Design and Deployment of Obstacle Avoidance Functionalities in Tensai Gothalo

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Path tracing and obstacle avoidance are two important modules of our lab grown robotic vehicle device that is required in the process of developing autonomous movable router in order to troubleshooting computer networks. We have already completed the research on path tracing module of this device, however, obstacle avoiding functionalities in TG (Tensai Gothalo) has not been implemented yet. This device has aimed to implement various abilities such as routing, monitoring and management to perform the predefined works. A micro-controller with Raspberry-Pi is integrated to execute the functionalities of navigation while avoiding obstacle and collision between the routers. In this paper we also describe the collision avoidance technique while there are multiple obstacles in the ground.

1. Introduction

Tensai Gothalo [1] is a movable network device which can participate in a network as a movable router. Furthermore it is built upon the concept to monitor, manage and trouble shoot the network. The movable feature of Tensai Gothalo which also can traces the path has been implemented in our previous researches [1],[2][3]. However, previous implementation has no obstacle avoidance feature. It has the capacity to trace the path and proceed to the troubled node, however, when it finds the obstacles in the path, it could not avoid it. In this research paper we are implementing the obstacle avoiding features of the robotic vehicles Principally Tensai Gothalo waits the signal from its master node and proceed to the troubled node while it gets alarm from the master. Therefore it always remains in standby position in the predefined area or in the range of computer network or server where it can be easily charged using solar energy during standby. When trouble is occurred in a network, master TG receives the signal from server that there’s some trouble in the computer network. In response to it, master send the command to the slave to proceed and slave TG will autonomously find the path, avoid the obstacles, reach to the server and troubleshoot the network problems and return back to its original standby position. Originally our focus of study and research is grounded on the use of best sensor for real-time obstacle avoidance and detecting the best path instantly with minimum error.

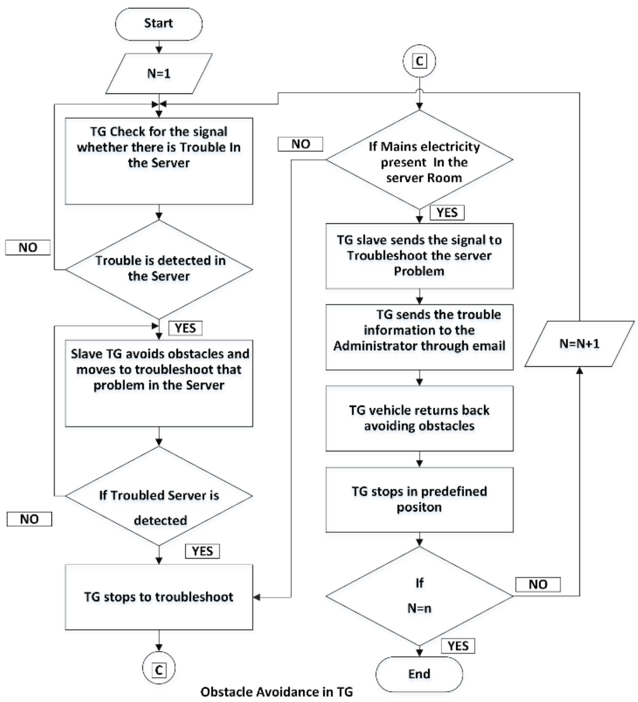

Figure 1: Working Concept of Tensai Gothalo

2. Issues and Objectives

The ultimate goal of Tensai Gothalo is to monitor and manage the network not only in normal situation but also in disastrous situation. We assume that the field of network might have a lot of obstacles in the path. The previous implementation of Tensai Gothalo only operates over black topped path. There was no implementation of obstacle avoidance module. Therefore, we require to implement obstacle avoidance module in order to meet this capacity. Furthermore, in order to deepen our understanding and the utilization of IR sensor, we decided to implement obstacle avoidance module by IR sensor. The reason behind utilizing of IR sensor is due to its cost effectiveness to the project. These sensors were chosen in this research because of their property of robustness, lightweight and low cost. Furthermore, there are very limited step wise research that utilizes the IR sensor for obstacle avoidance.

