INNOVATION IN CLEANING TECHNOLOGY: THE AUTONOMOUS FLOOR CLEANING ROBOT

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An automatic cleaner robot is used for cleaning a room or area with minimal human intervention. Such a robot will execute tasks like vacuuming and mopping to keep the room clean. A path planning algorithm is executed for the robot to find out the layout of the room or area by itself. An ultrasonic sensor helps in detecting obstacles and deciding an alternate path of operation. This autonomous vacuum cleaning robot, which designs the best course of action independently using the path planning algorithm helps in keeping the room clean with minimal human effort.

KEYWORDS: path planning algorithm ,autonomous vacuum cleaning ,obstacle detection.

1. INTRODUCTION

One of the most tedious and laborious chores in today's world is the cleaning of rooms and floors. In today's social condition, with almost everyone busy with their daily routine, no one has enough time to spend on cleaning. Robotic cleaners are being widely used to overcome this problem. Robot cleaners help in cleaning the room with minimum human effort. Home appliance robotics is one of the major areas in which researches are done in robotics. Different robotic systems use different methods to achieve their goal of keeping the room clean. Some of these cleaners are controlled by using a smart phone or a remote control while some are more autonomous and find their own path around the room. The latter ones are more autonomous and require nominal human intervention. So these are preferred over the former ones. Since different areas need different types of cleaning methods, these robots have many cleaning tools attached to them for the proper treatment of the floor to obtain maximum hygiene. Cleaning tools like buffers, scrubbers, mops, extractors and vacuum tubes are used by these robots to keep the room clean.

The robotic cleaners help in cleaning the room by vacuuming, mopping, sweeping, etc. There are a number of such robotic cleaners available in the market today. iRobot, EUFY Robovac, Dyson, etc. are examples of such cleaners available in the market today. These cleaners are not perfectly autonomous and require human assistance on a frequent basis. These robots however do not have effective mechanisms to avoid obstacles in their path and arrange their path accordingly. It will be very difficult for them, while encountering obstacles on their way, to find an alternative course of action. These cleaners may require human assistance to change their direction away from the obstacles on their path. So it is not really much helpful to the working class community as they may need to control the robot's actions occasionally.

In this paper we aim to find a solution to this problem by developing a completely autonomous robotic cleaner. This system uses a path planning algorithm to alter its path on encountering obstacles. Ultrasonic sensor is used in the robot to sense and detect the obstacles hindering its course of action. The sensors generate binary information regarding the properties of the obstacle which is then processed by a path planning algorithm. SLAM (Simultaneous Localization And Mapping) algorithm is the path planning algorithm used here [5] . The algorithm also helps in the navigation of the robot. This robot performs cleaning functions like mopping, vacuuming and sweeping the floor. The robotic system can also be manually controlled by using a smart phone and an android app. The robot is aimed to be cost effective and less noisy. The system is also lightweight compared to the other bulkier cleaners available in the market. The paper is concluded by analyzing the performance of the robot.

2. LITERATURE REVIEW

With almost all the households getting automated, domestic robots are becoming a household name. This change in trend causes researches in the domestic robot field to increase exponentially. The field of domestic robots range from home assistants to room cleaning robots to robots assisting sick people.

The most popular form of autonomous robotic vacuum cleaners is the Roomba [5] , which uses basic sensors to allow it to change directions, detect dirty areas, and sense stairs. While easy to operate and able to clean a room thoroughly, the Roomba has been seen to have a number of limitations. A bumper around the robot is used to bump into objects and walls, protecting the robot's interior from collision damage. However, this still introduces some force of impact on the robot. The pattern of cleaning carried out by the Roomba relies on simple algorithms, such as spiraling out while cleaning, or by changing its direction to continue cleaning after bumping into an object. While simple, this proves to be a time inefficient method of cleaning a room.

