systems for handling sidewalk violators.

II. RELATED WORK

Research conducted by Shinde, Pranav, et al., discusses Smart traffic control system using YOLO [23]. In his paper, he proposes a control algorithm based on traffic flow in real time using computer vision and machine learning to have traffic flow characteristics at crossroads. This is done by state-of-the-art, real-time object detection based on Convolutional Deep Neural Networks called You Only Look Once (YOLO). YOLO is implemented on embedded controllers using Transfer Learning Techniques, which makes it possible to perform Deep Neural Networks on limited hardware resources**.**This system facilitates the movement of cars at intersections, thereby reducing congestion, reducing CO2 emissions, etc. The richness that video data provides highlights the importance of advancing advanced object detection.

In the paper, The real-time detection of traffic participants using YOLO algorithm [24], written by orović, Aleksa, et al., in this paper provides a demonstration of using the latest YOLOv3 algorithm to detect traffic participants. Trained the network for 5 object classes (cars, trucks, pedestrians, traffic signs and lights) and has demonstrated the effectiveness of the approach under various driving conditions (clear and cloudy skies, snow, fog and night). The main benefit of the solution proposed in this paper is that it specializes in YOLO neural networks for real-time detection and tracking of multiple classes of participant traffic.

Furthermore, research conducted by Lewandowski, Marcin, et al [26], with the title Road traffic monitoring system based on mobile devices and bluetooth low energy beacons, proposes a method, which utilizes mobile devices (smartphones) and Bluetooth beacons, to detect vehicles that are traveling through traffic. pass and recognize the class. Traffic monitoring is carried out by analyzing the strength of the radio signal received by mobile devices from beacons placed on the opposite side of the road. This approach is suitable for crowd sourcing applications that aim to reduce travel time, congestion, and emissions. The proposed solution is effective in detecting three classes of vehicles (private cars, semi trucks, and trucks).

III. MATERIAL AND METHODS

The detection system on this motorcycle is carried out in the sidewalk area. The detection system includes hardware including placing a microcontroller device in the form of a Raspberry Pi equipped with a webcam module as an interface unit and a detector placed at 2 points on the edge of the sidewalk, which is about 30 meters between raspberry pi. Stream video can be clearly visualized on webpage due to Raspberry Pi, which is having picture quality configurations [18]. In this case, the object that is used as research is a motorcycle that is installed with a Cubeacon Card device which functions to assist in processing RSSI data processing based on the signal strength received from the Raspberry Pi which is integrated with Bluetooth Low Energy beacons which can be shown by a description of the system work as shown in Figure 1.

From Figure 1, the first step, the vehicle must register the motorcycle identity with the vehicle owner's name, vehicle plate number and MAC Address on the Beacon. The data will be created in the MySQL database as primary data. The function of making vehicle owner identity data is to synchronize the cubeacon card data which will be detected by the Raspberyy Pi.

The second step is to determine the positioning point of the two Raspberry Pi. In the schematic, it is shown that there are two Raspberry Pi, which are spaced according to the testing and calculation of the tool. Each Raspberry Pi in the system can be thought of as the main part of a node which is part of a network that collects measurement data from multiple locations, and stores it in the main database [17]. The Raspberry Pi can scan more than one Beacon Device, so if there is more than one driver crossing the sidewalk, the Raspberry Pi immediately scans the data. In this case, the location for the placement of the two Raspberry Pi is in the Outdoor area, namely the area on the edge of the sidewalk where violations usually occur. In determining the location of the Raspberry Pi point, it is set to have a distance of about 30 meters between the Raspberry Pi in order to avoid interference between nodes. The function of the Raspberry Pi is as a detector of the Beacon Card which will later read or detect the movement of motorized vehicles that have the Beacon Card installed. As well as assisting the process of object image data retrieval carried out by the webcam device.

