Smart Robot Cleaner Using Internet of Things

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ABSTRACT:

The rise of smart home tech and automation has seen great growth in the interest of service robots which in turn perform everyday home tasks. Among the most common is indoor cleaning which we do for great lengths of time and puts great physical strain. With the introduction of robotics, embedded systems and the Internet of Things we have seen autonomous cleaning robots emerge as a great solution for maintaining indoor health with minimal human input This research reports on the development of a smart robot vacuum which we have integrated with the Internet of Things. We designed this system to do both dry and wet floor cleaning in indoor settings like homes, offices and small commercial spaces. The system we put together includes an Arduino based microcontroller. In manual mode users have the control of the robot through an Android smartphone which is a via of Bluetooth. We see that through the use of IoT we are also able to remote monitor and control the robot which in turn gives better user convenience and system flexibility. In our tests we report that which which we put forth a robotic cleaner does very well in terms of navigation, cleaning coverage and also has very reliable wireless performance in indoor settings. Also the design of the system is that of a very flexible and low cost structure which makes it a go to for academic research, educational projects and practical smart home uses. Our results also put forth the fact that there is great value in the combination of IoT tech with robotics in the development of affordable and smart cleaning solutions.

KEYWORDS : IoT, Autonomous Robot, Smart Cleaning Robot, Arduino, Obstacle Detection, Bluetooth Communication, Home Automation

1. INTRODUCTION

In present day, automation is a key element of what we see in our everyday lives. From large scale industry to home appliances we see the introduction of automated systems which in turn reduce user effort and see improved efficiency and performance. Also of great study is the field of domestic service robotics in which we see a great deal of development of cleaning robots[1][2]. Indoor cleaning is a routine and time extensive task which we do for health and hygiene. We see today that manual methods of cleaning which include sweeping, mopping, and vacuuming require great effort from the person doing the task and also take up a great deal of time. In settings like offices, hospitals and in residences maintaining a high level of clean is a issue. Robotic cleaning systems put forth a workable answer to this issue. These robots are designed to do the cleaning tasks on their own while they figure out their way through indoor environments spaces. In the use of sensors, microcontrollers and communication technologies robotic cleaners are to detect. Obstacles identification, path planning, and cleaning task performance which is done efficiently[4][5]. Into the Internet of Things (IoT) we see to which robots' devices, cloud platforms, and users are connected. Through the use of IoT robots are able to collect operation data, give remote commands response, and integrate with other smart home devices. This connection in turn improves the usability and functionality of robotic cleaning

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systems[6].Although there is a choice of commercial robotic vacuum cleaners at present many products are very expensive and also they fall short in terms of customizability. Also most commercial systems are put together as closed platforms which in turn limits the scope for research and development. For this research we aim to design and implement a cost effective. Smart robot vacuum which is powered by the IoT. We have designed it to clean autonomously at the same time that it gives the user remote control via wireless. Our put forth design is simple, economic and modular which in turn makes it easy for use in future research

2. RELATED WORK

Robotic cleaning technology has developed greatly over a 20 year period. In the early days of robot vacuums they featured very basic navigation which for the most part was random in nature. Although at the time they could perform the base functions of vacuuming they did not do an efficient job of cleaning large areas out which the name of the game was put forth.[2] Also to date we have seen many commercial robotic vacuum cleaners come to the market. Companies that have put out products like Roomba, Neato XV-11, and Dyson Eye-360 have incorporated into their designs advanced navigation technologies which include laser scanning Cameras, and SLAM. These technologies allow robots to make maps of their environment and plan out efficient cleaning paths[9]. In other research we see that many different approaches have been put forth to improve robotic cleaning systems. Some research is into better navigation algorithms, others into sensor integration and system wide optimization. For example research has been done in vision based navigation, laser based mapping, and machine learning for better performance[7][8]. But many of these high tech systems use expensive hardware which in turn increases the price of the full system and which in turn limits their access for education and research. Recently we have seen growth in the use of microcontrollers like Arduino and ESP32 which has enabled the development of more affordable robotic systems. These systems put forth a simple design which enables easy integration of sensors, actuators, and communication components. As a result which allows researchers to create cost effective robotic vacuuming solutions that offer basic autonomy as well as flexibility for design adaptation[10]. Our presented system is built from this foundation out of which we have created a robotic vacuum that includes features of object avoidance, wireless networking, and dual cleaning actions in a modular design.