3. Related Research

There are plenty of researches [4],[5],[6],[7]on going in this field. Researches have been taken places for many different approaches to avoid the obstacles and to navigate the path. For example, early obstacle avoidance work by using sonar sensor followed by the method of scanning laser rangefinders are often used. Most of these approaches utilize the path planning methods before proceeding into the filed. These methods are also producing fantastic results. However, we would like to add the dynamicity

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in those method. Dynamicity can be added by utilizing real time information from the obstacle and feed those information into the system. Finally, we review some related work and decided to utilize the dynamical feedback systems approach in our system. Considering, this feedback from real-time environment can be included in the path planning later on. As most of the researches were done in simulation, we would like to implement this research with working hardware model and get the real output data that can benefit for the future researchers.

We assume that the destination and the distance are known by utilizing previously implemented algorithm that these quantities can either be calculated directly or may be given to the robotic program. For example, a destination point and the planning of the path can be provided by already implemented path planning module. We do assume that obstacles can be off any size and shape. These assumptions will obviously require the real time information from the obstacle as pre-planned information may not be sufficient so that the vehicle can avoid the obstacles. We believe that research focusing in IR sensor for real time obstacle information as we planned are not sufficient.

4. Working Concept and The Architectural Components

4.1 Working Principle

Figure 1 portrays the working principle of TG. In this particular figure we are focusing how the slave TG operates after it receives the signal from master TG. Generally, slave TG is always in standby position and preforms the predefined troubleshooting operation as soon the trouble is detected in the server. Trouble shoot operation may starts from providing power supply, starting halted services and further. In order to realize this operation, an embedded program has been developed where the functions loop starts from 1 and continues forever for infinite loop. Loop n in the flow chart defines the number of operation of vehicle which may require to operate incrementally. In order to keep alive the slave operation to monitor the networks we utilize this feature where slave is always in ON state and operation can be halted o only when the network administrator wants it to halt or the battery supply of the vehicle is below the threshold which cannot drive the vehicle to reach the destination. In this way, master and slave operates in order to solve the problem arises in the network.

4.2 Movement Controlling Circuit

Figure 2 shows the entire controlling circuit of TG. There are two motors M1 and M2. M1 is responsible for direction control.Direction is controlled by giving right or left signal by interpreting the value of IR sensors. If the obstacle is found at left side, the motor will avoid it by turning to the right hand side and similarly it will turn into left hand side if it founds the obstacle in the right side. While both sensors find the obstacles, it will stop the motor for a while and turn the vehicle backward. The detail of this logic is given in table 1. These values are interpreted by microcontroller after doing proper amplification of the voltage. The details process of which is described in section 5.

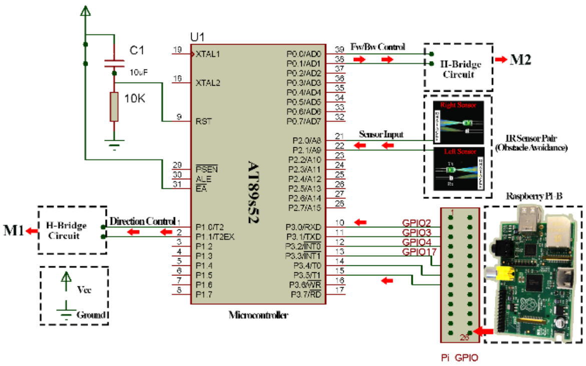

Figure 2: Overall Controlling Circuit of Tensai Gothalo

Table 1: Direction Control

Left Sensor	Right Sensor	M1
0	0	Forward
0	1	Turn Left
1	0	Turn Right
1	1	Stop and Backward

4.3 Power Control Module and Controlling Operations

Power management is done by using solar panel and 6 v, 4.5 AH battery. This battery is charged with 9V solar panel. TG operates having this configuration regarding to power management. The next components related to power supply is the power management of server. We need to manipulate this power supply of server by our TG while the server goes offline or power off.

