An Improved Obstacle-Avoiding and Perpendicular Parking Car Development Using Microcontroller-Based Robotics

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Abstract: This research project aims to alleviate the problems associated with parking by demonstrating with the aid of a miniaturized robot car, how this driving chore in the dimension of perpendicular parking can be relinquished to the car to perform by itself.
The research project employs an 8052 microcontroller-based robotic system in controlling sensors and actuators with strategic planning and coding. One sensor at the front of the miniaturized robot car ensures a wide-ranging obstacle detection and avoidance, while a separate sensor on the left side of the car is used in detecting an appropriate parking spot with a view to performing smooth maneuverings into the space.
The research project unravels the underlying technical principles of the control mechanisms of obstacle avoidance and perpendicular parking in semi and fully autonomous vehicles. A miniaturized robotic vehicle capable of navigating itself autonomously along imitated road paths without colliding with obstacles is implemented. The car is also able to detect a suitable space in a simulated parking lot and turn itself smoothly into it.

Keywords: 8052 microcontroller, obstacle avoidance, perpendicular-parking, robot car.

I. INTRODUCTION

Parking is often a difficult problem in driving. This is especially so for beginners among human driving agents. It can be much more complicated in densely populated areas and tight cities with lots of commercial activities and the attendant high number of cars and very busy roads. The problem usually starts from finding a suitable place to park, which might be tricky from the driver's point of view in tight circumstances. One might have to drive for longer than necessary with a view to finding the right spot. And after the available space might have been located, there is the other problem of maneuvering the vehicle into it, as the spots are often tight. Apart from the mental stress this usually induces in human driving agents, minor collisions, dents, and scratches become inevitable; not to mention the unnecessary fuel consumption and traffic disturbance usually associated with this. These problems would be greatly alleviated if the task of parking were to be relinquished to the cars themselves to perform automatically.

Significant advancements have been made in recent times in vehicle automation. Mechanisms that were hitherto solely based on mechanical principles are now being automated, with a view to making driving easier and safer among other benefits. We have seen innovations bordering on Advanced Driver-Assist Systems such as Automatic Cruise Control, Lane Keeping System, Intelligent Parking Assist System, to mention but a few, in the world of driving recently.

Vehicle automation, autonomy and connectivity are mechanisms of mechatronics bordering on a good number of engineering disciplines including electrical, mechanical, control and computer engineering. Its advent is fast revolutionizing the field of automobile engineering and road transportation [1].

The world is inching closer to the level of full self-driving automation whereby the robot car without human inputs embarks on a trip itself and monitors the route it plies safely with the aid of highly sophisticated sensors providing real-time information on the happenings in the environment. The vehicles are imbued with the ability to update their maps based on percepts received, helping them to be cognizant of their position even when conditions change or when they venture into uncharted road environments [2].

II. RELATED WORKS

Automatic Parking Vehicle System – Liao, Yeh & Chen, 2016

In this project, an RC (remote-controlled) toy car is modified by integrating ultrasound sensors and Arduino with a high current shield to control the vehicle movements and the parking processes. Parking strategies and the corresponding algorithms are explored and programmed through Arduino. During testing, the car is able to move to detect the imitated "roadside" environment, judge a space suitable for parking or not, and then drive to park automatically. The project is focused on achieving the single task of automatic parallel parking by integration of sensors and actuators controlled by microcontroller and strategy planning/coding.

Obstacle-Avoiding Robot – Tabassum, Lopa, Tarek &Ferdosi, 2017

This project is designed to detect obstacles in its path and maneuver around them without making any collision. It employs an Arduino microcontroller and three ultrasonic distance sensors to detect obstacles. The Arduino board was selected as the microcontroller platform and its software counterpart, Arduino Software, was used to carry out the programming. The three ultrasonic distance sensors enhance the horizontal range of searching obstacles. They work in combination to measure distance to the surrounding objects and detect the presence of obstacles if they are within the threshold distance [3].

Line Follower and Obstacle Avoiding Bot Using Arduino – Attar, Ansari, Desai, Khan & Sonawale, 2017

This project combines two robotic functions of "line following" and "obstacle avoidance", using an IR sensor and ultrasonic sensor respectively. The IR sensor is meant to trace a particular line and ultrasonic sensors are meant to detect obstacles which it encounters. It employs an Arduino UNO R3 as its base, which is a microcontroller board based on the ATmega328 (data sheet). When any obstacle is encountered by the robot, it stops automatically and Bluetooth module HC-06 is activated and user can then control the robot manually [4].