This project aimed to improve these limitations by introducing path logic of the robot's movement, along with collision detection and avoidance, resulting in the entire room being cleaned in the shortest amount of time possible. This was to be done using SLAM – Simultaneous Localization and Mapping, the concept of using a mobile robot to build a map of the unknown environment [2] , while using the generated map to navigate the environment at the same time.

3. BLOCK DIAGRAM

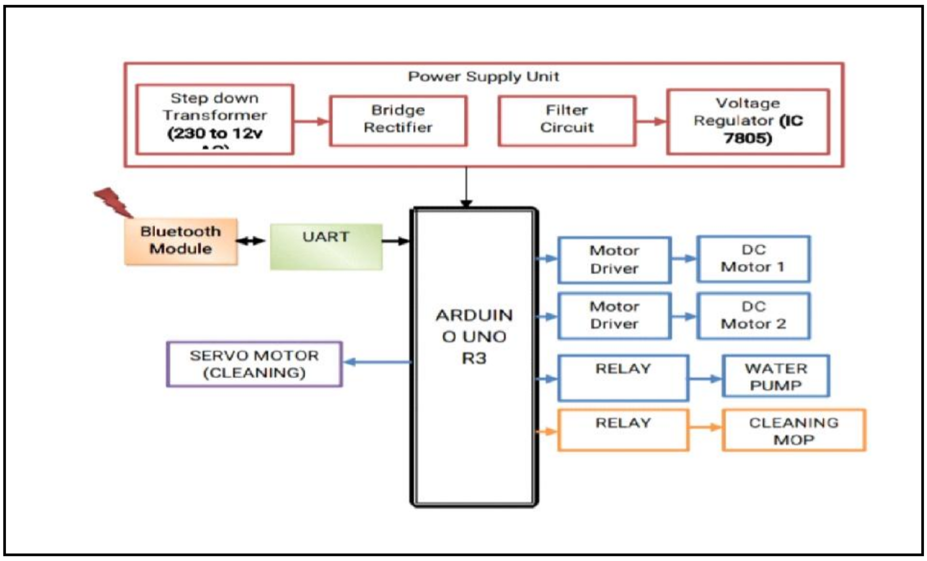

Fig.1 Block Diagram

This cleaner system performs cleaning functions like mopping and vacuuming. It has three ultrasonic sensors on three sides (front, right, left) to avoid hitting obstacles on its way. An Arduino UNO processes the signals from the sensors and controls the motors likewise [4] . There are four dc motors present to guide the robot and two motor driver ICs are used to control the rotation of these motors. Servo motors are used to provide necessary rotational motion to the cleaning discs. Cleaning discs are present on the front side of the robot for the purpose of mopping using cleaning agents. Rollers are used to dry the floor after mopping it. The robot system has an additional bluetooth module attached to it in the case of a failure of the SLAM navigation system [3].

4. COMPONENTS

4.1 Arduino UNO

Arduino is an open source platform which is based on user friendly hardware and software. The microcontroller board, Arduino UNO is based on the ATmega328p. It is an 8 bit microcontroller with 32kb flash memory. The Arduino UNO also has an advanced RISC architecture. The Arduino UNO has 14 digital input/output pins of which 6 pins are used to obtain PWM output. It also has an additional 6 analog pins. It also has high endurance of non-volatile memory segments.