The details of different mode of the computer is shown in table 2.

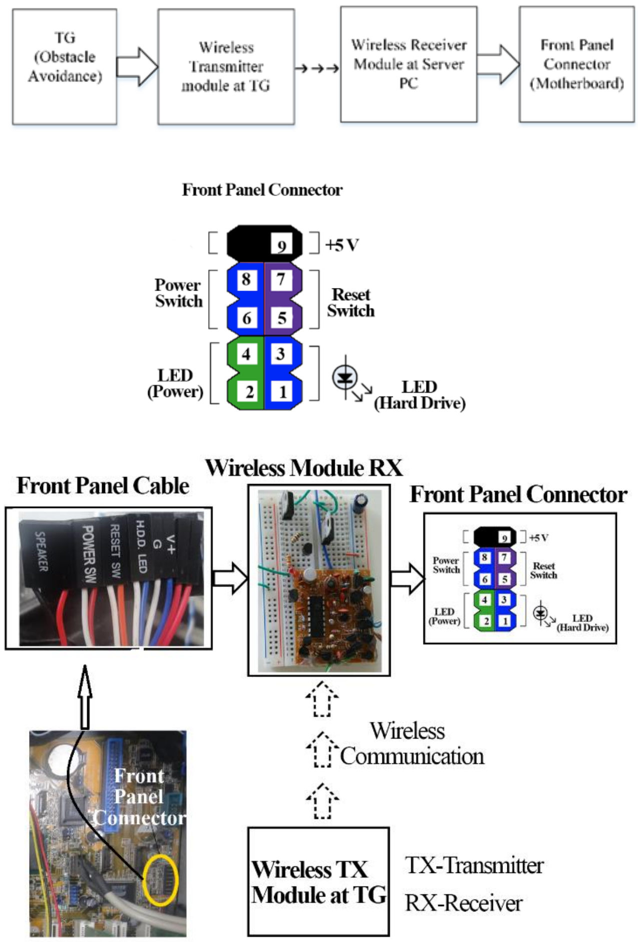

Figure 3: Power Control Scenario

Table 2: Operation mode of the server

s. no	control signal from TG	operation	total no. of high levels	time period (sec)
1		Restart	1	1
2		shutdown*	2	2
3		hibernate*	2	2
4		standby*	2	2
5		power off (instant)	5	5
6		turn on redundant network	4	4
7		turn off redundant network	4	4

The power related array of inputs are shown in the middle part of figure 3. In TG, we have designed wireless transmitter (TX) receiver (RX) module in order to control some basic power control operation in motherboard. As shown in the figure 3, our wireless sensor is responsible to communicate with front panel connectors in motherboard. And thus power controlling operation is conducted by TG. Besides the management of operation mode, we have also designed to activate the Wi-Fi of redundant network the research of which is also done [8],[9] by the authors.
Currently, the TG can activate power offed server to power on. It can shutdown, restart the servers too. It also can change the server to hibernate, standby or shutdown. However, the state of hibernate, shutdown and standby is required to set or defined with timing by the administrator before our TG is brought to the operation.

4.4 Network Management Operation

Though the detail operation of this module is out of scope of this paper, TG is equipped with the capacity to switch on the emergency network while the primary network goes offline due to some unavoidable consequences or while the network cannot be restored. Feature of providing redundant network by utilizing switching capacity of our module can be used for network management operation. Authors are involved in the research of redundant networks[8],[9] by utilizing TG in their other research project. Thus, we think that this module can be utilized for that purpose too.

