Unmanned Vehicle Using Received Signal Strength Indicator (RSSI) in Instant Beverage Industry

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***Abstract*— Unmanned Vehicle like Forklift in the warehouse of Instant Beverage Industry is not permanent and may change anytime depending on piles of pallets. The alert for moving forklift is just the horn, so the operators must be cautious while passing in the aisles. To minimize human error which may cause forklift collision, and to accelerate the picking and delivery activities using the forklifts, an alert system in the form of flexible and accurate traffic LED is really needed. The traffic LEDs of the forklift are designed to be flexible which can move alongwith the forklift. So, the LED can alert forklift operators faster as they work automatically when there are other forklifts passing around. This traffic LEDs utilizes wireless technology in the form of WI-FI signal. Changes in WI-FI signal strength will indicate the presence of a transmitter towards the receiver. Then the signal is changed into the radius of the object. The distance of the forklift approaching at a certain radius will activates the "proceed" LED on one of the forklifts and the "stop" LED at another forklift. Hence, the forklift traffic can run smoothly and safely. The ESP8266 module has a fairly accurate RSSI measurement which has low presentation error, no more than 10%. However, the Wi-Fi network scanning time a little bit longer to make RSSI conversions to the actual distance, so that the action-taking process of the prototype becomes slower. For further research, it is expected that there will be components / tools that can convert RSSI faster so that the development of distance measurement technology using Wi-Fi signals can be improved.**

Keywords—ESP8266, Forklift, Received Signal Strength Indicator

I. INTRODUCTION

Rusdinar et al. [1] reduced the disruption of vehicle that was vertically measured from horizontal view using extended Kalman filter and artificial landmark on the ceiling. This research discusses the movement control algorithm of weighted vehicle by trolley using Fuzzy Inference System [2]. Sensing and tracking of a moving object/human from a robot is an important topic of research in the field of robotics and automation for enabling collaborative work environments [3]. Jaiganesh et al entitled Automated Guided Vehicle with Robotic Logistics System [4] measured the distance between two nodes (we used NodeMCU as sensor node). The NodeMCU is an Arduino type board which runs on ESP8266 moduleIndoor positioning is an interesting topic and an enabler in several fields of application, and consequently subject to a significant number of research activities. Vehicle intelligent position systems based on Received Signal Strength Indicator (RSSI) in Wireless Sensor Networks (WSNs) are efficiently utilized [5]. Received Signal Strength Indicator (RSSI) location algorithm is a range based localization algorithm. It uses the connection between communication distances and the received signal strength to calculate the coordinates of unknown nodes[6][7].

XYZ. Ltd, which manufactures bottled tea has warehouse to store all ready-to-ship beverages and used bottles from consumers. The warehouse is located in one area with the main office. It is also located next to the production department to ease the process of order picking and storage of the beverages.

In order to transfer the beverages, the forklift is needed. The forklift is used to transport goods from warehouse to production and from warehouse to the distributor (order picking). The storage system in warehouse is in the form of palleted boxes, with aisles among the piles of boxes for the route of forklift.

The aisles is not permanent since it depends on the piles of the boxes. The aisles are changed when the boxes are all transferred and reloaded. To avoid crash between forklift, the operators depend on the horning signs while moving on the aisles [8]. This sign is considered sufficient to make all forklift operators keep aware of the moving forklift. However, this is not considered as an effective way since the operators need to be very careful and cannot drive the forklift fast. It makes the process of transferring goods becomes slow and sometimes late.

When it comes to solving this problem, an intelligent system which includes forklift detection to prevent forklift crash is needed. The system works automatically, so there will be an alarm when the system detects forklift in a particular distance. With such alarm system, a crash between forklift will never occur and the operator can drive it fast and safely.

In the instant beverage company, forklift collision may happen when two forklifts are passing in different directions with medium speed, then when meeting one of the forklift operators surprised and swiftly stop the forklift causing the cargo brought fall to the ground.

Therefore, an intelligent system is needed to help alert the forklift driver to easily find out other forklifts that are approaching at a certain distance. In addition, an intelligent system can prevent collisions between passing forklifts.

This intelligent system uses radio transmitter technology in the form of Wireless Fidelity (Wi-Fi) signal. By utilizing Received Signal Strength Indicator (RSSI), the value is converted to a radius between the sender and receiver of the signal. The distance of the approaching forklift at certain radius will activate the "drive" LED on one of the forklifts and "stop" LED on another forklift. So, the forklift traffic can run smoothly and safely.

Since the forklift's path can change at any time, the traffic LED of the forklift is designed to be flexible, which can move along with the forklift. So, it can alert forklift operators faster as it works automatically when there are other forklifts passing around.

