Wireless Indoor Mobile Robot with RFID Navigation Map and Live Video

A thesis in the partial fulfilment of the requirements for the degree of

Masters of Engineering

in

Mechatronics

Massey University
Palmerston North
New Zealand

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2011
Abstract

A mobile robot was designed in order to move freely within a map built in an indoor environment. The aim is for the robot to move between passive RFID (Radio Frequency Identification) tags in an environment that has been previously mapped by the designed software. Passive RFID tags are inexpensive, the same size and shape as a credit card and are attached to other objects. They don’t require any power of their own but operate through an RFID reader that induces a magnetic field in their antenna, which then creates power for the tag. This makes the tags inexpensive, and easy to setup and maintain.

The robot is a three wheeled vehicle driven by two stepper motors and is controlled wirelessly through a PC. It has a third omniwheel at the front for maintaining the balance of the robot. Since the PC communicates continuously with the robot, all the major processing and data management can be done on the computer making the microcontroller much simpler and less expensive. Infrared distance sensors are placed around the robot to detect short range obstacles and a sonar sensor at the front can detect obstacles further away. This data is used so that the robot can avoid obstacles in its path between tags. An electronic compass is used to provide absolute orientation of the robot at all times to correct for errors in estimating the angle. A camera is attached to the front of the robot so that an operator can see the robot and manually control it if necessary. This could also be used to a video a certain environment from a robot’s perspective.

The sensors and the RFID tags are all inexpensive, making the mass reproduction of the robot feasible and implementation practically possible for small firms. The RFID tags can be quickly attached or detached from an environment leaving no trace of their prior existence. A map can then be formed on a PC automatically by the robot through its detection of the tags.
This makes the entire system very flexible and quick to set up, something that is needed in the present day as changes to buildings and factories become more common.

There are still many improvements needed to improve the stability of the compass’s signal in the presence of magnetic fields, the stability of the wheels so that slippage is rare, and the range of the wireless signal and camera.

A flexible, easily configurable moving robot could be used to serve fields such as the medical field by transporting goods within a hospital, or in factories where goods need to be transported between locations. Since the system is flexible, and maps can be formed quickly, the robot can fit in with the changes to an industry’s environment and requirements. However, since the robot can only move to approximately five metres from the computer controlling it and the inaccuracy in sensor data, it is not currently ready for industrial use. For example, the sensors are only placed at 6 orientations around the robot and so do not cover a full span of the robots area. These sensors also only detect a two dimensional plane around the robot so could not detect obscure objects that have a part sticking out at height higher than the sensors. Therefore, further work is needed to be done to make the robot reliable, safe, and fault-proof before it could be used in industry.

Since the movement of the robot with inexpensive sensors and motors is bound to have problems in perfectly moving between RFID tags, due to small dead reckoning errors, simple algorithms are shown in this research that moves the robot around its current location until it finds a tag. These algorithms involve finding a path between two RFID tags that will make use of any tags in between them to localise itself and moving in a spiral to search for a tag when, due to odometry errors, it is not detected where it is expected to be.

The robot built has demonstrated being able to navigate between RFID tags within a small lab environment. It has proven to be able to avoid obstacles with a size of 30 x 30 cm.
Acknowledgements

In completing this master degree in mechatronics engineering, I would like to give my sincere appreciation and thanks to:

My supervisor Dr Liqiong Tang, who encouraged me at times of failure, gave useful advice, corrected errors, and guided and supported me to the completion of my project.

Christopher Kiesewetter, who made the initial design of the robot base and who was more than willing to help when asked for information.

Mark Deng, who accompanied me through the entire project, provided useful advice and encouraged me when progress was slow.

Bruce Collins and Anthony Wade, in the electronics workshop, for their useful advice, providing of electronics components, and producing of printable circuit boards.

Nick Look, for his help with networks, computer issues, and the rapid prototyping machine.

All the staff in the mechanical workshop for their advice and help in making mechanical parts.

The staff in the seat administration for their cheerful and friendly support in all the administrative matters needed in my project.

The Lord Jesus, for His supply enabling me to have the patience and ability to finish this research.
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<td>ADC</td>
<td>Analogue to Digital Converter</td>
</tr>
<tr>
<td>AGV</td>
<td>Automated Guided Vehicle</td>
</tr>
<tr>
<td>ASCII</td>
<td>American Standard Code for Information Interchange</td>
</tr>
<tr>
<td>DAC</td>
<td>Digital to Analogue converter</td>
</tr>
<tr>
<td>DTE</td>
<td>Data Terminal Equipment</td>
</tr>
<tr>
<td>EIA</td>
<td>Electronic Industries Association</td>
</tr>
<tr>
<td>GUI</td>
<td>Graphical User Interface</td>
</tr>
<tr>
<td>IC</td>
<td>Integrated Circuit</td>
</tr>
<tr>
<td>I2C</td>
<td>Inter-Integrated Circuit</td>
</tr>
<tr>
<td>MIPS</td>
<td>Million Instructions per Second</td>
</tr>
<tr>
<td>PAN</td>
<td>Personal Area Network</td>
</tr>
<tr>
<td>PC</td>
<td>Personal computer</td>
</tr>
<tr>
<td>PWM</td>
<td>Pulse Width Modulation</td>
</tr>
<tr>
<td>RFID</td>
<td>Radio Frequency Identification</td>
</tr>
<tr>
<td>USART</td>
<td>Universal Synchronous Asynchronous Receiver Transmitter</td>
</tr>
<tr>
<td>SCL</td>
<td>Serial clock</td>
</tr>
<tr>
<td>SDA</td>
<td>Serial data</td>
</tr>
<tr>
<td>TTL</td>
<td>Transistor-transistor logic</td>
</tr>
<tr>
<td>TWI</td>
<td>Two-wire Interface</td>
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