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Dual purpose Automatic Solar Grass Cutter and Home Cleaning

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Arduino, Integrated Development Environment; microcontroller; Android; Bluetooth.

ABSTRACT

Commercial automatic cleaning robots for households are quite common nowadays. However, a robot that provides cleaning as well as mopping functions, while being autonomous as well as remote-controlled, is quite expensive. This paper presents the design and implementation of a smart autonomous floor cleaner with an Android-based controller. The implementation is based on an Arduino MEGA microcontroller, a floor cleaner system and a mobile application with wireless connectivity. The Android application features a secure user login system and connects to the robot cleaner through Bluetooth. It can be used to control the robot motion to guide it in a specific direction to vacuum or mop the floor. The user has complete control over the robot either in the autonomous or remote- controlled mode. The implemented cleaning system consists of five main blocks namely the power block (rechargeable dc battery), the motor system (driving wheels, rotating brush, vacuum fan, water pump), communication block (Bluetooth control, HC 06 Bluetooth module) and software block (Android remote controlled). Upon the implementation and testing of this prototype, it was observed that the robot works as programmed, and is equipped with most of the functionalities of a household commercial state-of-art cleaning robot Using a traditional engine-driven grass cutter to operate the grass cutters is a task that no one appreciates. Cutting grass will take longer time. Grass cutters with motors cause pollution as a result of the noisy motor, as well as contamination in the surrounding air. Similarly, an engine-controlled motor necessitates routine maintenance, such as changing the motor oil. Despite the fact that electrically operated solar-directed grass cutters are eco-friendly

1. INTRODUCTION

Autonomous floor cleaning robots are common nowadays in the market. These technological devices are built to work without any human assistance. Furthermore, these devices are programmed in such a way that they perform their tasks in a timely and precise manner. Floor cleaners have evolved over the years. From only vacuum cleaners to autonomous floor cleaners having both vacuuming and mopping features, these devices also feature an application for navigating and controlling them.

Commercial products like the Roomba iRobot, Samsung Jetbot, Ecovacs OZMO, Eufy RoboVac, [1] and many others have invaded the marketplace. However, due to their high costs, these are still beyond the budget of many families, especially the lower classes. Our project aims to bridge this gap by proposing a working prototype of a cleaning and mopping robot, that could eventually be developed as a low-cost robot with the majority of functionalities proposed by commercial robots. In the recent past, several research works were carried out for the development of such kinds of robots.

Researchers experimented with state-of-art microcontrollers, sensors, actuators and motors for better response of the robot. For example, a mobile sweeping, vacuuming and wiping robot was proposed in [2] for domestic use. The authors utilized infrared as well as ultrasonic sensors for collision prevention. The robot successfully operated in autonomous as well as in manual mode. Furthermore, in ref [3], authors explored the use of Dual Tone Multi Frequency (DTMF), for controlling a cleaning robot, from any distance by a cell phone. The robot was developed using the Arduino Uno [4], as the main microcontroller. Besides, the human-machine interaction as well as the home ecosystem was also studied, with the inclusion of cleaning robot in the home. In ref [5], a study was carried out on the use of the Roomba robot in the home. The authors focused on people's expectations of robots and of the Roomba; how the Roomba changed the practice of housekeeping; and how the Roomba fitted in the home environment. The research gave interesting insights on human-robot interaction in the home. In addition, other researchers have elaborated on the lessons learnt from robotic vacuum cleaners, entering the home ecosystem. In ref [6], the authors studied the suitability of robots for household chores, as well as their integration inside the user's space and perception. The results of surveys highlighted that users' perceptions were not sufficiently taken into account during the design phase of the robot. This contributed to robot rejection due to incompatibilities with in the users' ecosystem. With the development of artificial intelligence, a fuzzy logic based obstacle avoidance scheme was proposed in ref [7], for an indoor cleaning robot. The simulation results were very conclusive. Utilizing a traditional engine-driven grass cutter for lawn maintenance is a task that garners little appreciation. This approach not only consumes more time but also presents several drawbacks. Engine-powered grass cutters, in addition to being time-consuming, contribute to environmental pollution due to their noisy and polluting motors. The emissions and air contamination caused by these machines are concerning. Furthermore, the maintenance demands of engine-controlled motors, such as regular oil changes, add to the inconvenience. However, there exists a more environmentally conscious alternative in the form of electricoperated, solar-powered grass cutters. While these electric models share some advantages with their engine counterparts, such as being eco-friendly, they still come with certain limitations. One notable drawback is their potential danger, as they may not be user- friendly for everyone. Additionally, if the electric grass cutter relies on a corded power source, the risk associated with the cutting process is elevated, making it a hazardous option.

