Navigation Systems for Autonomous Robots

Project Skills

Literature Review

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Abstract

This paper explores the problem of implementing an autonomous navigation system on a mobile robot using low cost equipment by critically analysing the current trends in mobile robotics. In the hobbyists robotics community there is a current lack of intelligent robots capable of simultaneously mapping and localising themselves within an environment. The work presented here builds upon the research of a past student at the Institute of Technology Blanchardstown who set out to create such a robot. In order to address that issue this paper looks at tracking a mobile robot's position within its environment using commodity mouse sensors sourced from Avago Technologies. It then goes on to discuss how a central agent can aid a mobile robot(s) in constructing a consistent map of its environment using the *FastSLAM* algorithm. Finally it looks at where such technology can actually be applied beyond the research lab.

Literature Review

Mobile robotics is one of the fastest growing research areas in computer science, it covers everything from humanoid robots such as Honda's ASIMO to the autonomous driving vehicles being developed by Google (Knight, W. 2013). And over the last few years a hobbyists robotics community has emerged as a result of affordable technologies such as the Arduino microcontroller (Poenar, S. 2013). The focus of this literature review is to explore the possibility of creating an autonomous robot that makes use of commodity equipment to map its surrounding environment.

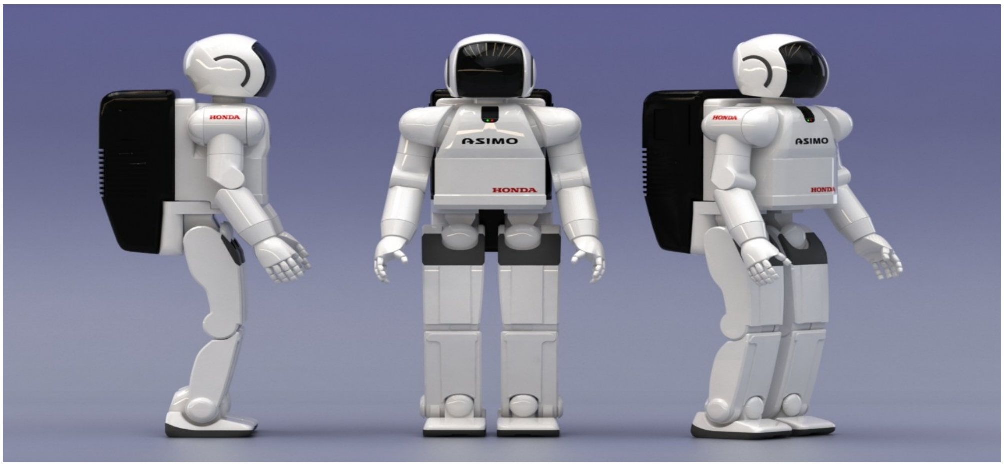

Illustration 1: Honda's ASIMO (Asimo – Honda Asimo Robot)

In May 2013 a fourth year student at the Institute of Technology Blanchardstown Sebastian Poenar (Poenar, S. 2013) set out to build an autonomous rover capable of navigating and mapping an indoor environment. The robot would use several internal sensors connected to an Arduino microcontroller (Poenar, S. 2013) to collect data about its physical surroundings, this information would then be processed on a host PC and from it a real-time map would be created.

Overall Sebastian's project fell short of its intended goal and many of the envisioned features remained unimplemented. The robot's behaviour was limited to wandering and recording the distance to any objects encountered. In all Sebastian's final result left much to be desired. Further efforts could have been made to construct a dynamic map from the data being recorded by the host, it this technical challenge that is the central focus of this project.

Odometry – Knowing Where We Are

A major issue faced by researchers in the field of indoor robotics is being able to determine how far the robot has travelled and its current orientation. Precise navigational systems such as GPS are not reliable in indoor environments and this has forced researchers to explore other options. One of the emerging trends investigated by Steven Bell uses an array of optical mouse sensors to track a mobile robots position and orientation. Steven Bell's approach is significant because it is inexpensive, it based upon commodity Avago Technologies mouse sensors (ADNS-2610 and ADNS-5060), and accurate, it doesn't suffer from issues such as wheel spillage as encoders do.

The solution proposed by Bell is designed to be implemented on a robot with a two wheel differential drive system but could be easily applied to Sebastian's model. The suggested implementation uses an array of six optical mouse sensors fitted with high magnification lens allowing the sensors operate centimetres above the surface rather than millimetres. The mathematical findings presented by Bell support the theory that it is possible to use the data from an array of mouse sensors to accurately track a robots *x* and *y* movement while also being able to calculate its orientation using the displacement data retrieved from the mouse sensors.