5. Lab Experiment Setup, Case Studies and System Evaluation

Figure 4 shows the picture of Tensai Gothalo which was designed and developed in our lab. The details components are labeled as shown in the figure. It is equipped with solar panel for the power supply. There are 2 sensors that can sense the obstacle the controlling circuit with H-bridge has been placed on the top of the body. Similarly, experimental setup was designed indoor which is shown in the figure

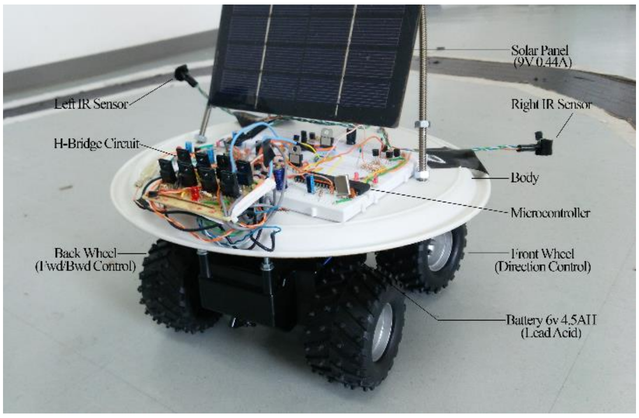

Figure 4: Obstacle Avoidance Tensai Gothalo

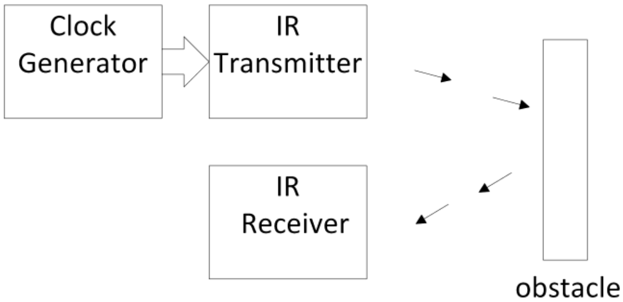

Figure 5: Figure IR TX-RX System in TG the Case 1

5.1 Case studies

5.1.1 Case 1: Usage of 555 Timer

In this case study we use simple IR transmitter and receiver diode pair and implement it on our robotic vehicle. First we generate a 20 kHz signal using 555 timer and then pass this signal to the IR transmitter diode and receive using normal IR detecting diode. Figure 5 shows the basic concept of this case study.
However, we found the following limitations to this implementation:

- White non-metallic objects were detected from maximum distance of 11 cm.
- Where as metallic objects were detected from 11 to 15 cm only at maximum.
- Nontheless, black colored objects were detected only from 3 cm.
- IR receiver is not able to filter sun light and other IR generating sources such as electric lamps, heater and other IR signal generating sources so this system consists of several errors.

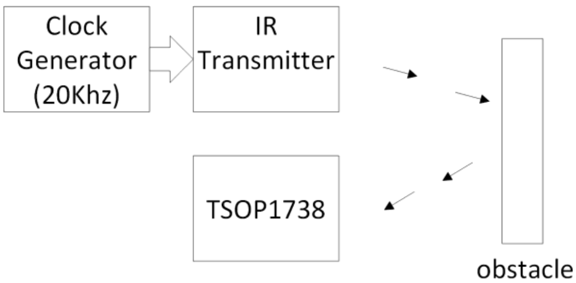

Figure 6: IR TX-RX System in TG Case II

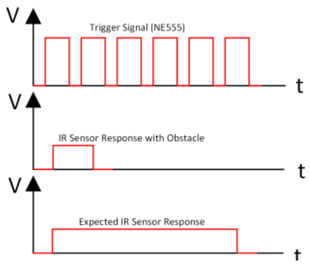

Figure 7: Wave Form

- Sensor show errors and obstacle is not avoided when the robotic vehicle is taken to outdoor environment i.e. exposed
- The obstacle detection time range of vehicle is quite short.This could not captured well in order to give proper control

5.2 Case 1: Usage of TSOP1738

In this case we made a slight change in the circuit of figure 5 and use TSOP1738 (as shown in figure 2) instead as an IR signal receiver.