II. METHODOLOGY

A. Functional Block Diagram

The functional block diagram discussed in this research is forklift based traffic LEDs with prototypes. At the initial use, the Wi-Fi signal input is carried out by reading the signal around the device. Then, the results of the reading are processed by the microcontroller. If the measured Wi-Fi signal is in accordance with the Set Point given, the microcontroller will activate the DC Relay, and then activate the traffic LED.

B. Forklift Traffic LED Working Mechanism.

The forklift traffic LEDs in this research are made semi-portable where they will stick to the forklift but require power from the forklift. The system that is implemented is measuring the distance between the traffic LEDs by using Wi-Fi. The signal emitted by the Wi-Fi from ESP8266 device will cause variations in the signal strength changes measured by RSSI in dBm. Changes in the value of RSSI will be converted into distance between LEDs, then processed by the ESP8266 microcontroller to get the minimum distance to turn on the indicator on the traffic LED. The following is the overall working system of the traffic LED system as shown in Fig 2.

C. Hardware Design

Fig 3. shows the design of hardware used for prototypes, which include designing prototypes and control circuits

D. Prototype

The prototype is a simulation of a forklift car in the warehouse. It is made from a used car that can move when ignited at a certain speed. To give control the speed, Speed Control circuit is used by utilizing a trigger from the transistor. Fig.3. shows more details on construction design and the component layout in the prototype.

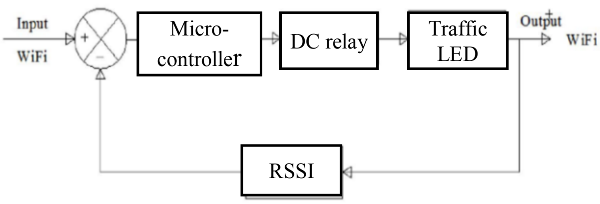

Fig 1. The Block Diagram of System

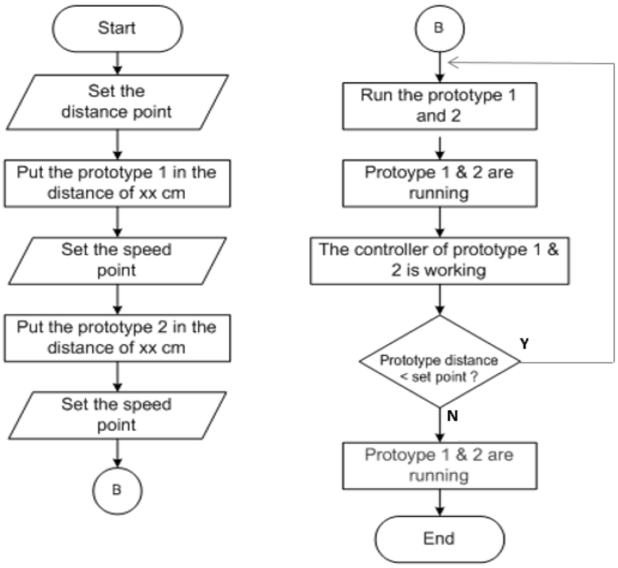

Fig 2. Flowchart of the Working Mechanism of Forklift Traffic LEDs

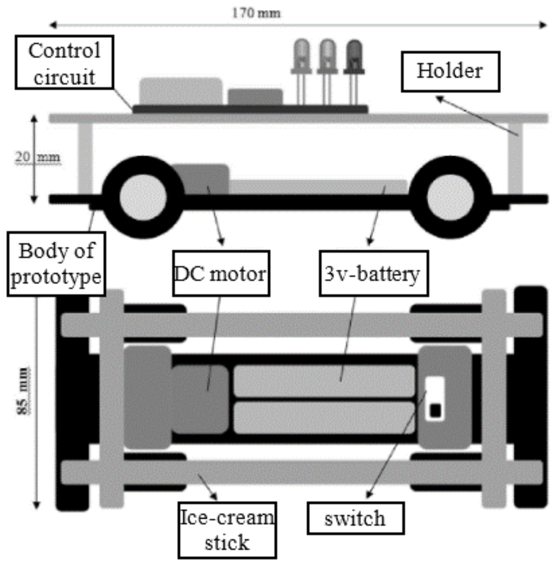

Fig 3. Prototype design seen from sideway and from above

E. Traffic LED Control Circuit.

Traffic LED control circuit serves as the controller of LED to work properly when there is a forklift approaching. The closest distance to turn on the traffic LED can be set by changing the RSSI set point in the ESP8266 program language.

