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Grid Based Robot Navigation System for Automated Car Parking and Retrieval

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ABSTRACT: In urban areas, there is shortage of parking spaces due to the increased dependence of people over personal vehicles as a means of transportation. The currently available public parking services do not facilitate parking by displaying available parking slots, as a guide, to the car driver. Large amount of time is wasted in searching the parking slot. This issue is addressed with the introduction of a new guiding system which includes a user application, an array of sensors, and navigation software. A payment mechanism along with the option to retrieve the car is also included in the user application.

KEYWORDS: robot; navigation; guidance; grid-based maps; ultrasonic sensors; IR sensors.

I. INTRODUCTION

There has been a tremendous increase in the number of vehicles plying on the roads due to the increased income of urban population. With poor urban planning, there is shortage of space for parking the vehicles which is a major problem. Lack of mechanism to inform the driver about the available parking slot in the public parking service has lead to such a problem. Car equipped with tools to be parked itself is included in the proposed system.

Detection of the path and the obstacles lying in the path in the guiding software come under the tools. From the list of available parking slots, the owner can select one through the application and also pay for the service provided with the help of application along with an option to retrieve the car. Thus the overall operational time required to park the car is reduced.[9]

II. RELATED WORK

All the previous research in the field of grid based robot navigation involved different techniques to map the indoor environment before letting the robot to navigate. This paper [3] is an implementation for indoor environments wherein a laser range finder based localization algorithm is used for map based robot navigation. A list of vertices is used to represent the sequence of grids and global map information for a navigation path .In order to globally localize the mobile robot a matched pattern is found between the set of vertices from the map and the set of vertices from range of data. [3]

HCTNav algorithm, A* and Dijkstra's algorithms are implemented on grid-based maps and then their obtained path lengths are compared. These three algorithms are well known for path finding on graph, but can also be adopted grid maps. The three algorithms have been implemented in a straight line until finds obstacle using ANSI – C language, and are optimized for low resource systems, especially low memory ones, so that they can be used in low cost robots. Experimental results demonstrate that HCTNav has a good potential for solving path planning in embedded systems with less computation resources, especially the memory. Hence, HCTNav can be a considered a good alternative for navigation in low cost robots. [4]

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The paper [5] involves a novel, sensor-based, biologically inspired, neural network algorithm, proposed for real-time, collision-free navigation, and mapping of an autonomous mobile robot in an unknown environment. One of the major challenges in intelligent robot systems is real-time navigation and mapping of an autonomous robot. With the equipped sensors, the robot can compute only a limited range of surroundings even with grid map representation. The optimal real-time robot path is computed through the dynamic activity landscape of the neural network without any prior knowledge of the environment, and without any learning procedures. Therefore, it is computationally efficient.

The paper [1] includes, grid made up of black lines over a white surface, used to navigate the robot as a line following robot to reach its destination. This kind of robot should sense the line with its LED-LDR sensors that have been installed under the robot. Then, specific transition buses transmit the data to the processor. The processor then decides the appropriate commands and sends them to the driver, which will then be interpreted and followed by the line follower robot. The robot traverses entire grid in a defined manner until it detects any object in its way and if it detects any object, it goes to the start location via a shortest path from that location. Ultimately the robot will search the object in the grid, pick that object and bring to destination position in minimum time.

Indoor autonomous navigation of a mobile robot is being implemented. There have been many researches on autonomous navigation system and many of them have been implemented for practical use. These algorithms are not easily accessible to users for practical usage. Sometimes, it is difficult for user to adapt algorithm components for navigation implementation. For example, though there are many algorithms available for obstacle avoidance, it is not easy to incorporate all the algorithms into navigation system software for practical implementation. This research includes one of the successful implementations of the indoor navigation which is practically feasible in the respect that it combines various aspects of robot navigation in a coherent manner. [2]