Primarily a clock signal is generated and passed to an IR led and then we receive the reflected IR signal using TSOP1738. The improvement has been described below:

- IR diode continuously transmit the signal with 38 kHz using 555 timer IC.
- When an obstacle is detected IR sensor at first receives the signal and the signal is continuously transmitted till some period of time for instance 1.5 second or for 2 second. And suddenly that signal fades out i.e. converts zero and hence signal is very hard to captured by IR receiver even if there is obstacle in front of the robotic vehicle.
- In order address this signal fading problem (received from TSOP1738) we are required to changes further in our architecture otherwise it's still quite hard for vehicle to immediately change the path. If decision is not taken reciprocal to the signal vehicle has greater chance of collision with the obstacle then obstacle avoidance and reaching the targeted server is reasonably difficult.

5.2.1 Case 3: Usage of Vcc Generator

In this case we study Tsop1738 as an IR signal receiver with some modification which is shown in figure 8. Here, we generate a clock signal of discontinuous Voltage (Vcc) and give this voltage to next clock generator i.e. 38 KHz signal generator and passes that signal to the IR transmitter led. Modification is shown clearly in the circuit diagram of figure 4.

In this case, while an obstacle is detected signal is reflected back. The received reflected IR signal is detected using

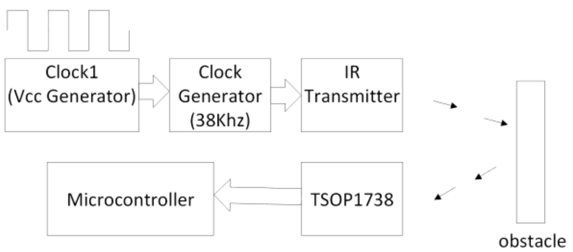

Figure 8: IR TX-RX System in TG Study III

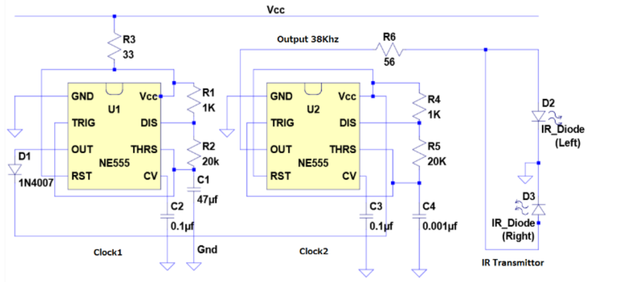

Figure 9: Final Circuit of IR transmitter

TSOP1738 IR receiver. For the enhanced solution of the troubles arising in the network we require faster and precise response from the sensor and hence the detection of the perfect path is possible. So for the instantaneous obstacle detection we use this modification in the circuit. Hence after certain modification in the programming the obstacle detection becomes easier than our earlier case studies.

Mathematical Calculation for clock 1 and its output is shown below.

Calculation for NE555 timer

Fout1(Clock1)=1.4/(R1+2R2)*C1 ………………………..1

= 1.4/ (1+2*20)*47

= 0.7265 Hz

This frequency is used to supply Vcc to clock2 38 KHz frequency generator.

Above solution gives us the perfect solution for TG vehicle to detect the obstacle and reach the target. The output waveform is shown below. The logic behind the longer time duration is that we have been successful to divide the frequency for further so that response from IR sensor are timed with lower frequency at which the DC motor can continuously get the voltage. In fact, the voltage of motor is interrupted however, this interruption has no significant impact to the motor. We wanted this effect to our motor so that it can continue its operation. This kind of tricky scenario was necessary in order to implement workable module in the field. On the basis of this output, we were successful to get the expected output from the TG. Figure 10 shows the wave form on the basis of this logic.