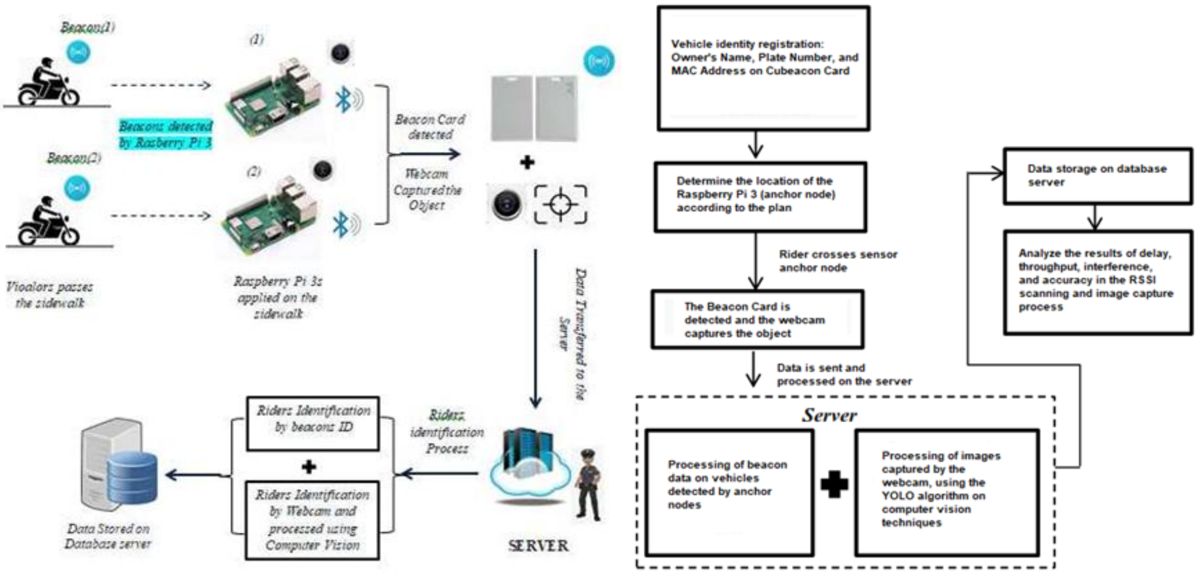


Fig.1. System working schematic and block diagram

The third step is data detection on violators. The data obtained on the beacon is RSSI data, as well as taking pictures of violators via a webcam device using the YOLO algorithm on the computer vision technique carried out by the Raspberry Pi. When a motorcyclist or violator crosses the sidewalk and in accordance with the specified estimated distance, automatically the sensor nodes on the sidewalk will detect the motorcycle ID (initialized by the beacon) and take a picture of the violator as evidence that the motorcycle user has committed a violation. Then the two data are sent and processed directly by the server. Beacon detection is taken based on the RSSI range that has previously been sampled and determined. The process of beacon detection and image processing is carried out simultaneously using a threading program on Python. Python functions as RSSI collector and finds the average value of the incoming RSSI [16].

The fourth step, when the server has received data from the driver in the form of Beacon addresses, RSSI, and images, then these data are directly entered into the database server created using the MySQL database.

The fifth step is to analyze the results of delay, interference, and accuracy in the RSSI scanning process and image capture.

It can be seen in the illustration in Figure 2 above that the height of the beacon card to the road surface is 75 cm while the height of the Raspberry Pi to the sidewalk is 1.1 m, so the height of the beacon card to the raspberry pi is about 35 cm.

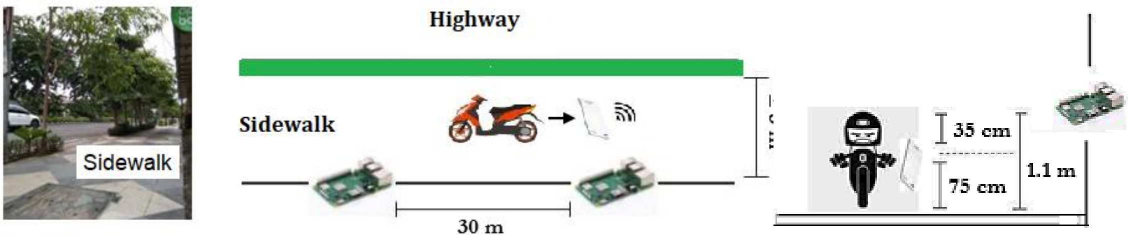
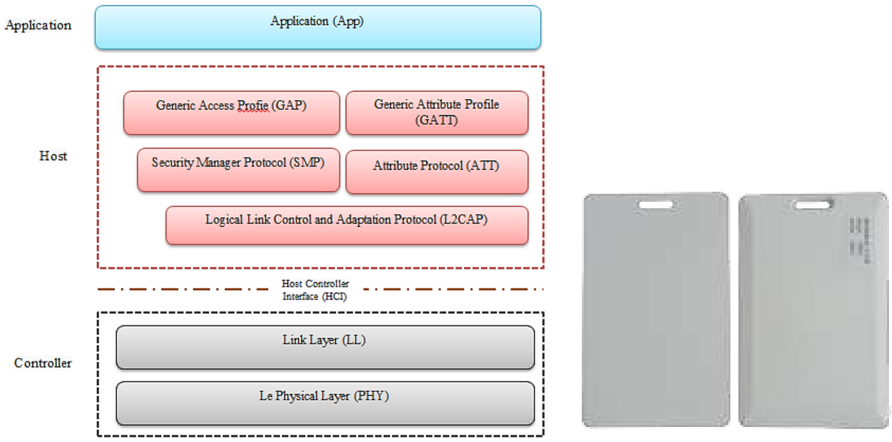