III. PROPOSED SYSTEM

To resolve the problems of existing systems, we propose a new approach, that is, "**Grid Based Robot Navigation for Parking System**". The proposed system will solve the problems related to traditional parking system. This project work is implementation of Automatic car parking system which comprises of Arduino ATMega Microcontroller, IR sensors, Ultrasonic sensors Wi-Fi module, Desktop & Mobile Applications. This system aims to ease the parking process, by letting the driver choose the parking slot and letting the car park itself. [6]

- The sensor unit, placed on the car is used for detecting the grid map and obstacles in the path.
- Arduino board consists of a microcontroller which receives the information from sensor unit. It also communicates with the Mobile application through Wi-Fi module.
- The Microcontroller controls all the components of the robot. The power supply is used to provide DC voltage to the components on the board. The computer runs the system application which provides the interface to the user.

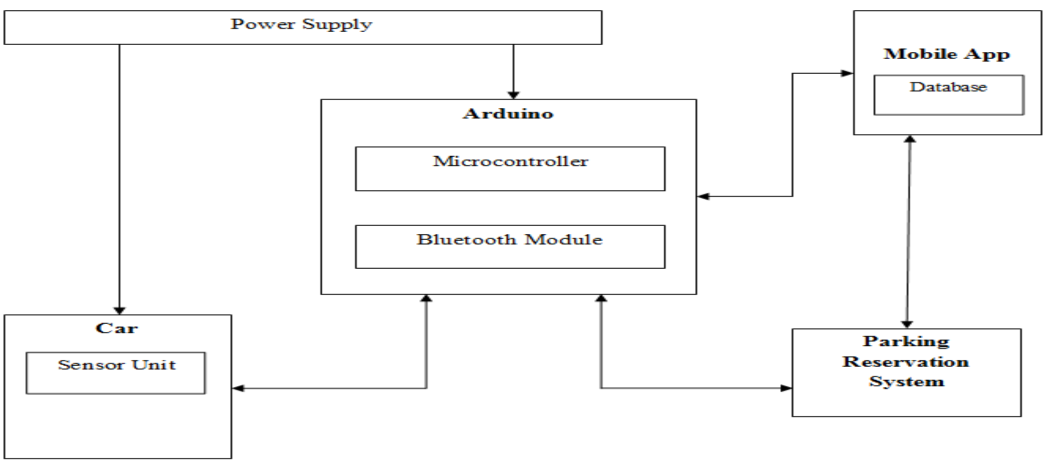

Figure No. 1: System Block Diagram

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IV. Pseudo Code

Step 1: Start
Step 2: Declare the instance variables which are global variables.
Step 3: if slot 1 or slot 2 is selected then set Global variables final_x & final_y to corresponding grid co-ordinates.
Step 4: if Car-Park selected, check the condition "while curr_x!= final_x || curr_y!= final_y"
If Retrieve selected: Go to step 10.
Step 5: ytraversal():
Until robot reaches final_y co-ordinate, set previous_x to current_x and previous_y to current_y. Afterwards perform lineFollow() function.
if obstacle detected: perform moveBackward() function till previous node and then moveRight(). Go to step 7.
if obstacle is NOT DETECTED: lineFollow().
if node detected: Increment current_y.
Step 6: Check "if current_x!=final_x" then moveRight().
Step 7: xtraversal():
Until robot reaches final_x co-ordinates, set previous_x to current_x and set previous_y to current_y then lineFollow() function.
if obstacle detected: execute moveBackward() function till previous node and then moveLeft(). Go to step 5.
if obstacle NOT DETECTED: lineFollow().
if node detected: then increment current_x.
Step 8: Check "if current_y!=final_y" then moveLeft(). Go to step 5.
Step 9: slotDirection():
If robot reaches final_x and final_y, then set direction of robot according to comparison of previous_x with current_x & previous_y with current_y.
Step 10: Read left and right sensor, then moveBackward() till previous node. Then moveLeft()
Step 11: Check the condition "while curr_x!= final_x || curr_y!= final_y"
Step 12: xtraversalRet():
Until robot reaches initial y co-ordinate, Set previous_x to current_x and set previous_y to current_y then folloLine().
If obstacle DETECTED: execute moveBackward() function till previous node and then moveLeft(). Go to step 14.
If obstacle NOT DETECTED: lineFollow().
If node DETECTED: then decrement current_x.
Step 13: Check "if current_x!=0" then moveRight().
Step 14: ytraversalRet():
Until robot reaches initial y co-ordinate, Set previous_x to current_x and previous_y to current_y then lineFollow();
If obstacle DETECTED: execute moveBackward() function till previous node and then moveRight(). Go to step 12.
If obstacle NOT DETECTED : lineFollow().
If node DETECTED: Decrement y
Step 15: Check "if current_x!=0" then moveRight(). Go to step 14.
Step 16: exitDirection():
If robot reaches initial_x and initial_y, then set direction of robot according to comparison of previous_x with current_y and previous_y with current_y.
Step 17: Stop.

