Enhanced Line Follower Robot Using IR coding as an Artificial Landmark

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***Abstract*—in this paper, an invented artificial landmark technique is discussed and tested. The technique is called IR coding and it is designed especially to enhance the line follower feature. The IR coding is used with the line follower robot so it will localize itself without adding any sensors. This technique is inexpensive and it has other features as well. In this paper, the focus was in embedding the IR coding in '+' intersection so the line follower robot will easily identify it and it will take the decision accordingly.**

***Index Terms*—IR coding, Intersection, Mobile Robot, Technique.**

I. INTRODUCTION

LINE follower robot is one of the mobile robot navigation that has the ability of moving from one location to another following specific path. It also categorized to be under the unmanned ground vehicles (UGV) classification. For UGV class, the mobile robot is designed to move in land which means that the mobile robot is wheeled or legged [1]. Line follower robot has a simple structure and electronic circuitry. It has a sensor unit which can be constructed by using either IR pair (IR transmitter and IR detector) or LDR (light dependent resistor) with LED. The actuator unit is simply a DC motor. Moreover, microcontroller can be used as a controlling unit that will take the input from the sensor, match the exact action that needed to be performed and then send the output to the actuator. Figure 1 shows the relation between sensor, actuator and controlling unit.

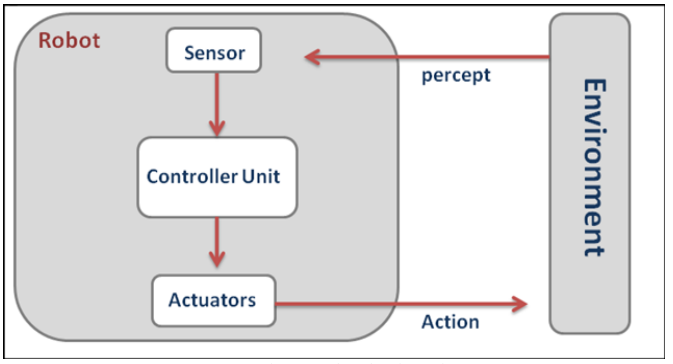

Fig 2. Robot basic units.

The concept of the line follower robot is pretty simple. The path is designed with dark color (black) so it will absorb the IR waves or the light waves. The surface that is surrounding the path will be constructed by using light color (white) which will reflect the IR waves or the light waves. Furthermore, two or three sensors needed to be used so the action (left, right, straight and stop) will be easily determined. The output of the sensor will be feed to the controlling unit so it will take the decision accordingly. Then, the controlling unit will either activate one DC motor (in case of turning to right or left) or both of them (in case of going straight). Whenever the output of the sensor is high (meaning that it cannot see the path anymore) both DC motors will be deactivated. Figure 2 shows

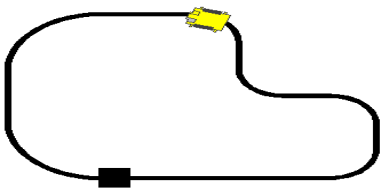

Fig 1. Simple line follower robot's path.

simple path for line follower robot.

As discussed above, the line follower robot does not have the ability to localize itself or even take the decision in case of having two paths intersect with each other forming a '+' intersection. In order to enhance the line follower robot to be able to perform such a decision, landmark navigation must be used. Landmark is simply a recognizable mark that can be either natural or artificial [2], [3]. Natural landmark is done by using a camera which will be placed on the robot and the output of the camera will be sent to the computer. Signal processing is done to analyze the photo to recognize what the robot is seeing. On the other hand, artificial landmark is not complex as natural one since it uses special landmark that the robot can easily detect. Examples of the artificial landmark are RFID tag [4] and barcode [5]. Also, simple '+' intersection have been used with counter so the line follower robot will navigate itself [6].

This research is organized as followed. Section II shows related work regarding artificial landmark. Section III discusses the invented technique "IR coding". Moreover, section IV shows a comparison between IR coding and simple '+' intersection. In section V different scenarios are shown regarding the use of IR coding. The conclusion is covered in section VI.

II. Related work

There are different techniques that the authors have suggested to be used as artificial landmark. In [4] RFID tag has been used in different location and the RFID reader is placed in the mobile robot. Other technique is to use the barcode as an artificial landmark and the mobile robot will have the barcode reader [5]. Furthermore, special landmark can be used with the camera and then the signal processing is performed to recognize these landmarks [7]. Moreover, other authors discussed the fusion of artificial landmark and RF TDOA distance [8]. The paper represented the use of camera to obtain the image information and the distance information obtained from distance node. However, other authors have focused on writing an algorithm so the robot can locate and update the landmark. Also, this algorithm overcomes the noise problem so it can be used in industrial environment [9].

