SecuriBot: Autonomous Security Robot

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Abstract: This is the second iteration of the SecuriBot project at Northern Illinois University’s College of Engineering and Engineering Technology. The goal of the SecuriBot project is to develop a reasonably priced autonomous system for monitoring a number of safety, security, and environmental related conditions in an indoor setting. This design for SecuriBot has focused on using well documented components together with software in order to ensure that troubleshooting and future development can both go smoothly.

I. INTRODUCTION

Many of the active security systems available on the market today are designed for commercial or government use. The existing solutions for home security are static and primarily focus on passive monitoring. The SecuriBot robot is designed to be able to monitor an indoor space for changes in temperature, humidity, and barometric pressure. SecuriBot is also capable of detecting motion within the area that it patrols. Any detection of irregular environmental conditions or motion while on patrol can then be sent via email to a specified individual so that the situation can be rectified immediately.

II. MECHANICAL DESIGN

The primary component responsible for SecuriBot’s mobility is the Create 2 robotics platform manufactured by iRobot based on their popular Roomba robotic vacuum. The Create 2 includes a large number of sensors onboard which can be used to provide a large amount of information to the rest of the system. The Create 2 also comes with a charging dock which includes IR signaling to enable automated docking of the robot for autonomous charging.

The electrical components of SecuriBot are housed on a 3-D printed platform which provides a place to mount the motion sensors as well as the camera. The platform is attached to the top plate of the Create 2 using #6-32 machine screws and locking nuts to ensure that they do not back off during the small vibrations caused by movement.

III. ELECTRICAL DESIGN

A. Power Delivery

The power supply for SecuriBot is drawn from the onboard battery of the Create 2. The Mini-DIN connector on the top of the Create 2 is capable of supplying 200 milliAmperes of 12 Volt power, this power is routed through a 5V regulator to power an Arduino Mega. The Raspberry Pi and USB hub have their power provided by the main brush drive circuitry on the Create 2. This power system is designed to power an inductive load like a motor directly, so it was necessary to add a fixed inductor into the circuit to ensure smooth and reliable power delivery. The main brush drive power is supplied to a Buck converter capable of supplying up to 20 watts.
B. Communication

The Arduino Mega acts as a communication handler between the Raspberry Pi and the Create 2, as well as controlling the docking and undocking procedures which are conducted with the Raspberry Pi powered off. The processing components communicate via the UART (Universal Asynchronous Reciever-Transmitter) protocol at high speed to minimize any potential bottlenecks caused by communication between the modules. User input is only required to setup the system and is conducted primarily through a controller connected to the Raspberry Pi through the USB hub.

C. Sensors

The motion detection system relies on four motion sensors connected to the Arduino to provide 360° coverage of the area around the robot. The overlapping fields of view help to increase the directional accuracy of detected events in order to correctly orient the system so that an image can be captured of the object in motion.

![Figure 3: The overlapping sectors covered by the motion detectors at a distance of one meter](image)

Using signals and the atmospheric pressure we can properly and accurately detect the change of atmospheric pressure thanks to the pressure sensor, and it gives us the current pressure at its given time.

The temperature Sensor gives out the current temperature at that time, but it also gives alerts when the temperature has changed. It measures the temperature of its environment and converts the input data into electronic data to record, monitor, or signal temperature changes.

The hazardous gas sensor is one of the most important sensors allows for the detection of dangerous gases with the same concept as the other sensors which are signals. The sensor identifies gases by measuring the current discharge in the device.

IV. Software Design

A. Arduino

The software flashed onto the Arduino Mega has been designed to loop rapidly through a single function to ensure fast response to any input from the Raspberry Pi. Multiple signal wires, in addition to the serial lines, are connected from the general purpose Input/Output lines of the Raspberry Pi to the digital pins of the Mega to enable the logic running on the Arduino to quickly differentiate between different control conditions.

Using the documentation supplied by iRobot, a number of functions are implemented in C to handle the communication with the Create 2 to control the motion of the platform and query the numerous onboard sensors to ensure safe operating conditions and prevent the battery from running to low and causing damage.

B. Raspberry Pi

The Raspberry Pi Zero W was selected for this project to control the main logic because of its low power requirements, as well as its fast processing, and built in support for the PYTHON programming language. The Pi handles the higher level functions and data processing that would be difficult and time consuming to implement on an Arduino.

The libraries available in PYTHON are used to simplify many aspects of the programming. The GPIOzero library was used to control the GPIO pins of the Pi for signaling the Arduino. The PiCamera library enables direct interaction with the camera attached to the Pi through the onboard camera connector.

V. Conclusion

The current version of SecuriBot is able to monitor the environment, and send e-mails with alert messages. It can also patrol a course, that is set up with user input, and scan for motion at designated points along that path. If motion is detected, SecuriBot can capture an image in the direction of the motion and then e-mail it to the designated individual. SecuriBot can also dock and undock with the charging station to ensure battery safety and continued operation without user input.

The original design of SecuriBot included a 360° LIDAR rangefinder, which would have allowed for better localization along the path as well as obstacle detection. Due to logistical issues and the global health crisis, there was less time for troubleshooting than would have been ideal.

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