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Glance on maze wanderer robot

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Abstract: Intelligent machines that can perform tasks that they have been programmed to perform are called robots. They have demonstrated importance in reducing the amount of human labour, particularly in industries. Robots are the technological advancement that would undoubtedly make life easier and more convenient. The design, programming, and implementation of a maze-wanderer robot that uses obstacle avoidance to determine its motion direction are the main topics of this paper. The robot's intelligence will be provided by a program. Additionally, the paper will be limited to a motorized vehicle that has been endowed with the intelligence to successfully navigate a specific maze.

1 Introduction

Robots are intelligent machines that can carry out preprogrammed tasks. They have proven important in reducing the amount of work that humans do, particularly in industries. Robots would be the solution if there was one technological development that would undoubtedly make life simpler and more convenient [1].

The manufacturing sector is where robots are most commonly used. Long-term repetitive tasks can cause people to grow bored and weary of their work, which may lead them to start performing their duties against their will. At this point, the individual will not be as productive and efficient as they were at the beginning of their career. Additionally, because humans are naturally tired, there is a limit to how long we can work. The significance of robots becomes apparent at this point. They can be programmed to operate continuously throughout the production process, delivering the same high-quality output. As a consequence, there are more manufactured goods of consistently high quality and fewer products with flaws [2,3].

There are numerous advantages for industries using robotics. As a result of increased productivity, businesses will generate higher profits. Also, because defective products are reduced to nearly zero, the company will lose less money. In all manufacturing sectors, automation and robotics are becoming more and more significant. In many industries, humans can be replaced by robots. When it comes to jobs requiring accuracy, speed, endurance, and dependability, robots perform better than humans. Dangerous and filthy tasks can be safely completed by robots. Robots can process multiple tasks at once and don't require the same environmental comforts as humans [4-6].

Robot lawnmows can be guided by a path in factories that use the same path for repetitive tasks, eliminating the need for a human operator. More advanced path followers can be used to deliver drugs in a hospital and mail inside an office building. Autonomous vehicles that drive on freeways may eventually use the technology, which has been proposed for operating mass transit systems in factories and other industries [7,8].

The capabilities of rescue robots under development include searching, mapping, and reconnaissance; removing debris; delivering supplies, including medical supplies; and even evacuating victims [9,10].

It is clear from the aforementioned applications that robots are a crucial tool for our daily tasks. In order to satisfy the device's constantly increasing demand, engineers have endeavoured to ensure that this instrument is properly designed and implemented, taking into account safety, accuracy and precision, cost, and efficiency.

2 Implementation methodology

2.1 Hardware development

The hardware component needs to be properly designed to guarantee that the operation will function as intended. Determining how to use the H-bridge and sensor to control the DC motors and how to link this circuit to the micro-controller circuit is the primary task. The program code for the microcontroller controls both the microcontroller and the H-bridge. The power supply unit, sensory array module, central processing unit (controller), and drive system, also known as the motor control unit, are the three circuits that make up the main circuit. These circuits are covered in the following sections.

2.1.1 Central processing unit (controller)

An electronic system known as a control unit receives inputs from a variety of sensors that gather environmental data and can operate the output devices in accordance with the conditions imposed by different limitations. A programmable logic device known as a microcontroller makes up the control unit. The microcontroller is a kind of electronic device that can be pre-configured to meet our needs. Various input and output pins on each microcontroller allow for the connection of various I/O devices. Other peripherals of the microcontroller are also integrated into the same chip. Thus, all other peripherals are integrated into a single microprocessor, which is what a microcontroller is. We use a microcontroller as the control unit whenever we need to manage the systems dynamically based on the environment.

2.1.2 Design of the obstacle sensing unit

Using reflected infrared light from its light source, each infrared range sensor calculates the distance to an object. This can be seen in Figure 1. The sensor can measure the angle at which reflected light enters the detector thanks to its electronics. The detector receives light at a sharp angle when the sensor is near an object. The detector receives light at a slight angle when it is far from an object. A variable analogue voltage is produced by the sensor based on the angle at which the reflected light enters the detector. By using this method, the sensor becomes insensitive to both the reflectivity of the object being detected and ambient light, guaranteeing that the output voltage depends only on the distance to the object being detected.