Fig.2. System implementation on sidewalks.

3.1. BLUETOOTH LOW ENERGY

All Bluetooth Low Energy (BLE) is a wireless networking technology designed and marketed by the Bluetooth Special Interest Group (Bluetooth SIG) and intended for new applications in health, security, and industry. Bluetooth Low Energy (BLE), also known as Bluetooth Smart, is an emerging short-range wireless technology aiming at low-power, low-latency, and low-complexity communications [6]. The use of the Bluetooth Low Energy beacon method for navigation or distance estimation [7].



(a) (b)

Fig.3. (a).BLE protocol stack and (b). Cubeacon card

Figures 3 (a). shows BLE Protocol Stack. The protocol stack of BLE maintains a similar lower layer structure as Classic Bluetooth, but also provides revised implementations and a few new layers, such as the General Attribute Profile (GATT) and the Attribute Protocol (ATT) [6]. PHY(LE Physical Layer) is the lowest layer that contains analog communication circuits, has the ability to modulate and demodulate analog signals into digital signals. LL (Link Layer) is the part that interacts directly with PHY. This layer is usually implemented in a combination of specialized hardware and software. This layer is responsible for meeting all the timing requirements defined by the Bluetooth 4.0 Core specification. L2CAP (Logical Link Control and Adoption Protocol) has two main functions, namely a protocol multiplexer that gets data from several protocols above it and then packs it in the standard BLE format and vice versa. Fragmentation will be carried out if the packet obtained from the layer above is more than 27 bytes which will be forwarded below it. Another function is recombination if several packets are received from the lower layer which are then made into one complete package for the layer above. ATT(Attributes protocol) is a simple stateless client/server protocol used by BLE devices.

Figure 3 (b). is a cubeacon card that is used in the system and placed on a motorcycle vehicle.Beacon is a Bluetooth Low Energy (BLE) technology that is used for tracking or doing push notifications when they are within reach. Beacon Card is hardware solution to solve most of smart RF device requirements using Bluetooth low energy / iBeacon protocol [19]. The concept of a beacon is like a beacon, something that shows and provides information and navigation to smartphone users. The Bluetooth Low Energy (BLE) beacons are used to mark the locations within 100 meters radius in real-time. The distance from the beacon is calculated based on the signal strength and measured power. Signal strength is assessed via the Received Signal Strength Indicator (RSSI) [8].Beacon devices are part of a system that is positioned indoors and outdoors as well as an IoT (internet of things) network, beacons use proximity technology to detect the presence of nearby objects. When a user passes through an area where a positioning system is set up, a nearby beacon will send a code to their device. Most schemes assume beacons emit Universally Unique IDentifiers (UUIDs) that act as a key into a local or cloud database to find further details such as beacon location [21]. Each beacon has a unique ID made of numbers and letters as well as identifying information that is emitted by bluetooth several times every second. The unique ID that is emitted to the receiver can transmit information that matches the beacon. The transmitted ID does not change, but the information provided by the application will change.