III. IR coding concept

IR coding is an invented artificial landmark that is designed for the line follower robot. Enhancing this feature will make the line follower robot more intelligent to localize itself. The number of the IR pairs that are used to build the line follower robot will determine the total combination of IR coding. For example, table 1 shows the complete combination of three IR pairs. Four combinations are required for the line follower robot's functionality (which are left, right, straight and stop). The rest can be used as IR coding. There are two types of IR coding; one is unique IR coding which means that it can be read from any direction that the line follower robot is coming from. Example of unique IR coding is the combination 0 1 0 and 1 0 1. Another on is not unique but has two combinations resulting in one action. For example, combination 1 1 0 is the result of 1 XOR 0 1 1 which means that the four combinations

TABLE I
COMBINATION OF THREE IR PAIRS

IR1	IR2	IR3
1	1	1
1	1	0
1	0	1
1	0	0
0	1	1
0	1	0
0	0	1
0	0	0

This table shows the complete eight combinations for three IR pairs. Only four combinations are required for basic functionality of the line follower robot.

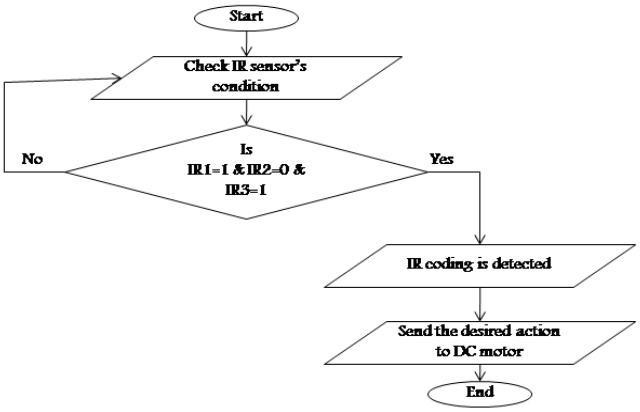

Fig 3. Flow chart of IR coding (101).

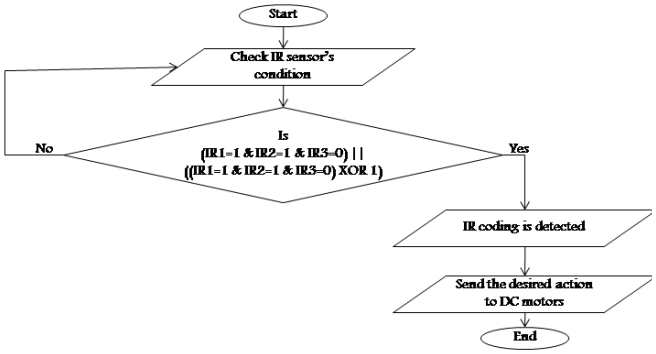

Fig 4. Flow chart of IR coding (110).

are actually two IR coding. Figure 3 and 4 shows the flow chart of both unique IR coding and other IR coding.

In case that there is a need of having more IR coding, more IR pairs can be added. The output combination can be obtained using the following equation.

$$2^X \quad (1)$$

Where x is representing the total number of IR pair. Since there are four combinations are used for the line follower direction, the total IR coding combination is equal to:

$$2^X - 4 \quad (2)$$

IV. USING IR CODING FOR DIRECTION DECISION

As the authors shown in [analysis], simple '+' intersection can be used for navigation with counter to count each '+' intersection. This technique is not accurate since it is highly depending on the counter value to specify each '+' intersection. For example, in case that the line follower robot was going back to the same intersection that it has already passed, it will assume that it is a new intersection. Moreover, this technique is not flexible because the counter value needed to be increased in case of adding more intersection; which means that the probability of using the counter value twice for different action is high. Also, another problem can arise in case that the power of the line follower robot is suddenly goes down. That means the counter value will be reset which tends to logical error like performing the wrong operation in the coming intersection. Figure 5 shows simple '+' intersection.

Fig 5. Simple '+' intersection.

In this paper, the suggestion is to use the IR coding in each intersection instead of having a simple '+' intersection. Figure 6 shows embedded IR coding for intersection.

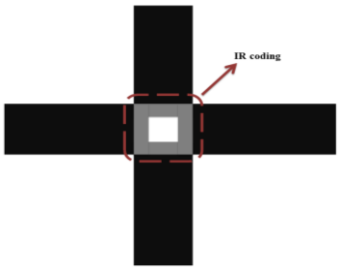

Fig 6. Embedded IR coding in '+' intersection.

There are many advantages of using IR coding embedded into the intersection rather than using simple '+' intersection. The main advantage is that the IR coding does not suffer from the problem that the simple '+' intersection has. Moreover, the line follower robot can come from any direction and will not have a problem in misreading the IR coding. Furthermore, the line follower robot does not depend on any variable that can be changed like counter value. That will help in reducing the error rate of having logical errors. Using IR coding as an artificial landmark is inexpensive and does not required adding more sensor units; Unlike using the RFID tag or the barcode which will increase the cost and the complexity of the system.