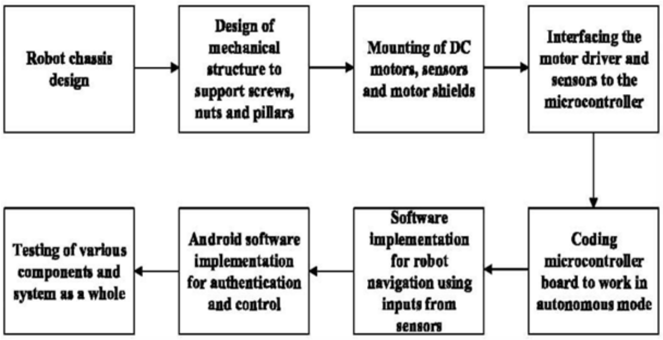

Figure 1 Steps for the development of the prototype

2. AIM

This paper presents the design and implementation of an autonomous floor cleaning robot with both mopping and vacuuming functions. Besides being autonomous, the robot can also be controlled by an android application via Bluetooth. The main objective is to provide users an easy-tooperate, battery charged (hence no attached wires) and wireless robot, that avoids obstacles, and can prevent itself from falling, for example off the stairs, through the use of cliff sensors. Taking into account user perceptions and invasion of users' private space, the robot has been designed to be as quiet as possible during operation

3. Methondology

Figure 1 shows the steps taken for the development of the robot prototype. The autonomous floor cleaning system consists of various types of sensors, all around and below the robot chassis. These sensors include one ultrasonic sensor and three infrared sensors that guide the robot for collision avoidance. A sharp cliff sensor is also included to prevent the robot from falling, for example off the stairs. All these sensors are connected to an AT MEGA 2560 microcontroller (Arduino MEGA)[8] which is pre-programmed to execute the required instructions. The microcontroller board has 54 Input-Output (I/O) pins, which is sufficient for the number of sensors and actuators.

For the cleaning process, a dc brushless vacuum fan is used to blow all the dirt into the dirt container. Whereas for mopping, a dc water pump is used to pump water at frequent intervals to a mop cloth. The whole robotic system is powered by a rechargeable battery of 12 V. An android application is used either to control the floor cleaner or to put it in autonomous mode. This enables the user to have flexibility of operating the robot from a distance of about 10 m. After the cleaning process, the dirt container is emptied, and mop cloth replaced. Figure 2 shows the different components used for the prototype. A brief description of the building blocks is provided in the following sections

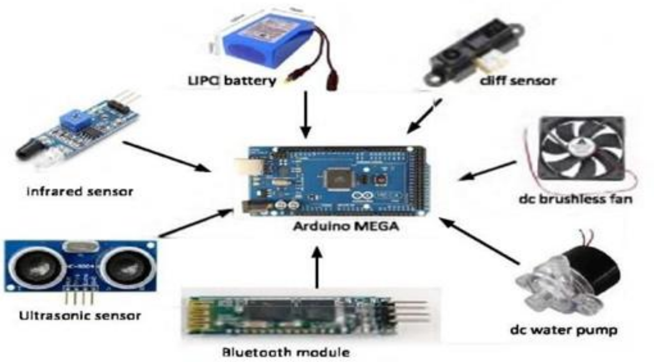

Figure 2 Components for the prototype

A. Arduino MEGA 2560 Microcontroller Arduino boards are very commonly used nowadays for the design and implementation of robotics and automation projects. The Arduino consists of a physical programmable circuit board known as a microcontroller as well as an Integrated Development Environment (software) used to program the board in its own specific programming language.

B. Battery A rechargeable LiPo battery of 12 V is used to provide direct current to the circuit. Due to the size limitation of the chassis, a relatively light weight and small battery is used, that provides current for at least one hour continuously.

C. DC brushless fan A 12 V dc brushless fan is selected for the project to perform the vacuuming action. The motion of the fan causes the dust particles to be sucked up into the dust container where it gets trapped. The fan is enclosed in a wooden box so as to prevent any air leakage.

D. Water pump This pumps water from the water container into a mop cloth that is used to mop the floor. A 12V dc water pump is used.

E. Ultrasonic sensor An ultrasonic sensor is used to guide the robot as well as to prevent collision against walls or obstacles. The sensor head emits an ultrasonic wave and measures the distance to th e wall, through the reflected wave back to the head. The distance measurement occurs by measuring the time between emission and reception.

F. Infrared sensor The infrared (IR) sensor has more or less the same working principles as the Ultrasonic but instead of emitting ultrasonic waves, it emits and receives infrared radiation. These obstacle sensors come as Light Emitting Diodes (LED) compatible with Arduino boards and they can emit rays from 700 nm to 1 mm wavelength. A knob is usually rotated on the sensor in order to reduce or increase the obstacle detection distance.

G. Cliff sensor A cliff sensor is required to prevent any fall and damage of the cleaner. Thus, a sharp GP2Y0A21YKOF distance sensor [9] is used to measure the distance of 10 cm to 80 cm vertically downwards. The sharp sensor acts as an infrared sensor by using a beam of infrared light to reflect off an object so as to measure the distance in between. The sharp sensor is a better IR sensor as it is unaffected by any temperature change and gives reliable and accurate readings.