3.2. RECEIVED SIGNAL STRENGTH INDICATOR

The use of Received Signal Strength Indicator (RSSI) is one of the most studied approaches for localization purposes because almost every node on the market has the ability to analyze the signal strength of the received message. Using the log-distance path loss radio propagation model, considers the received power (PRX) as a function of the transmitter-to-receiver distance in increments of several powers. This model is a deterministic propagation model and only gives an average value, for another propagation model, the log-normal shadowing model is introduced to describe the RSSI irregularity [9].

$$RSSI = 10 \times log\,(\frac{P_{Rx}}{P_{ref}}) \quad (1)$$

Where :
RSSI = Ratio of received signal strength to strong reference signal (meters).
P_{Rx} = Power received at the receiver (Watt)
P_{ref} = Power received at the reference distance (Watt)

The received signal strength (P_{RX}) for the LOS plane is the received power equation at the distance (d) of the sphere to the center of the sphere according to the Friss equation as equation (2).

$$P_{Rx} = P_{Tx} \times G_{Tx} \times G_{Rx} \left[\frac{\lambda}{4\pi d}\right] \quad (2)$$

Where
P_{Rx} = Power received at the receiver (Watt) at a distance d
P_{Tx} = Power delivered by transmitter (Watt)
G_{Tx} = Gain transmitter (Watt)
G_{Rx} = Gain Receiver (Watt)
d = Distance between transmitter and receiver (Meter)
λ = wavelength (Meter)
n = path loss exponential

Then the equation for receiving power at the reference distance (d0) is like equation (3).

$$P_{Rx} = \left[\frac{\lambda}{4\pi d_0}\right]^n \quad (3)$$

From the substitution between equations (1), (2) and (3), the following equations are obtained:

$$RSSI = 10 \times \log \left[\frac{P_{Tx} \times G_{Tx} \times G_{Rx}\left[\frac{\lambda}{4\pi d}\right]^n}{P_{Tx} \times G_{Tx} \times G_{Rx}\left[\frac{\lambda}{4\pi d_0}\right]^n}\right]$$

$$RSSI = 10 \times \log \left[\frac{d}{d_0}\right]^n$$

$$RSSI = 10n \times \log \left[\frac{d}{d_0}\right] \quad (4)$$

Where d0 is the reference distance between transmitter and receiver, which is 1 meter. The following is a reference table for the variance of Path Loss (PL), exponential (n) for different environments is shown in Table 1 [9,10].

Table 1. Path loss exponent for different environments.

Environment	Path Loss Exponent, n
Free space	2
Urban area celluler radio	2.7 to 3.5
Shadowed urba celluler radio	3 to 5
In building Line-of-sight	1.6 to 1.8
Obstructed in building	4 to 6
Obstructed in factories	2 to 3

In the RSSI algorithm, signal strength is very important in determining the estimated distance between nodes.

$$P_L = P_{L0} + 10n \times \log\left[\frac{d}{d_0}\right] + x\delta \quad (5)$$

After the Path Loss Exponent (n) value from the field of observation is obtained based on the signal strength received by the node, then by using the value of n, the estimated distance between the node and the transmitting node can be found. In this research, the access point is used as an anchor node (Tx) that doesn't move and a smartphone as an unknown node (Rx) that moves according to a predetermined test point. The calculation of the estimated distance of the unknown node to the anchor node with n can use equation (6) obtained from equation (5), namely:

$$d = d_0 \times 10 \left(\frac{P_L - P_{L0} - x\delta}{10n}\right) \quad (6)$$

Where, (n) is the path loss exponent which indicates the incremental value of path loss at distance d. (d) Transmitter and receiver distance (Meters), Reference distance (d_0) is determined from the closest distance to the sender. (xδ) Standard deviation. [9].

3.3. COMPUTER VISION ANDYOLO ALGORITHM

Computer vision is a fast-growing field for analyzing, modifying, and high-level understanding of images [25]. Computer vision is a technology by which machines can extract information from images. Computer vision is a technology that includes methods for obtaining images, processing images (image processing), analyzing image data, and understanding visual data such as images and videos. In computer vision, object detection refers to finding and identifying an object in an image or video [14]. Object detection does the work of combines these two tasks and localizes and classifies one or more objects in an image [11]. The core of the YOLO(You Only Look Once) target detection algorithm lies in the model's small size and fast calculation speed. The structure of YOLO is straightforward [12]. The detailed architecture is shown in Figure4. Project architecture of object detection [13].