V. SCENARIOS

A. Scenario I

In this scenario, there are two cases. The first case is that the one IR coding is used and the robot will go only in one direction. Figure 7 shows the flow chart of this scenario.

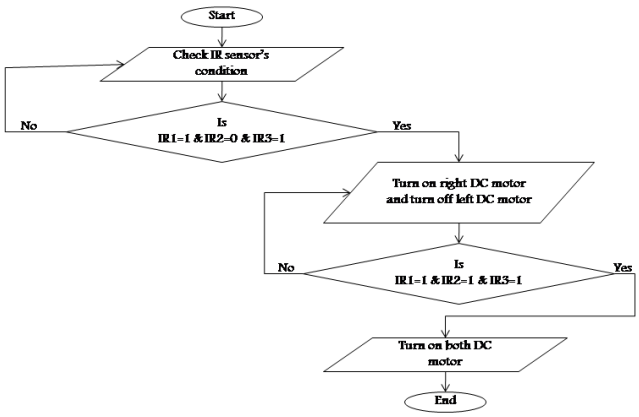

Fig 7. Flow chart of using IR coding in one direction.

Another case is that the line follower robot has the ability to go into two directions. It must come back to the same location that it has come from. Figure 8 shows the flow chart of this scenario.

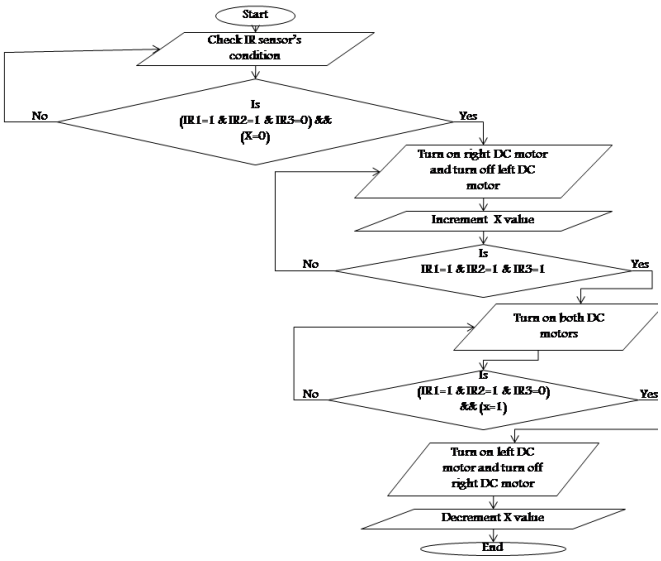

Fig 9. Flow chart of using IR coding for bi-direction.

B. Scenario II

In this scenario, the system has a user interface so the action regarding each IR coding is going to be feed by the user. An LCD and keypad are used to take the input or the action from the users. The IR coding and several actions are already embedded in the system so the user is going to select from them. Figure 9 shows the flow chart of this scenario.

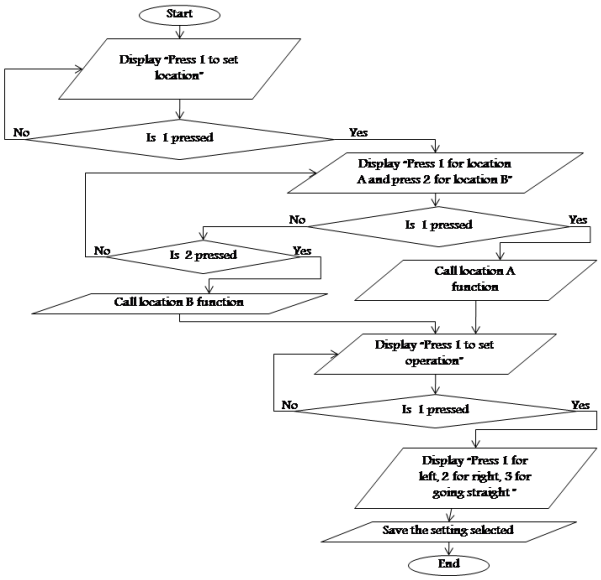

Fig 8. Flow chart of taking the operation from the user regarding each IR coding.

As the figure shows, two IR coding are used and named as Location A and Location B. The user will select the location and then select the proper operation that the line follower robot must perform. At the end, the setting will be saved for each location and the line follower robot will start its operation.

VI. CONCLUSION

In this paper, an innovation of artificial landmark has been discussed and tested. It is called IR coding. This artificial landmark is designed for line follower robot to enhance the localization feature so it will have the ability to localize itself. The IR coding has been tested to be used in the intersection. The line follower robot has the ability to identify each intersection and perform the action accordingly. This innovation has many advantages like flexibility, reliability and it is inexpensive.

FUTURE WORK

For future work, IR coding can be implemented to identify different location so the line follower robot will be intelligent to detect wither it has reached the desired location. Moreover, IR coding can be used as an artificial landmark for the other types of mobile robot like autonomous mobile robot.

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