3. METHODOLOGY

The presented approach to the system is a combination of hardware elements and software algorithms which we have put together for the autonomous cleaning. In terms of design we looked at system plan, chose our hardware, did the software development and did prototype testing. The robot we have designed uses a differential drive which enables it to go forward, back and turn in any direction.

Two DC motors which are attached to the wheels are the main drivers for the robot. We use ultrasonic sensors for the obstacle detection. The sensors constantly measure the distance between the robot and it's nearby environment. As soon as the measured distance goes below a certain pre determined threshold the system identifies that there is an obstacle. Upon detection of an obstacle the microcontroller looks at the sensor data and determines a different path which will avoid a collision. This in turn allows the robot to safely navigate through indoor settings. When the robot Moves around the floor the ultrasonic sensor reports back constantly on the environment which it is put in to watch out for any obstacles which may cross it's path. At the point that an object is identified within a set distance range the sensor reports back the distance of that object to the microcontroller.

The microcontroller which in turn studies this data and at once triggers a response to avoid a crash. Instead of the robot will stop forward progress and at that point determine a new path. Per the detected object's position the machine may also come to a full stop before going left or right prior to which it will continue its' movement. This dynamic change allows the robot to avoid furniture, walls and other indoor issues. By continuously going through this sensing and decision making routine the robot is able to move independently within indoor spaces and also at the same time minimize interruption during clean up.

In our system we have put in a cleaning which does both dry and wet cleaning at the same time which makes this robot outperform a single function cleaner. The dry clean in which we engage a vacuum motor that produces suction which in turn collects dust, sand particles and other small debris from the floor as the robot moves forward. Also as the robot goes the vacuum action is constant which in fact0.5 removes what is loose before we get into the mopping phase. Also we have included in the robot a water pump which together with the vacuum unit supports the wet clean function.

The robot uses a water pump to draw out of a small storage tank which is a part of the robot's body and supply it to a microfiber cleaning pad attached to the bot's bottom surface. The microfiber material does an excellent job at what it does which is to absorb moisture and to pick up dirt particles thus in turn removing light stains and surface dust.From inside its base, the machine pulls liquid using a tiny reservoir. This fluid moves toward a soft cloth fixed underneath. That fabric grabs grime while soaking up spills along the way. Instead of just vacuuming, adding damp wiping lifts more mess overall. Floors stay fresher because both methods work in sequence - sucking first, then gently scrubbing after.Inside it works with two parts - one sucks up loose particles, the other feeds water to a cloth that wipes grime away. Though small, the suction unit pulls in crumbs and grit each time it moves across surfaces. A steady drip from the liquid system keeps the mop pad damp enough to lift sticky spots. Communication happens without wires thanks to a tiny radio chip built into its frame. Instead of buttons on the device, someone taps their phone screen to tell it where to go. Signals travel from software on the mobile device straight into the machine's central processor.The flow diagram for the proposed methodology is shown in (Fig. 1

