Wireless Indoor Mobile Robot with RFID Navigation Map and Live Video

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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.

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List of Abbreviations

ADC	Analogue to Digital Converter
AGV	Automated Guided Vehicle
ASCII	American Standard Code for Information Interchange
DAC	Digital to Analogue converter
DTE	Data Terminal Equipment
EIA	Electronic Industries Association
GUI	Graphical User Interface
IC	Integrated Circuit
I2C	Inter-Integrated Circuit
MIPS	Million Instructions per Second
PAN	Personal Area Network
PC	Personal computer
PWM	Pulse Width Modulation
RFID	Radio Frequency Identification
USART	Universal Synchronous Asynchronous Receiver Transmitter
SCL	Serial clock
SDA	Serial data
TTL	Transistor-transistor logic
TWI	Two-wire Interface