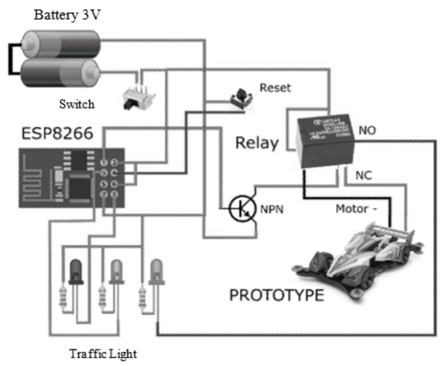

Fig 4. Traffic LED Control Circuit

The control circuit turn on the traffic LED as well as break the power circuit on the prototype by activating transistors and DC relays. The forklift traffic LEDs on the circuit are:

1. Green LED: serves as the ‘proceed’ indicator of the prototypes.
2. Yellow LED: indicates there is another prototype within a radius of 1-2 meters.
3. Red LED: indicates there is another prototype approaching, which is very close (less than 1 meter), and it also serves as ‘stop’ indicator.

III. RESULT

A. *RSSI Value Test*

Testing RSSI value means determining the RSSI value that is read by the ESP8266 module. This test is a continuation of the ESP8266 module test. In this test, the equipment, materials and circuit used are the same as in the ESP8266 module test. However, the circuit is used for the Receiver which functions as WiFi signals reader. For the transmitter system, an additional ESP8266 module, which is set to have a unique SSID, is used. It is intended to distinguish AP test items. In more detail, the stages of RSSI value test can be seen in the Fig 5.

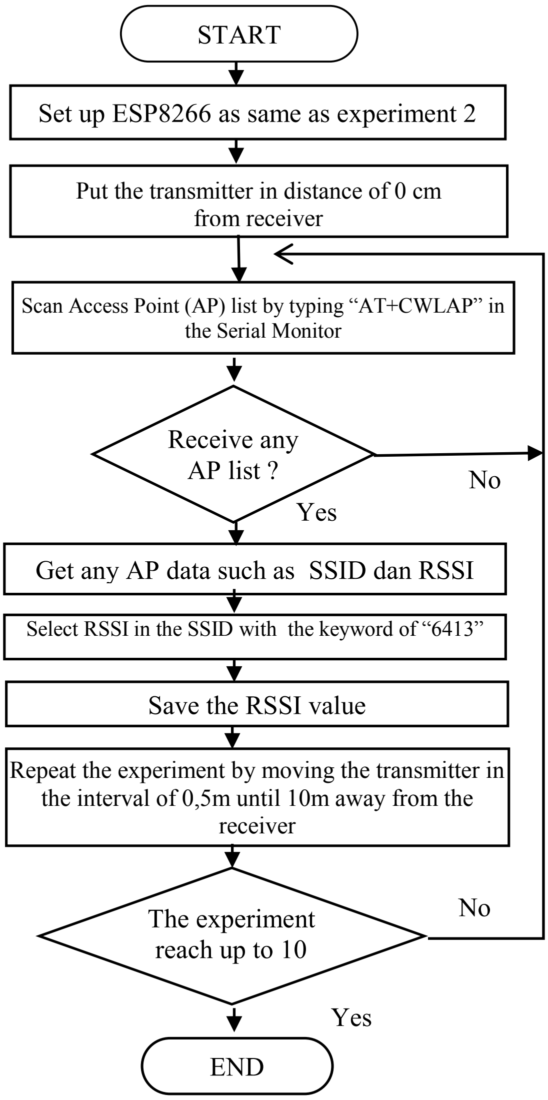

Fig 5. Method of Value Test

B. *RSSI Reading Test*

RSSI test is conducted to find out how big the effect of change in RSSI value toward the distance between the Station and Access Point (AP). This measurement is then converted to distance radius in meters. RSSI test begins with measuring the distance from the Station to AP by 0 meters, and then by changing the distance as much as 0.5 meters per test. After that, the test is carried out 5 times to get accurate results as expected in the theoretical calculation. Measurements are conducted outdoors in a large area. This is aimed to prevent interruption in the measurement of signals due to bouncing signals if it is carried out indoors. After the measurement is completed, the next process is to compare the results with theoretical calculation. The theoretical calculation uses the Free Space Path Loss (PL) formula as follows [9] [10].

$$PL = 96.6 + 10\,log(d^2) + 10\,Log\,(f^2) dB \qquad (1)$$

Where

f = frequency (GHz)

d = distance (Miles)

The formula (1) is the original formula of the PL. Formetric system, it can be reduced to the following formula

$$PL = 92.4 + 20\ \ log(d) + 20\,Log\,(f) dB \qquad (2)$$

Where

f = Frequency (GHz)
d = distance (km)