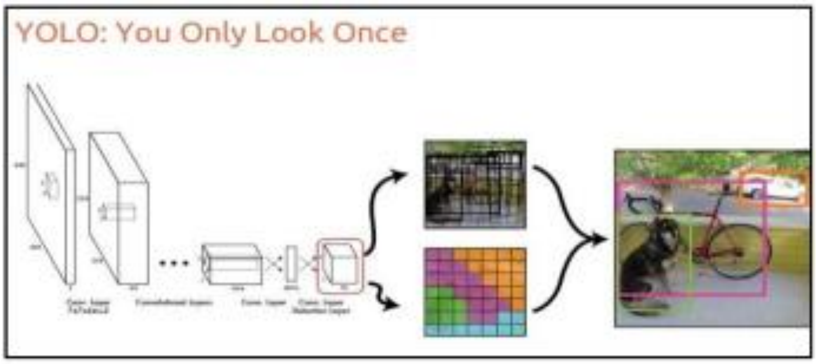


Fig.4. Overview of the detection process

Implementation of real-time detection in YOLO is complex. YOLO has a simple architecture, namely a convolutional neural network (CNN). With various CNN network architectures available, the You Only Look Once (YOLO) network is popular due to its many reasons, mainly its speed of identification applicable in real-time object identification [15]. Using YOLO, when an image is input, YOLO will process the convolutional network in one go, and the output will be 13x13x125 which represents the bounding box.

YOLO uses a regulation technique called batch normalization, which is located after theconvolution layer. Batch normalization (BN) is a technique to normalize activations in intermediate layers of deep neural networks [20]. Batch normalization is a neural network layer that has the best work performance when the data is clean. Ideally, the input to a layer has a mean of 0 and a small variance. Batch normalization scales similar features for data between layers this technique really helps neural network performance because it can stop data so as not to be damaged when passing through the network. Batch normalization usually occurs after the convolutional layer, but before the function is activated. Because convolution and Batch perform linear transformation on the data, it is possible to combine the Batch normalization layer parameters with weights such as convolution. With a little calculation, Batch normalization can be removed but also must change the weight of the previous convolution layer. For example, if x is the pixel in the input image and w is the weight for the layer, then the output for each pixel will be calculated, calculated as following:

$$out[j] = x[i] * w[0] + x[i+1] * w[1] + x[i+2] * w[2] + \cdots + x[i+k] * w[k] + b \quad (7)$$

out[j] is the product of the input pixels with the convoluted kernel weight, plus b. The following will show the calculations performed by Batch normalization into previous convolution output:

$$bn[j] = \frac{\gamma(out\,[j]-mean\,)}{\alpha^2}] +\ \beta \quad (8)$$

The four parameters (mean, variance, gamma, and beta) are the parameters used by Batch normalization when the network is used. To eliminate Batch normalization, randomize the two equations below to calculate the new weights and bias terms for the convolution layer.

$$w\_new = \frac{\gamma * w}{\alpha^2} \quad (9)$$

$$b_{new} = \frac{\gamma(b-mean\,)}{\alpha^2}] +\ \beta \quad (10)$$

IV. RESULT AND DISCUSSION

This section discusses the results of testing and processing beacon data, image data using the methods used in research. The type of vehicle for testing on the sidewalk uses a red Aerox motorcycle.

4.1. RESULTS OF PROCESSING BEACON DATA AND IMAGE DATA ON THE SERVER

In the process of sending data from the Beacon to the server, as previously explained, the Raspberry Pi runs a program called merge.py. Before running the program, make sure the wabcam module on the raspberry is active. Then on the server side, don't forget to activate the MQTT protocol. After all the tools are ready, then immediately run the merged.py program on the Raspberry Pi with the sudo python3 command and also run the servercan.py program on the server side with the python3 command. Before sending data to the server, the Raspberry Pi must detect the beacon device. If the Raspberry Pi does not detect the beacon signal then no data is sent, and the display on the Raspberry Pi is only an empty index. In Figure 5 and 6, it can be seen that the data detected by the Raspberry Pi is sent to the server with accurate data. The data sent is in the form of Mac Address, RSSI and images. The image data is not displayed on the terminal server, because the image data sent is still a byte data type.

