Autonomous Building Map Exploration Robot for First-Responder and Military Operations

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Abstract
Exploring an unknown environment using a mobile robot has many real-world applications. Map exploration robot is a robotic system operating on simple rules to solve the complex problem of creating a map of unknown environments within a building. Innovative techniques are used for mapping unknown environment in order to make the process faster and efficient.

Keywords: IEEE 802.15.4 Radio, SONAR, DC Motor.

Introduction
Though robotic map building is a relatively new field, a wide range of solutions have been proposed. One of the most popular sensors used is sonar, due to its low cost and the resulting its ability to sense a volume, and the speed at which sonar information can be moderated.

- Which sonar model to use.
- Which mathematical formula to use to incorporate the information from the sonar model with the world map.

Related Work
It is an important ability for any mobile robot to be able to estimate its posture and to gauge the distance it traveled [1]. We have addressed this problem in a dynamic quadruped robot by combining traditional state estimation methods with machine learning. We have designed and implemented a navigation algorithm for full body state (position, velocity, and attitude) estimation that uses no external reference but relies on multimodal proprioceptive sensory information only. A probabilistic fuzzy system is designed to reduce both of these uncertainties for more precise localization and map building [2]. The experimental results demonstrate the success and robustness of the proposed method for more precise and reliable mobile-robot localization and map building with various unexpected disturbances.

Proposed Work
The project aim is to build a tiny robot to map interior of a building. The robot moves on its own. Its movement can be monitored on a touch screen display unit that is kept outside of the building [3]. As the robot moves, it senses the surrounding environment and sends this information to the display unit where a map of the region will be generated and gets displayed. Mapping is done with the help of high precision Ultrasonic SONAR sensors and a technique called SLAM (Simultaneous localization and mapping). The robot must build the map while at the same time keep track of its own location and direction of movement. A Digital MEMS Magnetometer is used to keep track of the direction and movement along it [4] . The display unit is responsible for integrating all the sensory data collected by the robot and to present the information as a map on the LCD display. Apart from viewing the map, the human operator could take important decisions about the path the robot would take in special situations using the touch screen interface in the control unit. The robot interacts with the control unit using IEEE 802.15.4, a low power wireless network protocol. The control unit is a designed around a 65K Color QVGA TFT Touch screen Graphics LCD. The brain of the robots and control unit is a 32-bit ARM Cortex-M3 microcontroller [5].


[138-140]
The microcontroller handles the Graphics Library for Touch screen display.

Figure 1: Block Diagram for Robot Mode

Figure 2: Block Diagram for Display Mode

Figure 3: Circuit Diagram for Sonar Cell

B. Implementation of Slam

Practical realizations of probabilistic SLAM have become increasingly impressive in recent years, covering larger areas in more challenging environments. The experiment is remarkable because its return trip was fully autonomous. The robot was manually driven during the exploration phase, although without visual contact by the operator, who relied solely on a real-time rendering of the robot’s map.

C. System Design

Although the robots we see in science fiction movies appear to navigate with effortless precision, in reality mobile robot navigation is a difficult research problem. Indeed, simply answering the question “where am I?” in truly autonomous fashion is a serious challenge for today’s mobile robot. We use the term localization to refer to the process of determining a robot’s position using information from external sensors. Our research has focused on the provision of this capability using airborne ultrasonic range sensing, which shall henceforth be referred to as sonar.

It is an important ability for any mobile robot to be able to estimate its posture and to gauge the distance it traveled. In this paper, we have addressed this problem in a dynamic quadruped robot by combining traditional state estimation methods with machine learning. We have designed and implemented a navigation algorithm for full body state (position, velocity, and attitude) estimation that uses no external reference but relies on multimodal proprioceptive sensory information only. The extended Kalman filter (EKF) was used to provide error estimation and data fusion. The project aim is to build a tiny robot to map interior of a building. The robot moves on its own. Its movement can be monitored on a touch screen display unit that is kept outside of the building. As the robot moves, it senses the surrounding environment and sends this information to the display unit where a map of the region will be generated and displayed. Mapping is done with the help of high precision Ultrasonic SONAR sensors and a technique called SLAM. The robot must build the map while at the same time keep track of its own location and direction of movement. A Digital MEMS Magnetometer is used to keep track of the direction and movement along it. The display unit is responsible for integrating all the sensory data collected by the robot and to present the information.
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Transmitting and Receiving
The MiWi P2P stack transmits and receives packets according to the IEEE 802.15.4 Specification, with a few exceptions.

A. Transmitting Messages
There are two ways to transmit a message: broadcast and unicast. Broadcast packets have all devices in the radio range as their destination. IEEE 802.15.4 defines a specific short address as the broadcast address, but has no definition for the long address. As a result, broadcasting is the only situation when the MiWi P2P stack uses a short address. There is no Acknowledgement for broadcasting messages.

Unicast transmissions have only one destination and use the long address as the destination address. The MiWi P2P stack requires Acknowledgement for all unicast messages. If the transmitting device has at least one device that turns off its radio when Idle, the transmitting device will save the message in RAM and wait for the sleeping device to wake-up and request the message. This kind of data transmitting is called indirect messaging. If the sleeping device fails to acquire the indirect message, it will expire and be discarded. Usually, the indirect message time-out needs to be longer than the pulling interval for the sleeping device.

B. Receiving messages
In the MiWi P2P stack, only the messaged device will be notified by the radio. If the messaged device turns off its radio when Idle, it can only receive a message from the device to which it is connected. For the idling device with the turned off radio to receive the message, the device must send a data request command to its connection peer. Then, it will acquire the indirect message if there is one.

Conclusion
This type of robot would help civilians and military persons while dealing with dangerous situations like war and terrorist seeking operations. So this robot will help the first responders who could send in this robot to quickly search the building structure and send back a map. This way they’d have a much better sense of what to expect and they can work out a plan before entering the building.

Hardware Output

![Figure 5: Robot to detect Obstacles](image)

References