H. Bluetooth Module HC 06 The HC-06 Bluetooth module [10] acts as a medium of connection between the Android application and the floor cleaner robot. The maximum detection range is 10 m, which is sufficient for a house. The Bluetooth module works with an input voltage of 5 V. It receives a value of character type from the Android phone through the receiver pin and then passes on the value to the Arduino board through the transmitter pin where the MEGA board uses the received character to execute a function.

Methodology for a solar grass cutter involves several steps,

- Project definition and Planning
- Conceptualization and Design
- Solar power integration
- Mechanical Constructions
- Electronics and Control Systems
- Solar Power System Integration Testing and Iteration

4. Mechanical Design

The chassis of the floor cleaner robot is made using plywood. Plywood is sufficiently strong to hold the two motors, back wheels as well as the front castor wheel. An additional wooden chassis of the same shape and size is mounted on the ground chassis so as to accommodate the dust container, water container and the dc brushless fan. The electronic components are mostly fixed onto the ground chassis. The mechanical designs of the robot structure was made on the 3D builder software on Windows 10. The structure of the robot is then built according to dimensions in the designs.

A. Wheels For the free motion of the robot, a small castor wheel and two bigger back wheels are utilized. The castor wheel is attached to the chassis using bolts, nuts and washers. The back wheels are attached to two dc motors using bolts and nuts. It is observed that the chassis is slightly inclined, due to the bigger back wheels. To compensate for this, additional washers are included into the bolts to balance the height of the castor wheel to make the robot

Figure 3 Top and bottom part of the chassis

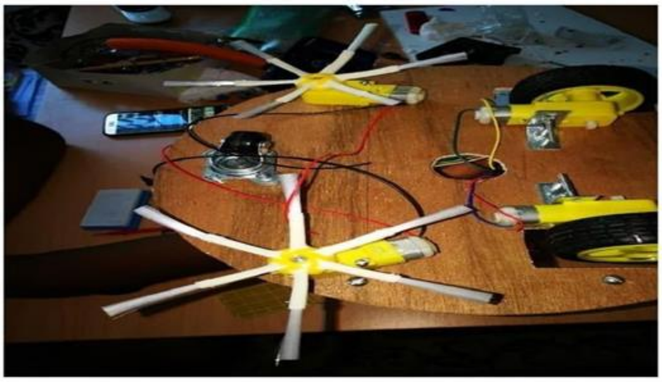

Figure 4 Chassis with wheels, bolts, nuts and side brushes

B.Side brushes The side brushes are on the two sides of the bottom wooden chassis. These are attached to two dc motors as shown in Figure 4. The geared dc motor enables the user to control the speed and direction of the bush rotation.

C.Vacuum Cleaner The vacuum cleaner system is designed so that it fits on the top part of the chassis. The vacuum box consists of an air tube to pull air inside the container and suck up dirt and dust through the action of the dcfan. To prevent the dust from passing through the fan, a HEPA filter cloth is used in between the air inlet of the container and the dc vacuum fan.

D.Water Tank The mopping system of the robot is designed using two water tanks where the first tank would provide water to the water pump and the second tank would push the water to the mop cloth attached to it. Several holes were made on the second tank to ensure that the water is distributed across a large surface of the mop cloth.

5. Testing

Component testing is done first, for example all dc motors are tested prior to attaching them to the wheels. Then, each functionality of the system is independently tested. Eventually, the integrated system (the cleaning and mopping) is tested. It is observed that the system responds as expected

6. Results and Discussion:

Reviving all the needs of the people, a suitable design of solar grass cut was made. The components were chosen based on the design requirement and considering a few of the other parameters in order to meet all the constraints. Based on the revived prototype model of the hardware and software system along with the ultrasonic sensor were demonstrated and the required output was obtained. The blade was designed in such a way that it can cut the grass efficiently and height from the ground level can be adjusted. A panel is placed in a position where it can obtain maximum energy from sunlight. So, among eco-friendly grass cutters, this device is the most efficient one.

7. CONCLUSION AND FUTURE SCOPE

The paper details the creation of a smart, autonomous cleaning and mopping robot powered by a 12V rechargeable Lithium Polymer battery. Utilizing the Arduino Mega board for its extensive GPIO pins and memory capacity, the system operates in both autonomous and application-controlled modes via an Android Studio-developed app with Bluetooth connectivity. User authentication is managed through Google Firebase, ensuring scalability. Open-source platforms like Arduino IDE, Livewire, and Android Studio were instrumental in development. Potential enhancements include artificial intelligence for smart navigation, voice control integration (e.g., Alexa or Google Assistant), and solar-powered charging for prolonged operation. The robot can connect to Wi-Fi, enabling real-time data transmission to online databases for monitoring and upgrades. Designed with accessibility in mind, the system is eco-friendly, cost-efficient, and suitable for tasks like grass cutting, reducing human effort and power costs. Its solar panel ensures consistent energy, even on cloudy days, making it practical and easy to use for non-skilled operators.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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