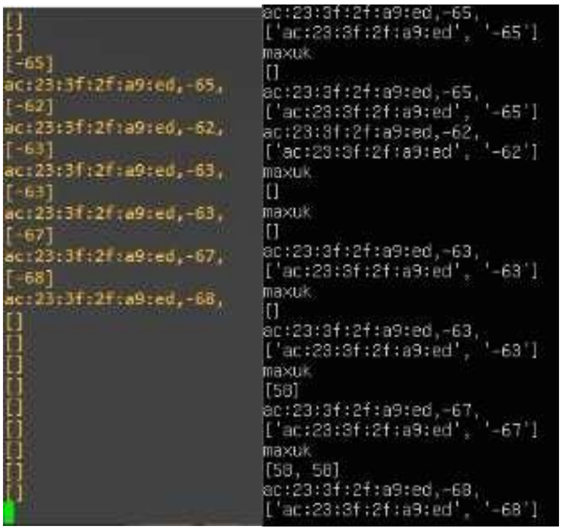


Fig.5. Detection results of beacon data delivery towards the server

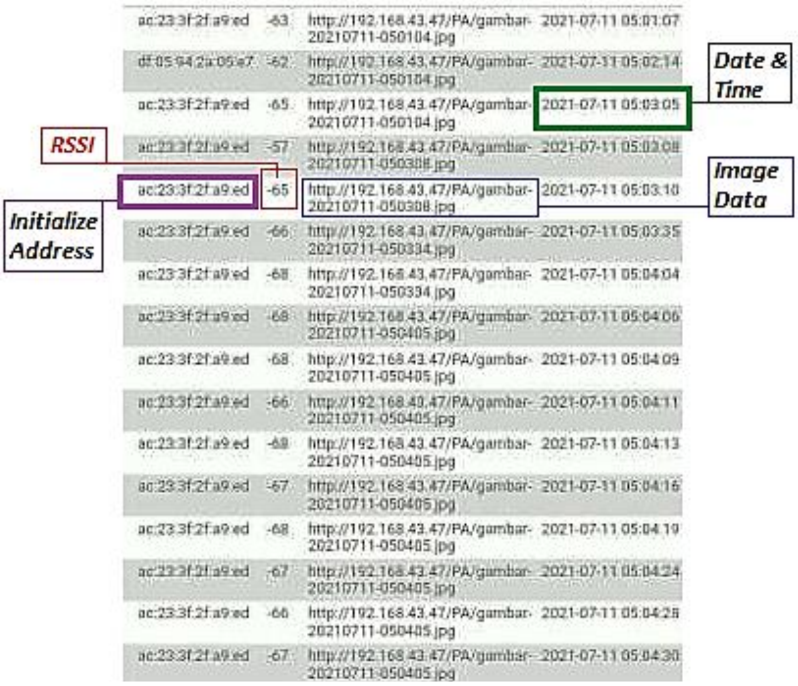


Fig.6. Data storage results in database server

After the Server receives the Beacon and Image data from the Raspberry Pi, it will be directly saved to the database server, the following will show the results of the storage in the database as shown in Figure 6. RSSI data retrieval uses a program that functions to scan 100 data beacons which will later display the RSSI values that often appear or the data mode that most often appears when communicating between the raspberry pi and the cubeacon card. Data retrieval on the beacon device is taken as much as 100 mode data, as a determination of the estimated distance between sensor nodes.

The picture above shows that the data detected by the Raspberry Pi has been sent to the server and stored in the server database. It can be seen that the data stored in the database is in the form of beacon addresses, RSSI values, Image Links and the date and time that the Beacon device was detected. All data will be stored in the database if the webcam detects a motor vehicle. If the webcam does not detect a motor vehicle, the Beacon data captured by the Raspberry Pi and sent to the server will not be stored in the database. To view and check the results of the images obtained, simply access the link provided in the table via a browser. For more details, in Figure 7 shows the results of the image data display.

Fig.7. Data storage results in database server

Based on the following image, it is shown that the webcam and the algorithm that processes the image are running well. To check the results of other images, which is enough to open the storage directory.

4.2. DATA ANALYSIS

One of the results of the detection of beacons stored in the database is as follows:

ac:23:3f:2f:a9:ed	-57	http://192.168.43.47/PA/gambar-20210711-050308.jpg	2021-07-11 05:03:08
ac:23:3f:2f:a9:ed	-65	http://192.168.43.47/PA/gambar-20210711-050308.jpg	2021-07-11 05:03:10

(a) (b)

Fig.8.(a). Data results with the same beacon address and image link, (b). Display image file xxx308.jpg

It can be seen that the link address xxx308.jpg has two lists of the same address, namely with the initial "ac" at the beginning of the beacon address, which means the vehicle used by the user is the same as the vehicle stored in the database.Based on the results of these data, it can be proven that the image process entered is valid. However, the image frame does not show the label on the motorcycle object. This happens because of a delay when performing the algorithm or identification process on the image and it could also be due to the webcam specifications used for testing.