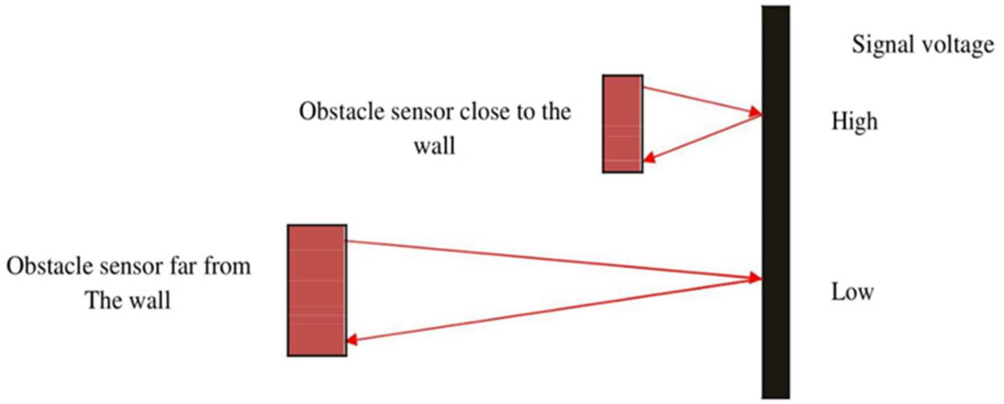

Figure 1 Sensing distance to the obstacle

Two configurations of break beam sensors and reflectance sensors can be used to implement the infrared-based object detector. The second setup will be incorporated into the robot's control system since it is highly appropriate for the robot's portability, which requires both the infrared fradiation (IR) source and the IR detector to be on the robot. The fundamental infrared emitter-detector circuit is depicted in Figure 2.

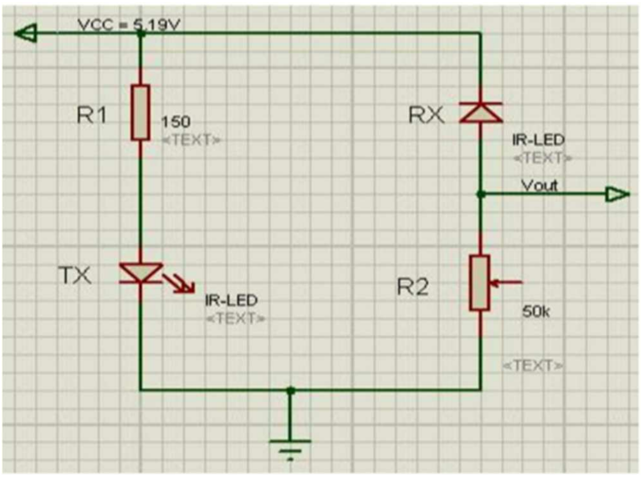

Figure 2 Infrared emitter-detector basic circuit

To stop the light-emitting diode (LED) from melting itself, R1 is set to 220Ω. The robot's sensitivity to the distance between it and the obstacle is determined by the resistance value of R2. For R1 = 220Ω, R2 = 22KΩ, and Vcc = 5.19V, the value of Vout is approximately 2.05V when there is no obstruction in front of the sensor. When an obstruction approaches within 15 cm, the value increases to 3.78V, and when the obstruction approaches within 5 cm, the value saturates to 5.06V.

In a similar manner, six units of the above-designed obstacle detector circuits will be used: two for detecting obstacles on the left wall while moving forward, and two for detecting obstacles in front and turning right if it encounters one. One on the right to tell you when to go forward when you're in reverse, and one on the back to help you turn when you're reversing. The microcontroller to be used only has six pins that can convert analog to digital, so all of the sensor outputs are analogue. Together with the microcontroller that will convert analog to digital, it also handles signal processing.

2.1.3 Design of the control signals processing unit

The control signals processing unit receives input signals from the obstacle detection unit's output signals.

These comprise the remaining six inputs from the circuits used for obstacle detection. As a result, the obstacle detection unit will provide six digital inputs to the control signals processing unit. The first step is to use the microcontroller's analogue to digital conversion feature to transform the analogue input signals into digital signals. The digital signals are then subjected to logical operations; for the obstacle detection circuits, the circuit with the highest value that is, the circuit that receives the highest value because of complete stability is chosen to indicate the robot's direction of motion, and for the obstacle sensors, the values are used to determine whether motion in a particular direction is allowed. Six infrared sensors will be installed on the robot, all of which will be positioned carefully to detect its motion. The sensors are oriented as depicted in Figure 3.