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V. RESULTS

We have developed a Desktop application and a Mobile application for the proposed system. In mobile application, upon successful login by the user, the user will be presented with the screen in which user will be allowed to select between 'Park' and 'Retrieve' option.

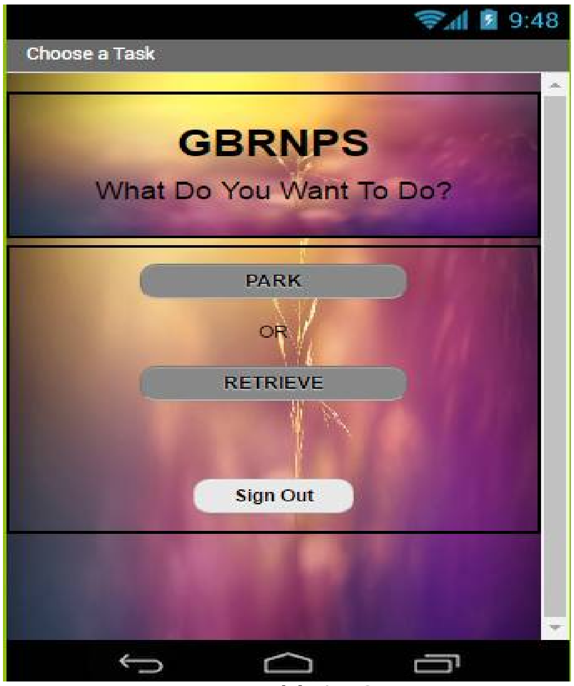

Figure No. 2: Mobile App Screen 1

After selecting the 'Park' option, the user will be allowed to choose the available parking slot amongst the two slots.

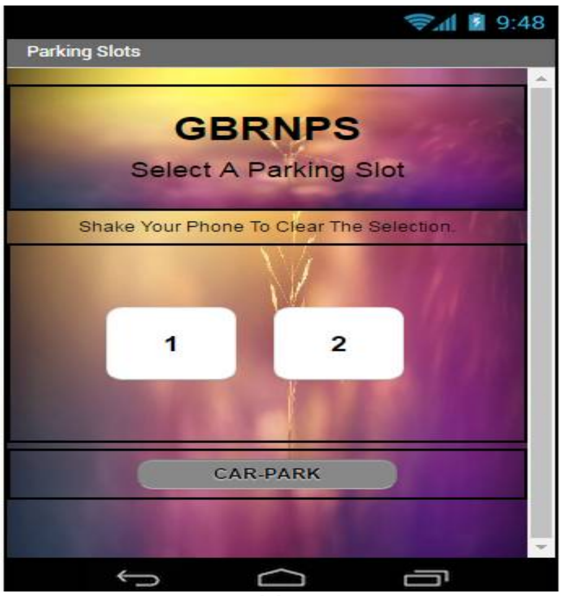

Figure No. 3: Mobile App Screen 2

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If the user selects the 'Retrieve' option, a screen will be displayed, asking the user to enter his/her card details. After entering the details, the user can click on the 'Pay' button to pay the amount and successfully retrieve the car.