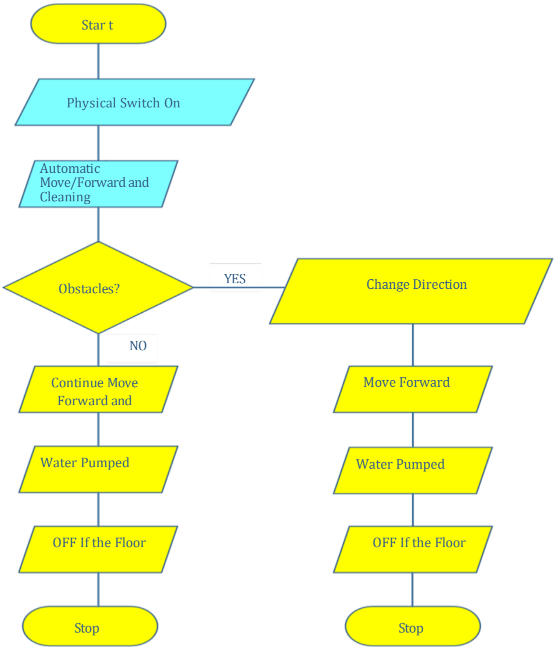

Fig.1: Flow of automatic operating system

4. Hardware Architecture

The presented robotic cleaning system's hardware architecture is a result of the integration of many electronic and mechanical elements that work as a team to produce efficient performance. Each element in the system has a special role in the processes of navigation, cleaning, control, and communication. We have taken a holistic approach to the overall hardware design which in turn makes for easy individual component replacement or upgrade in the future we develop. Also this modular structure we have put in place makes the system very flexible and suitable for use in research and academic settings. At the core of the system is the Arduino Uno microcontroller which we use as the main control unit of the robot. We chose the Arduino Uno for its simple design, reliable performance and that it plays well with a large variety of sensors and modules. It also includes the ATmega328P microcontroller, Which at the helm of processing data and running the program uploaded via the Arduino Integrated Development Environment (IDE) is the microcontroller. It receives input from sensors, processes that input according to pre determined instructions, and in turn puts out signals which in turn control different elements of the robot. In this way the Arduino plays the role of the robot's brain which is in charge of sensing, decision making and movement. To control the robot's movement motor driver circuits like the L293D or L298N are used. These motor drivers play the role of an interface between the low power signals put out by the microcontroller Star t Physical Switch On Automatic Move/Forward and Cleaning YES Obstacles? Change Direction 45o/ 90o/ 180o / Left/ Right. NO Continue Move Forward and Cleaning Move Forward and Cleaning Water Pumped While Cleaning Water Pumped While Cleaning OFF If the Floor Cle an OFF If the Floor Cle an Stop Stop Higher power output from the DC motors. As the Arduino is unable to deliver enough current to the motors we have to use a motor driver which amplifies. In that which we put as control signals we enable the motors to rotate in different directions. By the adjustment of the control signals sent to the motor driver the microcontroller is able to regulate both the direction and speed of the motors. This in turn allows the robot to go forward, back or turn in different directions as it goes about the cleaning area. The circuit diagram for the proposed Hardware Architecture is shown in (Fig. 2).