After, analyzing our case studies and obtaining proper result, we implemented our controlling circuit and designed the vehicle as shown in figure 4. Similarly, we setup a random scenario of the obstacles as shown in figure 11. These obstacles have different shapes and sizes. We have done several experiments in order to

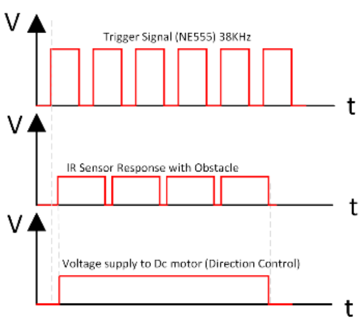

Figure 10: Final Wave form

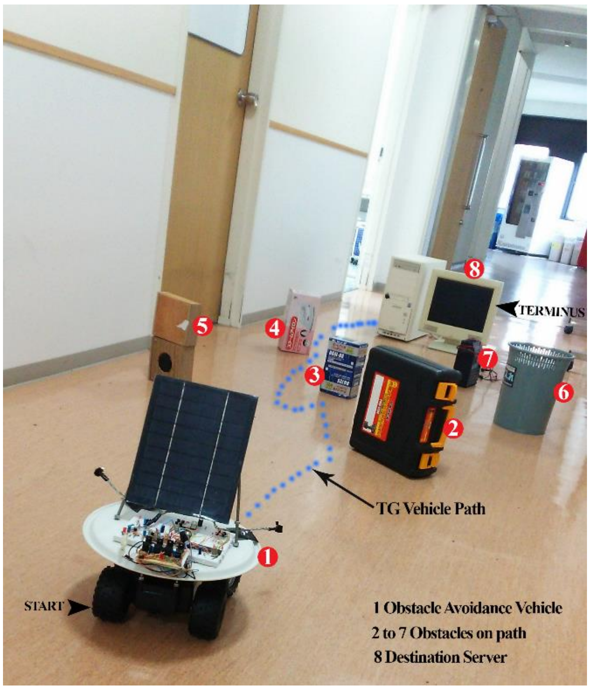

Figure 11: Experimental Setup for Obstacle

test whether the TG can avoid the obstacle or not. In our testing it has successfully avoided the obstacles.

6. Future Works

We have successfully designed and developed obstacle avoidance feature into TG. TG can detect and try to avoid the avoidance in order to forward to the destination. A detailed step wise study has been done using IR sensor in order to rectify the performance of TG. It can avoid obstacle randomly kept in the floor. However, while there are numerous obstacles in the floor, IR sensors faces difficulties to correctly proceed the vehicle. Thus, our future works will further intensify the performance by adding IR sensors. Similarly, we would like to compare the performance of IR sensor with ultra sound sensors for our future work. To summarize, let's list our future work below:

- Increase and optimize the numbers of IR sensors in order to increase obstacle avoidance performance
- Comparative study of obstacle avoidance by IR sensors and ultra sound sensors
- We need to categorize the positions of obstacles after calculating the proper angle between vehicle and the obstacle. The angle of input variable is necessary to properly control the vehicle and thus avoid the obstacle. This feature will be done in our future work

7. Concluding Remarks

The movement of Tensai Gothalo and its four wheels controlled by using DC motors and the inputs obtained from IR sensors. Their outputs our controlling system were the amplified signals received from IR sensor which were well manipulated by using TSOP178 chip. And their input variables were the signals transmitted back from the obstacles

In this paper we have presented a generic obstacle avoidance method implemented by using IR sensor. It enables a given device to follow the path by avoiding the obstacle found along the path. Our experiment ensures that relatively higher accuracy can be brought by using vcc generator, clock generator and by giving feedback from TSOP178 chip to the microcontroller. We are able to keep the signal of IR sensor relatively longer time by upgrading our design. Errors and constraints are kept within satisfactory level after the recodification in the design..

Obstacle avoidance has been a center of research in the field of robotic vehicle. Google has also implemented unmanned vehicle having this feature, however, there are plenty of works to properly proceed the vehicle without having collision in the path.

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