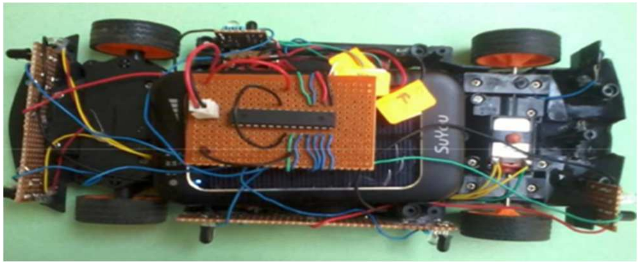

Figure 3 Orientation of the IR infrared sensors

It is anticipated that the robot will use six sensors in total. Given that the different sensors will be providing varying readings at any given moment, this suggests that there will be a variety of combinations.

2.2 Software development

The software's main goal is to always keep control of the hardware and solve the maze to figure out where to go. Reading the sensors, adjusting the motor speed, and interacting with any external peripherals are all part of controlling the hardware.

2.2.1 Algorithm

Finding its way out of the maze is the main objective of a robot. To do this, the robot employs a specific maze-searching algorithm. A great deal of research has already been done and is being done on searching strategies. Because of this, robots typically employ one or more of the three searching algorithms listed below: wall follower, depth first search, and flood fill. This only takes into account the wall follower algorithm.

2.2.2 Wall follower algorithm

Other names for the wall follower, the most well-known maze-navigating rule, are the left-hand rule and the right-hand rule. Keeping one hand in contact with one of the maze's walls will ensure that the robot doesn't get lost and will reach a different exit if the maze is simply connected, meaning that all of its walls are connected to either the outer boundary or each other. If not, the robot will return to the entrance. Another explanation for the effectiveness of wall following is topological. Should the walls be joined, they could be distorted into a circle or loop. Then, wall following becomes nothing more than a full circle walk. The boundaries between the connected parts of the maze walls are exactly the solutions, even if there are multiple solutions, to support this theory.

It is not guaranteed that this method will help achieve the goal if the maze is not simply connected (for example, if the start or endpoints are in the center of the structure or if the pathways cross over and under each other). It is possible to perform wall-following in 3D or higher-dimensional mazes if the higher-dimensional passages can be deterministically projected onto the 2D plane. The current orientation must be known, though, in order to identify which direction is the first on the left or right, unlike in 2D. Figure 4 below depicts a basic maze that was used as the foundation for an example of how the robot would move through it until it reached the exit.

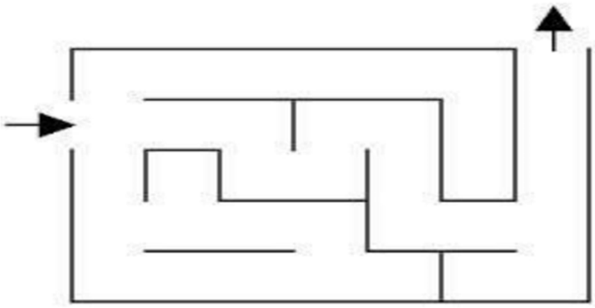

Figure 4 Simple maze for wall follower algorithm

As seen in Figure 5, the final implementation was completed with the entire system, including sensors, the CPU, and the power supply, and then coupled with the radio-controlled toy car below.

Figure 5 Final implementation

2.2.3 Programming environment

Arduino is a single-board microcontroller, intended to make the application of interactive objects or environments more accessible. The hardware consists of an open-source hardware board designed around an 8-bit Atmel AVR microcontroller, or a 32-bit Atmel ARM. Current models feature a USB interface, 6 analogue input pins, as well as 14 digital I/O pins which allow the user to attach various extension boards.

It comes with a simple integrated development environment (IDE) that runs on regular personal computers and allows writing programs for Arduino using C or C++ to the atmega 328 then the chip was transferred to the robot´s board. The Figure 6 and Figure 7 show the Arduino Uno board and the pin mapping for the chip.

Figure 6 Arduino Uno board

Figure 7 Atmega pin mapping

3 Simulation results

3.1 Simulation of the obstacle sensors

To determine whether there was an obstruction in the robot's path, six obstacle sensors were employed. Since each sensor was similar (having roughly the same output voltage for a specific distance from the obstacle), they all responded similarly. The circuit diagram for the robot's obstacle detector is shown in Figure 8.

In the study of the obstacle sensor, given a voltage value (Vcc) of 4.86 volts, a resistance value (R1) of 220 ohms, and another resistance value (R2) of 22 kilo-ohms, the obstacle was displaced linearly along the direction of the sensor. As a result, the distance of the obstacle from the sensor (d) and the sensor's output voltage (Vout) were calculated and tabulated in Table 1.