Figure No. 4: Mobile App Screen 3

The figure below shows the car navigating over the grid. The car uses the line follower principle to navigate over the grid using the IR sensor array to detect black surface and to align the car's path on it.

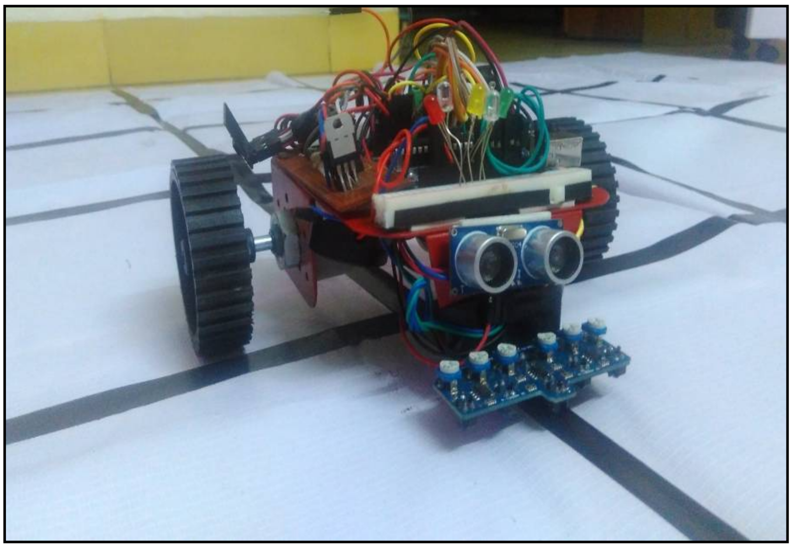
Figure No. 4: Robot Car on a Grid

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In Desktop Application, upon successful login, the manager will be presented with a screen in which manager will be allowed to select between the displayed options.

Figure No. 6: Desktop Application Screen 1

After selecting the 'Parking Slot Status' option, a screen will be displayed in which the manager will be able to see the available parking slot amongst the two slots.

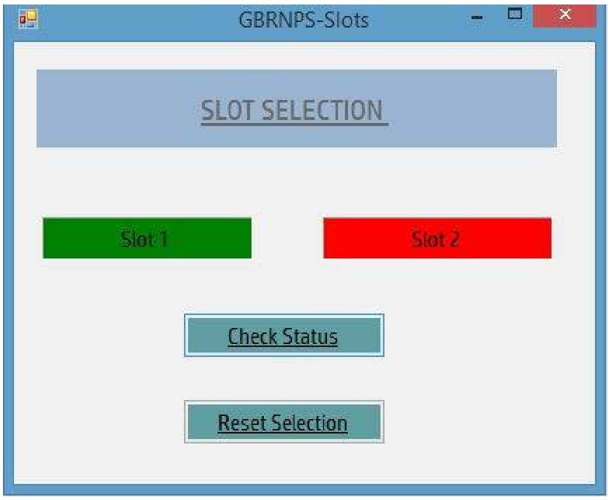

Figure No. 7: Desktop Application Screen 2

VI. Conclusion and Future Work

The simulation results showed that the proposed algorithm will ensure that the car is automatically parked in the parking slot without the help of the user. It will also enable the user to select his own parking spot and system will park the car by tracing the path and detecting the obstacles. Accordingly, the user will be notified whether the car is parked. The payment system determines the cost as per the duration and displays the final amount to the user and the payment is accepted. The car can be easily retrieved. Thus, parking hassles of the car drivers in populated cities will be reduced considerably by this system. This work can be taken far ahead using multilevel parking where many cars can be parked

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using at a multi-level parking system. The whole system can be taken on the cloud where all the data is stored at cloud level.

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