An Autonomous Self-Propelled Robot Designed for Obstacle Avoidance and Fire Fighting – Prathyusha & Suman, 2016

The project is executed to achieve obstacle avoidance and detect fire, sprinkle water along with the buzzer indicator. It employs an AT89S52 microcontroller as the control system, using an ultrasonic sensor and temperature sensor for obstacle avoidance and fire detection respectively. When fire is detected as the robot moves forward, the temperature sensor detects heat and sends data to the microcontroller, which in turn sends signals to the buzzer to sound an alarm, and the sprinkler for water to be released to put out the fire [5].

Self-Parking Car – Ni & Hsiue, 2012

This project is designed to implement the underlying working principles of automatic parallel parking using a four-wheel drive miniature vehicle. The car uses four infrared sensors to provide "eyes" which will feed data about surrounding environment to an on-board FPGA that will control its motors, using a finite state machine. The project demonstrates the ability of an FPGA to a very precise control system

to navigate a vehicle into a desired position. The finite state machine (FSM) is divided into ten states, each of which correlates to a step that is taken in parallel parking performed by human drivers [6].

III. PECULIARITY OF THIS PROJECT

As can be seen from the preceding review, none of the projects executes the two control functions that this particular undertaking has set out as its objectives. While some implemented automatic parallel parking, some others implemented obstacle avoidance. But this project proposes a design and implementation of two control functions of automatic perpendicular parking and obstacle avoidance.

IV. PROPOSED ROBOTIC SYSTEM

The research project with a view to achieving its aim and objectives will employ a microcontroller-based wheeled robot system with multiple sensors and actuators. The system takes in percepts about the surrounding environment with the aid of sensors; and generates forward, backward, left, and right motion with the aid of motors. The robotic vehicle is imbued with the capacity of operating in two modes. Based on the strategic programming of the microcontroller, the wheeled robot avoids obstacles detected in its path when in obstacle-avoiding mode; and senses a suitable parking spot before maneuvering itself into it when in perpendicular parking mode. The mode selection is achieved with the aid of a Bluetooth module as part of the system and wirelessly controlled from a smart phone.

V. SYSTEM'S BLOCK AND CIRCUIT DIAGRAMS

A diagrammatic overview of the main units that constitute the robotic system is explicitly provided below.

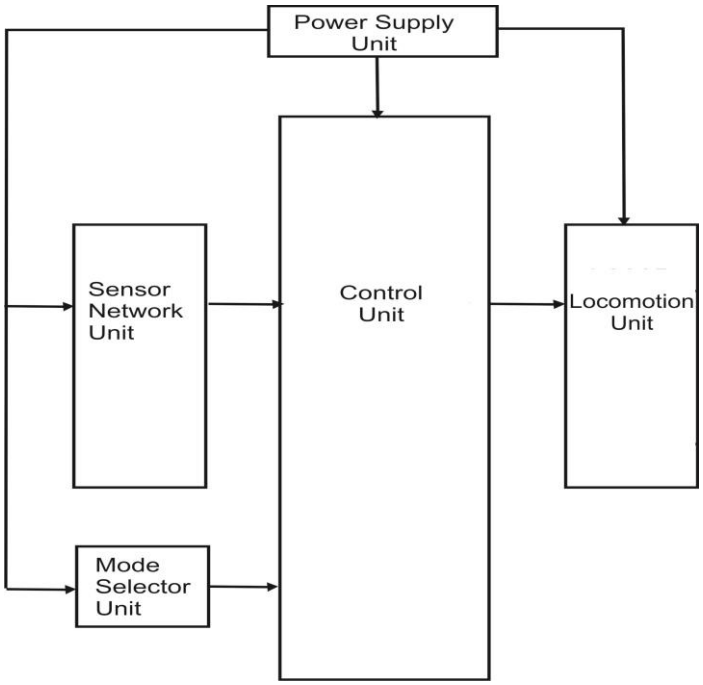

Figure 1: A block diagrammatic overview of the system's major units.

The robotic vehicle system is powered by two 9V batteries, and these primarily constitute the Power Supply Unit. The Locomotion Unit is mainly made up of a ULN2003A IC, a stepper motor, and a servomotor. The array of seven NPN Darlington transistors is used in driving the stepper motor which

is used in generating the miniaturized robot car's linear motion, as current from the microcontroller can't sufficiently achieve this. Two HC-SR04 ultrasonic sensors constitute the Sensor Network Unit. One is strategically placed at the front of the robotic vehicle for the obstacle avoidance function, while another is placed on the left side for the perpendicular-parking mechanism. The Mode Selector Unit comprises a Bluetooth module HC-06 as part of the system and a smart phone. The Control Unit of the entire system is an 8052 microcontroller.

The overall system's circuit diagram with the underlying schematics is comprehensively provided below.