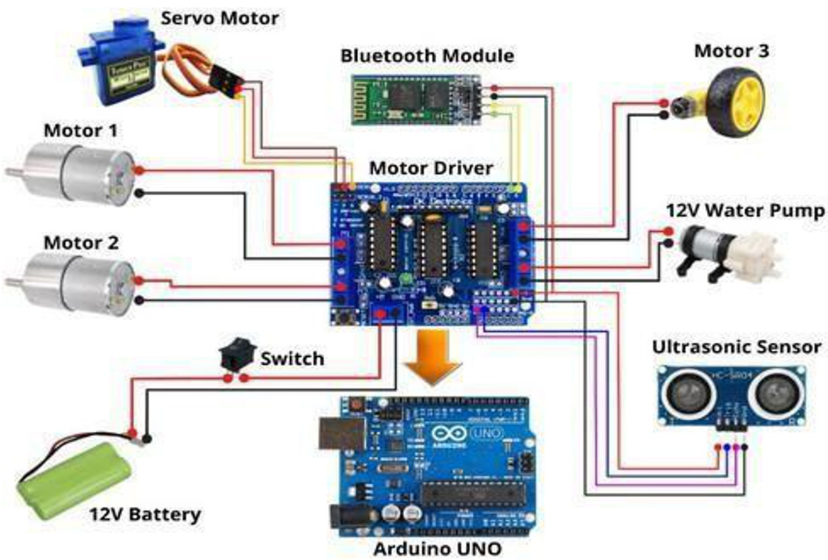

Fig. 2 : Experimental set up

In our design we have implemented wireless communication between the robotic system and the user via the HC-05 Bluetooth module. This module we found to be very reliable for establishing a serial communication link between the robot and a smart phone which in turn allows for command and control signal exchange. Also very popular in the field of embedded systems is the HC-05 module which we use for its stable performance, low power consumption and easy setup. Once the Bluetooth module is paired with a smart phone the user is able to use a mobile app we developed to send out commands which in turn control the robot's movement. These commands are sent wirelessly to the module which in turn reports to the microcontroller that in turn acts on them by which it activates the motors. This wireless feature we have added to the system improves overall usability and also enables remote operation. Inside the suggested robot vacuum lives a mix of electronics and moving parts. Main brain? That job goes to an Arduino Uno chip. Signals come in from sensors, then it sends out commands - this happens before anything moves. Instead of just connecting motors directly, special chips like L293D or L298 step in. Only after receiving instructions does each driver shift how fast or which way the motors spin. Wireless talks happen through the HC-05 chip. From robot to phone, data flows using serial signals sent without wires. To spot things in its path, the machine relies on ultrasonic sensors that judge distance. Out goes sound beyond human hearing, then waits - timing how long it takes to bounce back. A small spinning motor aims those sensors where needed. Sucking up dirt? That job falls to a compact vacuum unit inside. For wet floors, liquid spreads via a tiny pump pushing water out slowly. Power comes from stored energy in reusable battery packs carried onboard. Rolling across surfaces happens thanks to round parts underneath that turn when told. Each piece fits into place like one part of a quiet system working together.

5. Software Implementation

Running on code built inside the Arduino IDE, the robot cleaner operates through custom-written C/C++ programs split into separate parts handling movement, signals, and dirt removal. Sensor inputs feed live information to a pathfinding routine that checks constantly for barriers ahead. When something blocks its way, motion halts immediately while the machine picks a new heading. Control shifts under human guidance when switching to hands on operation, where directions come from a phone app via wireless Bluetooth links. These incoming signals get processed by the onboard chip which then adjusts wheel actions based on what it receives. While the robot moves, its cleaning system runs at the same time. Dust gets sucked up because the vacuum motor stays on, whereas the water pump wets the pad now and then. Future updates can include fresh functions without hassle since the software is built in separate parts.

6. Experimental Results

One version of the machine actually moved on its own, built just to see how well it might work in real homes. Built around a central computer brain, pieces like detectors, motion parts, scrubbing tools, and signal links were fitted together tightly. Once circuits lit up and code ran properly, tests began inside a room set up like a regular house. Furniture you'd find anywhere - chairs, low tables, corners, tiny scattered things - stood in the robot's path. Watching it deal with clutter gave clues about how smoothly it could handle everyday messes. Throughout each run, sound based detectors quietly guided movement, helping avoid crashes without slowing down much. Now moving, the robot kept checking how close things were around it through constant sensor scans. If something popped up too near, based on preset limits, signals flew to the brain chip without delay. That chip then acted fast - redirecting motion before any contact happened.

Midway through its path, the machine stopped just short of hitting an item, shifted course slightly, then carried on with its task. Because it could sense barriers ahead, it found ways past chairs and baseboards all by itself. Over several trials, the detection gear proved steady, keeping movement fluid across each run.

During checks, attention also turned to how well signals traveled between components wirelessly. A signal locked in place when the HC-05 chip linked up with an Android phone. After that handshake finished, moving the robot came down to taps on a screen. Messages traveled both ways without dropping held steady between roughly 8 and 10 meters, a span that covers most indoor spaces. While distance varied slightly, performance stayed consistent across rooms of average size. This range fits well where people usually need it - inside buildings with standard layouts. Not every spot was perfect, yet results showed little drop off near walls or corners. Even when obstacles appeared, signals managed to keep functioning without major dips. Quick reactions showed up each time a phone sent an order and the machine moved right after. With little delay seen throughout tests, Bluetooth proved able to handle live steering well. During trials, attention turned often to how well it cleaned.