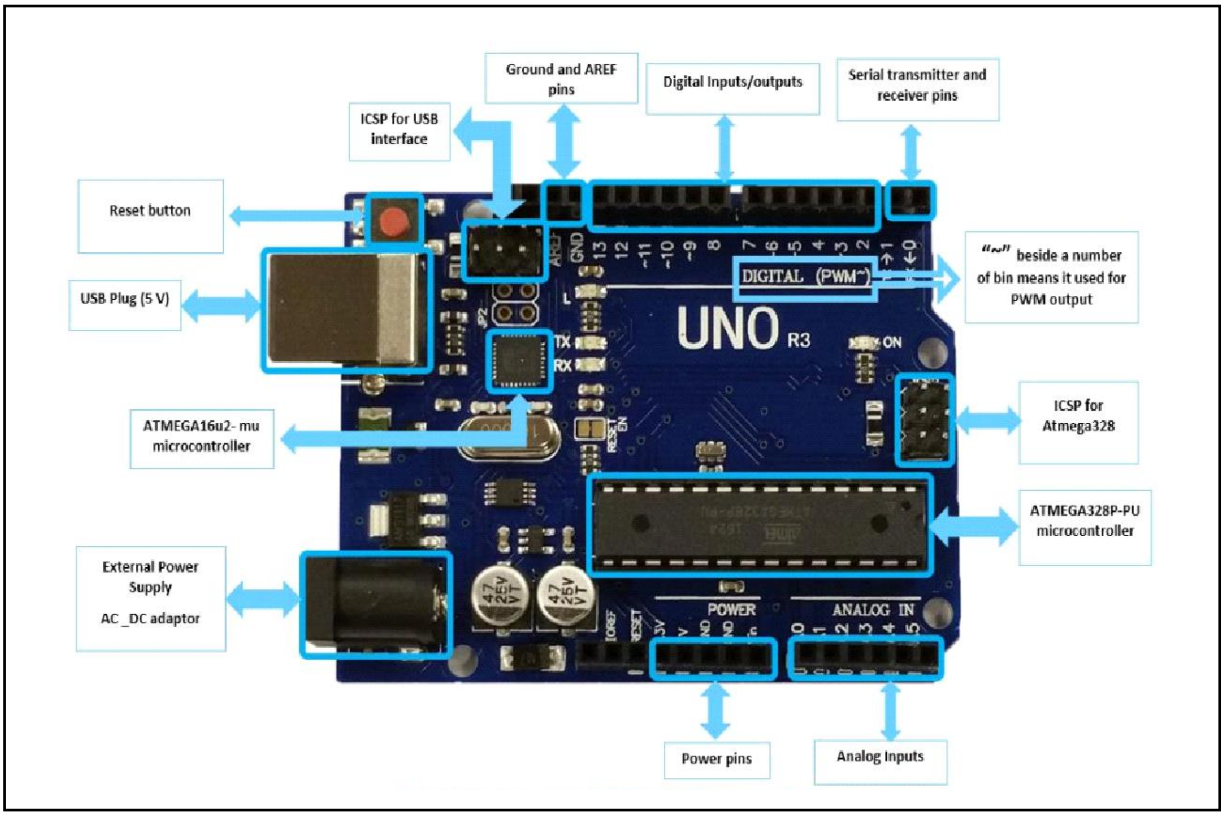

Fig.2 Arduino UNO R3

4.2 Bluetooth Module

The bluetooth module used here is HC-05, which is an easy to use bluetooth serial port protocol module. This module has operating voltages ranging from 4V to 6V. It also has an operating current of 30mA. The module has an operating frequency of 2.41GHz and uses Frequency Hopping Spread Spectrum. It can be easily connected with laptops and mobile phones via bluetooth. The UART and USB are most popular host controller interfaces for this HC-05 module.