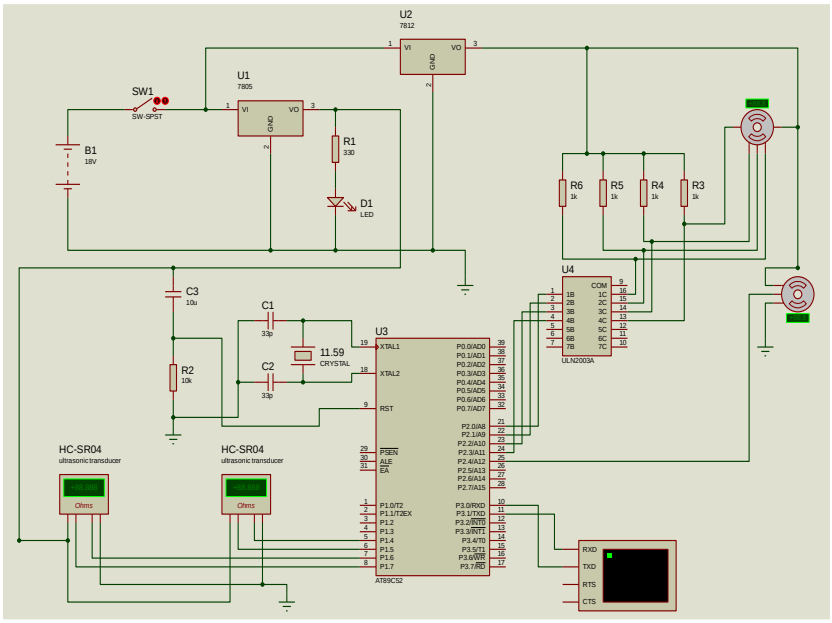

Figure 2: Circuit diagram of the complete robotic system.

VI. RESULT/MECHANISM OF OPERATION

Depending on the mode selected on the graphical user interface installed on the smart phone platform as part of the system's Mode Selector Unit, a signal is sent to the Bluetooth module HC-05 embedded in the internal circuitry of the system, and then the miniaturized robot car operates in either the obstacle-avoiding or perpendicular-parking mode. The robotic vehicle employs two ultrasonic sensors in detecting obstacles in its course, as well as the "cars" in the simulated park. These transducers send signals based on their perception to the microcontroller. The microcontroller in turn issues signals to the actuators in the Locomotion Unit, thus engendering motion in the right direction. The stepper motor is primarily used for the forward and backward movements of the car, while the servomotor is mainly used in generating the torque to turn the car left or right. Both are connected to the front wheel of the miniaturized robot car which employs a front-wheeled tricycle model.

When in the obstacle-avoiding mode, the mechanism initiated is presented below in an algorithmic flowchart diagram.

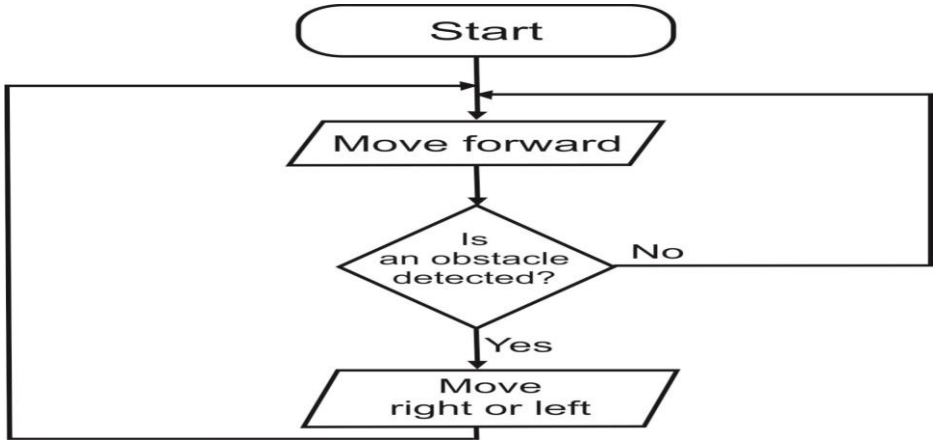

Figure 3: Algorithmic flowchart of system's obstacle-avoiding mode.

And when the perpendicular-parking mode is selected as the miniaturized robot car is placed in a simulated parking lot, the mechanism initiated is presented below in an algorithmic flowchart diagram.