To calculate all data obtained from the experiments, Microsoft Excel software use along with the formulas. The following is a table for calculating RSSI measurements by comparing data between theory and test:

Table 1. CALCULATION OF RSSI IN THEORY AND TEST

Distance		RSSI level (-dBm)						Theory	Error	Error
m	km	1	2	3	4	5	Average	(-dBm)	(-dBm)	
0.5	0.0005	43	55	45	45	44	46.4	33.98	12.42	36.5%
1	0.001	46	48	45	46	45	46	40.00	6.00	15.0%
1.5	0.0015	46	47	47	47	49	47.2	43.53	3.67	8.4%
2	0.002	49	49	49	49	48	48.8	46.02	2.78	6.0%
2.5	0.0025	52	51	51	53	53	52	47.96	4.04	8.4%
3	0.003	54	54	54	52	52	53.2	49.55	3.65	7.4%
3.5	0.0035	52	54	51	53	51	52.2	50.89	1.31	2.6%
4	0.004	54	56	56	56	54	55.2	52.05	3.15	6.1%
4.5	0.0045	57	56	56	56	54	55.8	53.07	2.73	5.1%
5	0.005	55	57	58	57	58	57	53.98	3.02	5.6%
5.5	0.0055	58	58	58	59	59	58.4	54.81	3.59	6.5%
6	0.006	57	60	60	59	61	59.4	55.57	3.83	6.9%
6.5	0.0065	60	58	59	58	58	58.6	56.26	2.34	4.2%
7	0.007	62	62	63	60	62	61.8	56.91	4.89	8.6%
7.5	0.0075	63	61	65	65	63	63.4	57.51	5.89	10.3%
8	0.008	61	62	62	61	61	61.4	58.07	3.33	5.7%
8.5	0.0085	63	62	63	61	62	62.2	58.59	3.61	6.2%
9	0.009	67	67	65	65	66	66	59.09	6.91	11.7%
9.5	0.0095	66	63	63	65	65	64.4	59.56	4.84	8.1%
10	0.01	65	65	64	66	67	65.4	60.00	5.40	9.0%

The Table 1. shows the results of RSSI calculations in theory and Test. The purpose of comparing the results of the two is to find out the RSSI reading accuracy level that can be carried out by ESP8266 module. The measurement is obtained from conducting RSSI test manually, which is by gradually move the station from the AP. The results of the experimental data above can be seen in Fig.6

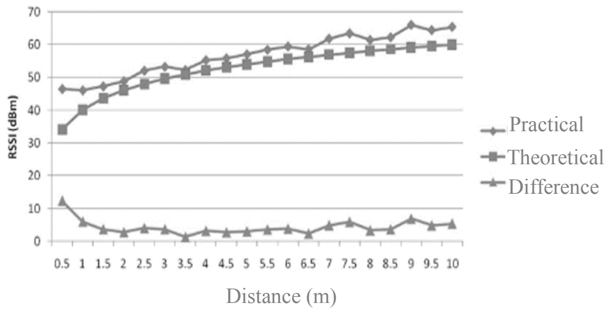

Fig 6. RSSI value from Theoretical and Practical Results.

In Fig. 6 the theory and tests show an increasing trend along with increasing measurement distance. However, the test shows a slight fluctuating value change. In theoretical calculations, the changing value of RSSI toward distance indicates an increasing trend. The highest error percentage, which is 36.5%, occurs in the measurement with the closest distance: 0.5. This is because in the measurement of closest distance, the position of the Wifi Station is at a large angle, causing a quite large change in the direction of the Line of Sight. While for the smallest percentage of errors, it is at a distance of 3.5 meters. After getting the data of RSSI tests, the next step is taking one of the RSSI values to be used as a set of common and farthest distance points for WiFi traffic LED control systems. The points for a medium 2-meter distance is -49 dBm and the farthest distance (more than 3 meters) is -53 dBm.

IV. Conclusion

The conclusion of all the tests carried out is as follows:

1. The ESP8266 module can be used as a Radio Frequency Meter for measuring the Received Signal Strength Indicator (RSSI).
2. The ESP8266 module has a good level of accuracy with low error percentage. However, it takes longer time to read Access Points around the module so the distance conversion from RSSI is considered slow to detect moving equipment.
3. The use of RSSI to measure indoor distance still need better research and development since the Wi-Fi radio signals can be easily interrupted by noise around the area so it affects the results of distance measurement.
4. The forklift prototype was made by using a very large 3 v DC motor which has high speed. It brought difficulty in controlling the speed. To overcome this problem, speed control was done manually by using remote control which was switched on periodically. This result in the unstable speed of the forklift.

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