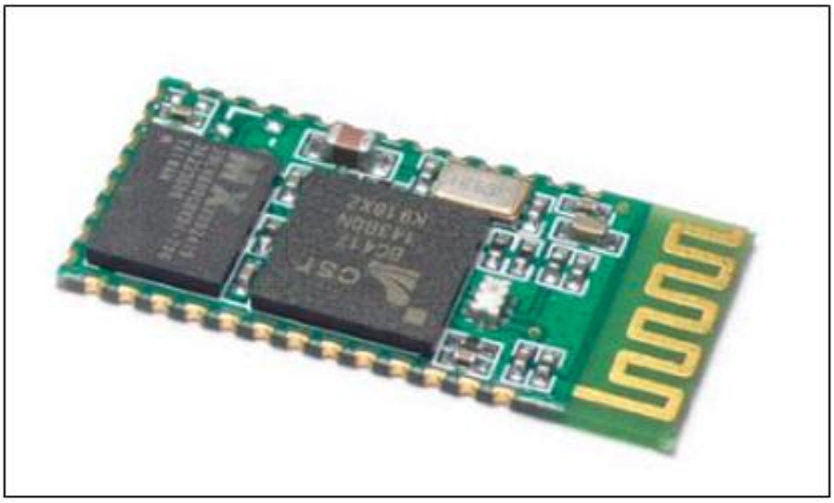

Fig.3 HC-05 Module

4.3 Motor Drive IC

L293D is the motor drive IC used here, which contains a dual H-bridge driver circuit. These motor drivers take low current control signal as input and provides a high current control signal as output, hence it acts as a current amplifier. The motors are then driven by this high current control signal. Two motors can be controlled by this driver simultaneously in its common mode of operation. The direction (forward and backward) of rotation of the motors can also be controlled simultaneously.

Fig.4 L293D

4.4 Ultrasonic Sensors

The ultrasonic sensor used here is HC SR04 ultrasonic ranging module. This module has a theoretical non contact measurement of 2cm to 400cm. It also has the ranging accuracy of 3mm. It has an operating voltage of +5V and an operating current less than 15mA. The operating frequency of this module is about 40Hz. An HC SR04 consists of a transmitter, receiver and a control circuit.

Fig.5 HC SR04

4.5 Servo Motor

The servo motor used here is SG90 9G servo motors. They are small in size and has lightweight. They also provide high output power. The motor can rotate in 180 degree with 90 degree in each direction. The servo motors generally have high speed response due to low inertia. The servo motor SG90 9G has a torque of 4.8V:25.00 oz- in (1.80 kg-cm).

Fig.6 SG90 9G Servo Motor

5. MOTION INTEGRATION

Two methods of traversing the platform were considered for the robot's movement; a square zigzag across the platform, or a spiral inwards to the centre. Both methods were to conduct an initial scan to identify the walls of the room and areas in which obstacles may be in. From this scan, the robot finds the closest wall detected and aligns itself to this wall. It then moves along the wall until a corner is found, with this corner becoming the starting position (0, 0), and the vacuum cleaning and mopping operation commences.

For the square zigzag method, the robot moves forwards across the platform, strafes to the right, and moves backwards across the platform again. It repeats this until it has reached the opposite side of the platform. For the inwards spiral method, the robot follows a cascading spiral movement, moving inwards until its stop point at the centre of the room [3].

The effectiveness of each method was based on the amount of coverage that could be achieved in the least amount of time, the complexity of the movements required, and the amount of difficulty in which SLAM can be integrated. Because of this, the inwards spiral method of movement was chosen. While both methods were seen to have the same amount of coverage potential, the square zigzag method was seen to have less potential for SLAM and mapping integration [1] . Due to the limited range of the sensor, each zigzag movement will only extend the map's range by the short distance that it has strafed, whereas an inward spiral can potentially map the entire platform within the first loop, and then confirm this map on subsequent loops. This produces a fuzzy map in a shorter amount of time.

The inwards spiral movement over the platform was able to be carried out in two different ways; either with the robot rotating 90° at every turn, or with the robot not rotating at all and moving in all four directions to cover the map. It was decided that the robot will rotate, as it will only require ultrasonic sensors to face the front and the left side which faces the wall, as opposed to sensors needing to be on all sides of the robot.