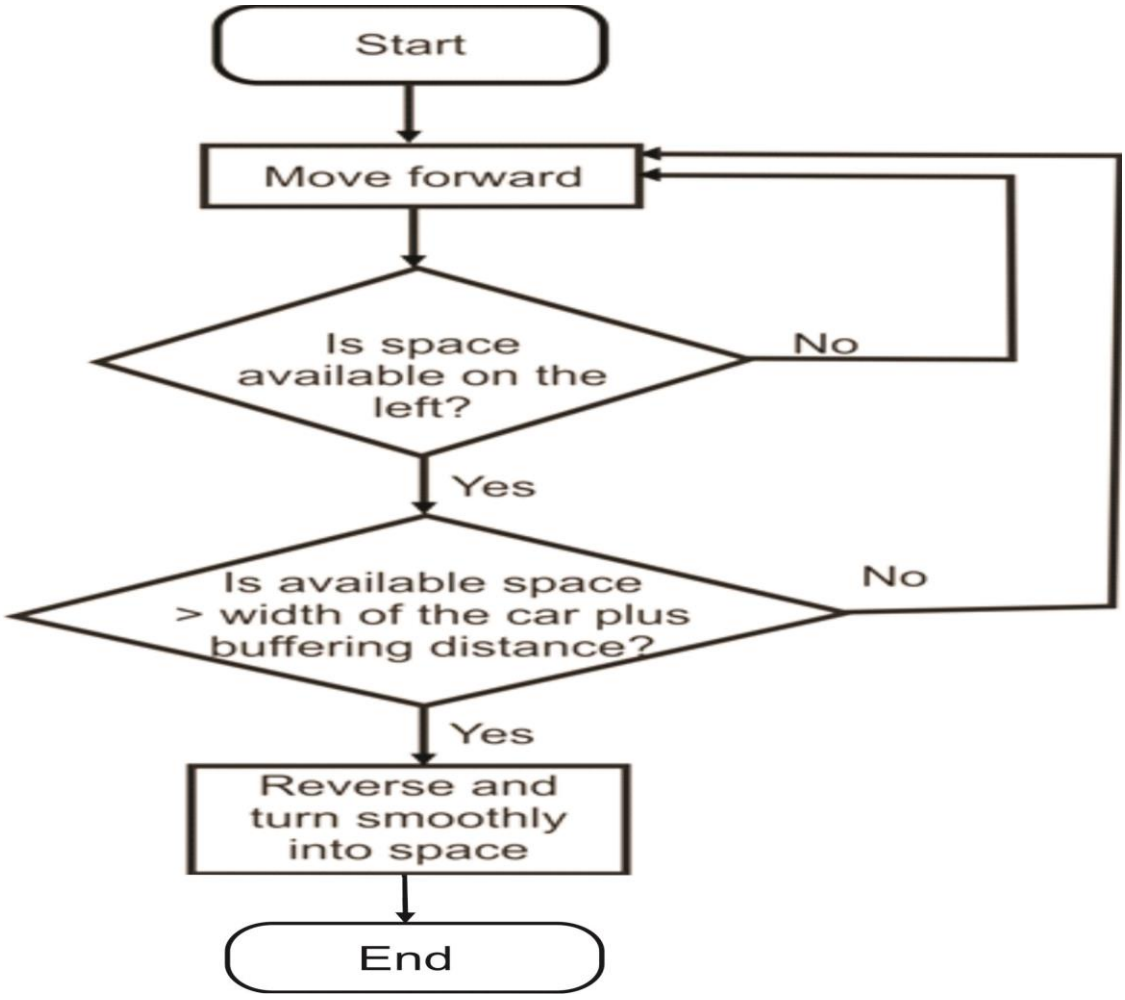

Figure 4: Algorithmic flowchart of system's perpendicular-parking mode.

The robot chassis fabricated using plywood is presented below.

Figure 5: Side view of the robot car.

VI1. CONCLUSION/RECOMMENDATION

This research project was implemented with a view to demonstrating how the conventional driving shore of parking can be automated in semi-autonomous and fully self-driving vehicles. Because of the constraints of knowledge and resources, the simple mode of left-in perpendicular parking was implemented. The project employed a robotic system that incorporated multiple sensors and actuators in exhibiting the control mechanism. An assembly language-programmed 8052 microcontroller is the system's control unit. The execution process was pretty challenging as technical inhibitions which were not envisaged were thrown up, they were however addressed and the project was ultimately successful.

The field of vehicle automation and autonomy is fast evolving. Academic and technological researches are ongoing with a view to having more driving functions relinquished to the car. In the context of parking alone, the world of driving has witnessed interesting developments in recent times. The most researched mode of parking is actually the automatic parallel parking. It is so because the mechanism is often more difficult to conventionally carry out by human drivers than the other modes. Therefore its automation somewhat solves a bigger problem than the perpendicular parking mechanism. It would have been preferred as the subject of this research but due to the limitation of resources, automatic perpendicular parking was chosen instead. A miniaturized robotic concept may be implemented in the future, exhibiting these two modes of parking, thereby improving on what currently obtains.

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