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Technology Review

Autonomous Robot Mapping

Introduction

Autonomous mapping with robots is a growing field involving both robotics and artificial intelligence. A robot equipped with sensors can explore areas that humans physically cannot while also recording data in ways that humans cannot. This data can be translated into a spatial map and used in many applications. This paper will summarize the applications of robot mapping, discuss the methods and algorithms that the robots use to create maps, and review the technology on mapping robots.

Applications of Robot Mapping

The key advantage to autonomous robot mapping is the use of the robot itself. Along with a multitude of sensors, robots can explore dangerous areas that humans would not want to risk their lives exploring. For instance, the military has used robots to map out and patrol hostile areas. If a soldier were to map the same area, he or she could be fired upon by enemy soldiers and killed. The life of that soldier is worth more than even the most expensive robots. Some commercial applications also involve robots mapping dangerous areas. Robots have been used in nuclear power plants to map out high-radiation areas following nuclear meltdowns. Following September 11, 2001, robots from the University of South Florida were used to explore and map out unstable tunnels in the World Trade Center. Robots have also been used to search volcanoes, meteorites in Antarctica, and map the sea bed. Other possibilities include robots used for mapping and other tasks. Currently there are warehouse systems in design that will map a warehouse, then use the same mapping robots to retrieve inventory that the workers specify.

Autonomous Mapping Methods and Algorithms

Autonomous robot mapping is a complex task that involves a sense of location and a method for exploration. While indoor mapping systems must find a relative frame of reference for location, many outdoor systems utilize GPS to record their absolute location and sensor data. These systems then take this information and integrate it into a spatial map. Because both robotic sensors and GPS have a degree of measurement error, almost all state-of-the-art autonomous mapping systems utilize a Bayesian probability

algorithm to infer information about objects and obstacles from the data. Many systems contain algorithms modified for their specific sensor types and sensor performance.

Robot mapping systems must also create an algorithm for exploring areas. These algorithms can range from basic to complex. The most basic algorithm is to start at a point, go straight until an obstacle is reached, and then return to that point and repeat. More complex algorithms may involve using probabilities to estimate where walls or obstacles are. The most efficient way to explore is the use of multiple robots. This allows the mapping to be divided and finished quicker. However, the use of multiple robots adds another layer of design to the system. Almost all multiple robots mapping systems require the robots to have some sense of relative location to the other robots. The system must also deal with integrating data from multiple robots which can lead to uncertainty when separate robot maps are pieced together. The Distributed Multi-robot Exploration and Mapping Group at University of Washington has designed an innovative system in which multiple robots will map out an area while actively searching for another robot to exchange sensor data with. After this exchange, the robots physically verify their integrated maps for increased accuracy then divide remaining areas for faster exploration.

Typical Mapping Robot Sensors and Parts

A typical robot used for autonomous mapping will require parts for location, movement, and recording data. Most outdoor systems use GPS receivers for locating the robot, while indoor systems use a combination of sensors and reference points. Kiva Systems Inc. has designed an indoor warehouse mapping system that uses barcodes glued to the floor. Indoor robots typically use wheels and motor to move around while a sturdier outdoor mapping robot may need treads such as those found on tanks to navigate bumpy terrain. All mapping robots have a distance sensor such as infrared or sonar and touch. Specialized mapping robots have sensors for their specific application. For example, robots mapping nuclear power plants would have radiation detectors. When multiple robots are used in mapping, a wireless communications medium such as WiFi must be added to each robot.

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