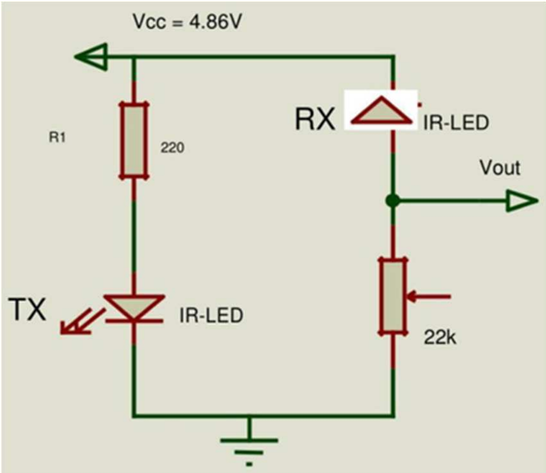

Figure 8 Obstacle detector circuit diagram

Table 1 Results of the obstacle sensors

Number	Distance, d (cm)	Output voltage (volts)
0	No obstacle	1.73
1	35	2.30
2	30	2.41
3	25	2.57
4	20	2.77
5	15	3.03
6	10	3.44
7	5	4.12
8	4	4.35
9	3	4.53
10	2	4.69
11	1	4.70

Figure 9 displays a plot of the obstacle sensor's output voltage in volts against the light source's distance from the sensor in centimetres.

A 1/d^2 variation in both distance and output voltage can be observed from the plot of the obstacle sensor's output voltage in volts against the light source's distance from the sensor in centimeters, where d (cm) is the source's distance from the sensor. Consequently, the output voltage rises as the obstacle's (the robot's path) distance from the sensor decreases.

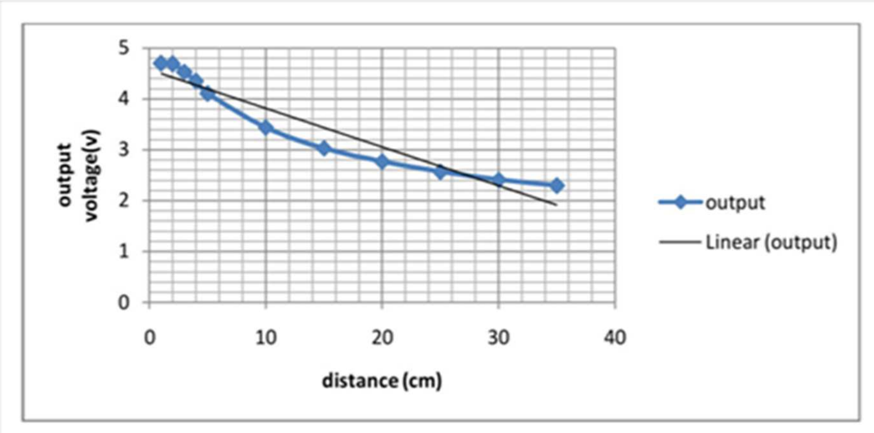

Figure 9 Variation of voltage with distance for obstacle sensors

3.2 Simulation of the signal processing unit

The control signals processing unit receives its inputs from the obstacle detection unit's output signals. These comprise the six digitally-based inputs from the obstacle detectors. This suggests that there are six digital inputs on the control signals processing unit. In the signal processing unit test, every single input signal from every sensor provided specific instructions for the signal processing unit's output. The different possible states of the robot are shown in Table 2 below, along with a suggested control action for each.

Table 2 States of the robot and the corresponding instructions

Number	Sensor	Instruction
1	Left _forward sensor	Move forward
2	Left _reverse sensor	Move forward with a left turn if left _forward sensor is clear.
3	Forward _left sensor	Move forward with a right turn if the left _forward is blocked
4	Forward _right sensor	Move forward with a right turn if it's not clear, else reverse with left turn until it's clear if all other options are not clear
5	Reverse sensor	Move reverse with left turn until forward right is clear.
6	Right _forward sensor	Move forward with right turn if it's clear and front and left not clear.

4 Conclusions

The wall follower algorithm technique was used in this paper to design and implement a maze wanderer robot. The device fulfills a fundamental requirement when designing any high-level robot since controlling a robot's movement is essential for practically all types of robots. Additionally, the wall follower algorithm was found to have accurate control, quick processing, a lower error rate, and above all cost effectiveness when compared to depth first and flood-fill algorithms.

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