In addition to these results will be shown some of the results of the data entered in the database. Here, we will show another case where there is some data that has the same image link address at a different beacon address.

ac:23:3f:2f:a9:ed	-67	http://192.168.43.47/PA/gambar-20210711-050405.jpg	2021-07-11 05:04:5
ac:23:3f:2f:a9:ed	-67	http://192.168.43.47/PA/gambar-20210711-050405.jpg	2021-07-11 05:04:5
df:05:94:2a:05:e7	-66	http://192.168.43.47/PA/gambar-20210711-050405.jpg	2021-07-11 05:05:1
ac:23:3f:2f:a9:ed	-59	http://192.168.43.47/PA/gambar-20210711-050405.jpg	2021-07-11 05:05:1
ac:23:3f:2f:a9:ed	-68	http://192.168.43.47/PA/gambar-20210711-050405.jpg	2021-07-11 05:05:3

(a) (b)

Fig.9.(a). Data results with different beacon addresses and the same image link, (b). Display image file xxx405.jpg

Based on the results of the image above, it can be seen that the captured image data is a red Aerox vehicle. In a case like this, it happens when a red motor is crossing the Raspberry Pi sensor but another motor is near the sensor, and the Raspberry Pi is also picking up signals from other motors. because the one in front of the Raspberry Pi sensor is a red motor, so the webcam captures objects in front of it. This happens because the Raspberry Pi catches the RSSI signal according to a predetermined range, and the signal on the motor that is not intended as an object is still within the range of the Raspberry Pi. In addition to that, it could be due to the placement of the webcam that does not cover the area, so that if there are other vehicles around the sensor it will not be caught by the webcam.

Based on the results of the process from detecting beacon device signals and images to data storage to the dataabse. It is also tested here to measure the performance between interfaces when sending data. The results are shown in Table 2.

Table 2. Average results of system performance testing.

Test to n	Delay (s)	Throughput (kbps)
1	0.011	0.564
2	0.008	0.564
3	0.052	0.564
4	0.003	0.564
5	0.007	0.564
6	0.006	0.564
7	0.011	0.564
8	0.010	0.564
9	0.008	0.564
10	0.003	0.564
Average	0.011	0.564

As is known, the parameters that need to be analyzed for this performance are delay and also throughput obtained from checking the Wireshark application. This data retrieval is done by taking 10 times the detection and sending of data using the MQTT protocol based on the distance between the Raspberry Pi and the Beacon Device that has been determined during the previous RSSI Test.

From the results above, it can be seen that, out of 10 test results, The average delay of the Raspberry Pi is 0.011 seconds and also for the throughput in sending data to the database, it is obtained an average of 0.564 kbps. In addition, the delay value ranges from 0.003 to 0.011 seconds. The shortest delay is 0.068 seconds and the constant throughput value is 0.564 Kbps. This value can also be affected due to the signal strength factor from the local internet connection that is connected via the available wifi tethering network and the environmental condition factor around the area where the Raspberry Pi is placed.

V. CONCLUSION

From the results of system testing and data obtained, it can be concluded that, From the results of the RSSI measurement when the Raspberyy Pi detects a beacon device with a distance of about 0.5 meters to 2.2 meters from the anchor node, the threshold value can be determined. From several calculations, the average RSSI value obtained a threshold of about -53 to -68 with the condition of the detector being neither blocked by objects nor obstructed by objects.

The RSSI measurement shows a large variation due to the influence of fading or shadowing caused by the observation conditions in the office area and traffic so that the RSSI becomes unstable.

The delivery concept shown in this research, when the Raspberry Pi detects a Beacon device with RSSI that matches the specified range, the webcam device will take an image of the object that passes through the sensor, then the Beacon data and image are sent directly by the Raspberry Pi to the server for processing. .

Storage of beacon data and image data in the database server, is influenced by the presence or absence of vehicles crossing the sensor. If no vehicle crosses the sensor, the Raspberry Pi only scans and sends it to the server, but does not save it to the database. If a vehicle crosses the sensor, the Beacon data and image data are directly sent by the Raspberry Pi and stored in the database server.

On the suitability of the image data stored in the database in the form of a link address with the detected Beacon address, it depends on the location of the webcam device and the device specifications and the distance between the raspberry pi and the beacon device.

The average delay in sending data using the MQTT protocol is 0.011 second. The throughput obtained in the process of sending beacon data and image data from the Raspberry Pi to the server is 0.564 Kbps. extentions.

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