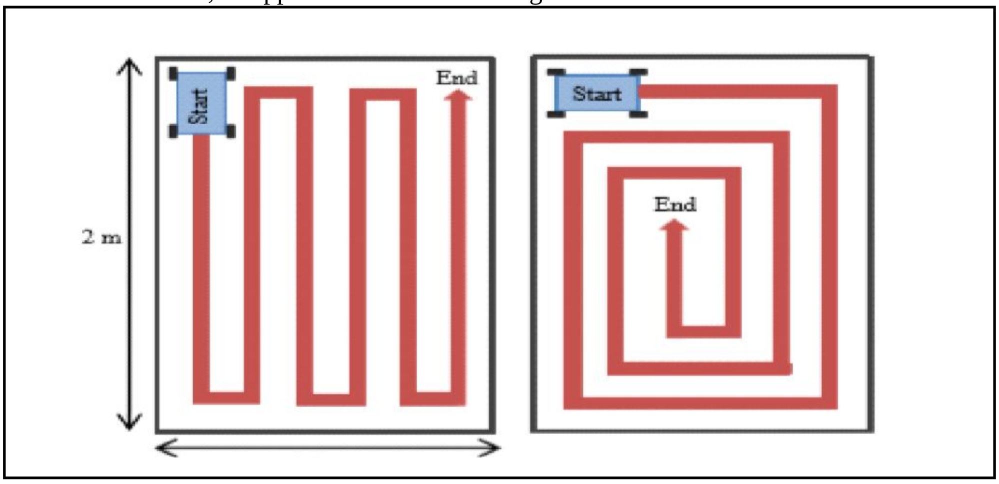

Fig.7 Motion Integration.

6. CIRCUIT DIAGRAM

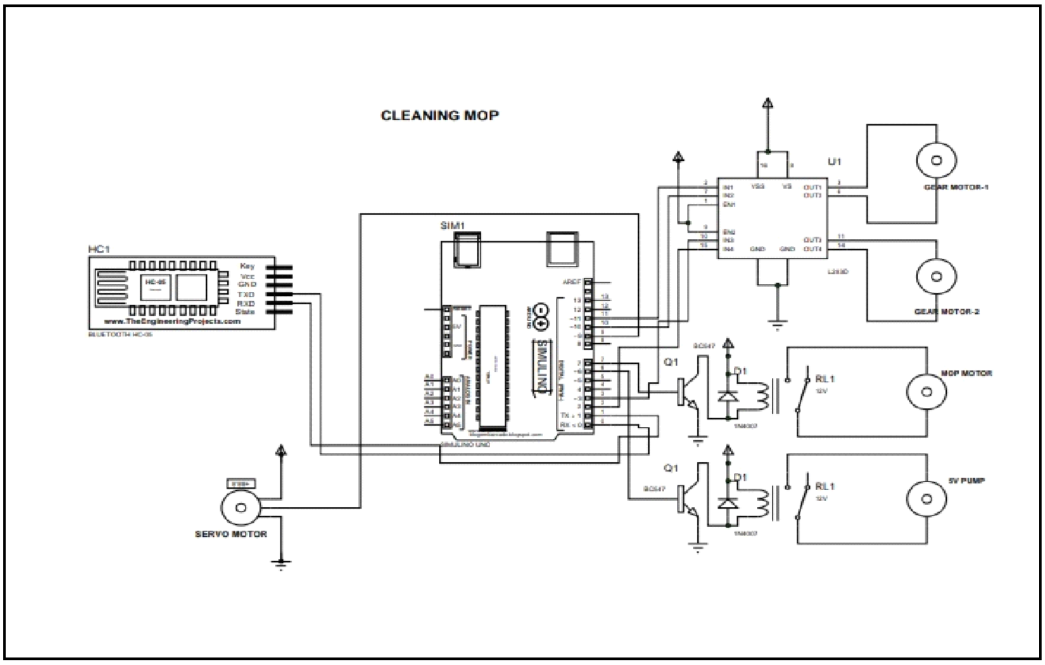

Fig.8 Circuit diagram

7. CONCLUSION

Objectives of the paper were to develop an autonomous robot that utilized SLAM (Simultaneous Localization and Mapping) to navigate a room, given a limited number of prescribed sensors. The robot was required to decide on a path and traverse the room for complete coverage, ensuring that any obstacles or walls in the room were avoided. Additionally, a map of the room displaying the robot's movement was to be built.

8. ACKNOWLEDGEMENT

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