A built-in vacuum runs as the machine moves ahead, pulling up dust and tiny bits from floors. Because it works nonstop, most dry mess gets drawn in fast. Meanwhile, liquid flows through a small pump into a cloth layer below. That damp cloth wipes away thin layers of grime missed by suction. Since both actions happen together, surfaces come out cleaner than when only one method is used. Floor types respond differently, yet overall results show clearer outcomes.

Through multiple runs, we watched how the robot acted each time it cleaned. It moved steadily every round, stayed connected without drops, also picked up debris well in various spots. Now and then, tight corners made its path shift slightly - yet it adjusted on its own, kept going without stopping. All this suggests solid performance when used for everyday floor cleaning indoors. From start to finish, tests showed the model worked as intended. Because it combined sensor-based navigation with remote signaling and two cleaning methods, the machine handled indoor chores without issue. Results proved the setup works well, keeps costs low, runs steadily, plus stays simple to operate.

7. Discussion

A working robot broom shows it is possible to build smart cleaning gadgets without spending much, thanks to internet linked parts. While store-bought models cost more, this version runs cheaper, fitting better inside labs and test projects. What stands out about the new robot cleaner is how it's built in pieces. Built so every part - hardware or software - works on its own but fits together. Flexibility shows up when building it or fixing it later. Outdated piece? Broken one? Needs improvement? Swap it without touching everything else. No full rebuild needed just because one chunk changes. Take sensors, say. Or think about comms units. Even motor controllers - each piece could get upgrades later, depending on what the next robot model needs. Because it splits into parts like this, universities find it works well for study Testing fresh ideas works well here because tech upgrades get tried out separately from what keeps the robot running. New tools mix in slowly while the main system stays steady. When one part stops working, just that piece gets fixed, leaving everything else running. Because each section works on its own, finding problems takes less time and effort. Fixing only what needs repair keeps the whole setup stable during updates. Trying new tools or code becomes easier since changes stay contained within separate units. Each block can swap out without rewiring the entire machine around it. Testing fresh ideas happens faster when pieces snap together like building blocks. Over months or years, replacing worn sections extends how long the robot remains useful. Custom setups grow naturally as needs shift across research projects. Individual upgrades mean progress does not wait for full replacements. Parts evolve at their own pace while fitting into the same frame. Even with those benefits, right now the robot moves around using a pretty basic approach. Instead of smart planning, it leans heavily on ultrasonic sensors to spot obstacles, then just shifts direction when needed. Because of that, it works fine in tidy, compact rooms but falls short compared to sharper navigation methods out there. Sometimes it circles back over spots it already handled, or skips patches entirely - mainly since it cannot build a map of where it has been. One way forward might be upgrading the system with smarter movement methods like SLAM. Instead of just moving blindly, robots can now sketch out their space on the fly - while knowing exactly where they are in it. Through tools like LiDAR, awareness grows step by step A robot might grasp the shape of a room much clearer if it uses depth-sensing cameras or clever blends of sensors. Because of that awareness, path planning becomes sharper, repetition drops, while reaching every corner grows easier. With richer spatial insight, sweeping routes tighten, wasted motions fade, full-room reach improves. Right now, the setup runs on a basic pathfinding method. Moving ahead, smarter map-building tools like SLAM might boost how well it moves around. A shift toward adding Wi-Fi could open doors to remote tracking through online platforms.

8. Conclusion

This study introduced a smart robotic cleaner built on IoT technology, designed to handle indoor cleaning without human guidance. Built around sensor arrays and microcontroller units, it links detection systems with motorized movement through seamless signal processing. Functioning either on its own or via remote input, the machine adjusts paths when objects appear nearby. Wireless signals allow real-time status updates while onboard motors drive suction and sweeping actions. Testing confirmed reliable responses to barriers, stable network connections during operation, along with consistent performance across different floor types One way to keep things clean at home might just work better than expected. This setup could actually fit into everyday household routines without much trouble. Down the line, new steps might include smarter movement systems, tweaks to how parts are built, or stronger links using common internet-connected devices.

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