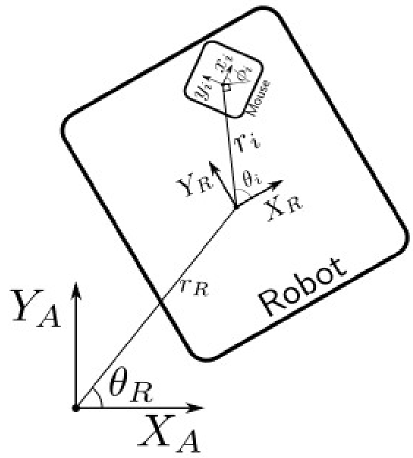

Illustration 2: Important frames of reference: absolute coordinates, robot coordinates, and mouse coordinates. (Bell, S. 2013)

Compared to other odometry solutions Bell's proposal is inexpensive, simple, and astonishingly accurate. However Bell's solution depends on the quality of the surface, it does no perform well on featureless surfaces and is limited to uniform environments where the distance between the ground and the sensor is constant. Both of these issues would not present a problem for an indoor mobile robot restricted to surfaces with uniform textures such as carpet.

Mapping an Environment

Something missing from Sebastian's work was a mapping algorithm capable of associating the data collected from the sensors with landmarks in a map. One such solution was presented in the research paper *Exploration with FastSLAM Technique.* Adão de Melo Neto et al. (2011) explored the feasibility of mapping an indoor environment with multiple vehicles controlled from a central agent using a occupancy grids and FastSLAM (Montemerlo, M & Thrun, S. 2003). The research was carried out in two groups of experiments, the first was conducted in a simulated *Player/Stage* (Brian P. Gerkey et al. 2003) environment, the second experiment focused collected data using a Microsoft Kinect (Stowers, J. et al. 2011) focusing solely on verifying the FastSLAM algorithm.

Adão de Melo Neto et al.'s research concluded that it is possible to efficiently map an indoor environment with multiple vehicles controlled from a central agent. It found that an increase in the number of vehicles led to a decrease in the time taken to map the environment. It also highlighted that as the number of vehicles increases so does the computational cost, which would need to be countered by an increase in the central agent's computing power. The solution presented in *Exploration with FastSLAM Technique* can be indirectly applied to Sebastian's original model which was based on a single vehicle mapping an indoor environment while communicating with a central host.

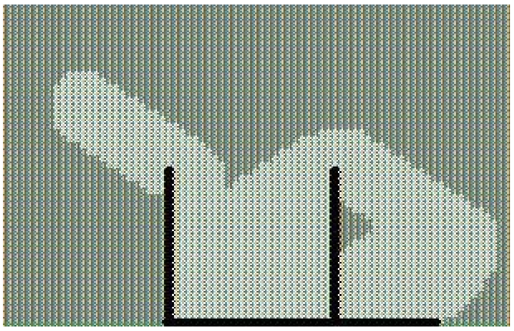

Illustration 3: An occupancy grid, the way a robot views its environment.
*(*Adão de Melo Neto et al. 2011)

A Real World Example

After discussing the current research trends in autonomous mobile robotics it is important to consider where this technology can actually be applied beyond the bounds of the research laboratory. One such application is autonomous driving vehicles, a subject discussed by Will Knight in the MIT technology review *Driverless Cars Are Further Away Than You Think*. Knight took the opportunity to test drive the latest autonomous prototype being developed by the German car manufacturing giant BMW. This self-driving prototype is capable of controlling steering, braking, and acceleration all on its own without any input from a driver. According to Knight car manufactures will be offering cars with such autonomy by the end of the decade.

From its own internal sensors the autonomous vehicle constructs a map providing it with a unique perception of the world around it. Scientist have predicted that such technology could reduce traffic accidents by up to 90%, saving 1.3 million lives a year (Knight, W. 2013). Knight concluded that while the technology is impressive it still has along way to go as it would have to be both flawless and ubiquitous. Despite this car manufactures have claimed that they will be offering cars with such autonomy by the end of the decade (Knight, W. 2013).

Illustration 4: Google's Self Driving Car (Google 500K miles Lexus)

Conclusion

From the research currently being undertaken in the field of mobile robotics it appears that it is more than possible to accurately map an indoor environment using inexpensive commodity equipment. Other research has supported the idea that a central agent can be used to build a consistent map freeing the exploration rover from the toughest computational complexities while also reducing errors caused by the robots limited perception.

Although the findings presented by Adão de Melo Neto et al. appear promising it is important to remember that their ideas were not applied to a real world model and were instead presented in simulations and controlled experiments. And while Steven Bell's research provides a solution based upon inexpensive sensors it to suffers from the fact it was based upon theory rather than experimentation. It will require a leap in technology for these systems to become as widespread as what Will Knight discussed. Further research should look at applying these findings to real world settings taking them out of the lab and into our world.

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