Implementing Monte Carlo Localization with the Lego Mindstorm

Senior Design Project  
Winter-Spring 2011

Seniors

Andrew Larger  
Zihao Lu  
Trevor Plassman  
Matt Schmucki  
Alicia Zwiebel

Advisor

Professor Dan Humpert

*Project Description*

**Purpose of the project:**

The purpose of this project is to explore the capabilities of the Lego Mindstorm and to program the Mindstorm to autonomously navigate through an environment.

**Specific objective or the project:**

The Lego Mindstorm is now running a version of Java instead of the software that came with the Lego kit. Using Java will enable us to use Monte Carlo Localization (MCL) to allow the robot to compute where it is within an environment with known boundaries and landmarks. Once the robot knows where it is, it will be able to autonomously navigate itself. Knowing where it is will allow the robot to avoid other boundaries and landmarks in efficiently and quickly.

**Scope or limits of the project:**

The scope of the project is focused on using only the Lego Mindstorm and MCL algorithms. By using products available specifically for the Lego Mindstorm, our group ensures that the robot remains cost effective. Third party sensors can be cost prohibitive and cause the group to focus on specifying the optimal sensors as opposed to optimizing the programming and imploring creative ways to use the sensors. Focusing on less important aspects of the robot can lead to scope creep which the group aims to eliminate while staying focused on the primary objective and means of obtaining the goals in place for the project.

*Description of Methodology to Complete the Project*

**Separating the project into tasks:**

1. Create a project objective.
2. Find seniors interesting in working on this project.
3. Research possible robotic systems that have the capabilities necessary for this project that are also cost effective.
4. After choosing a system, order the system.
5. Design and build a sensor testing platform to determine the accuracy of the sonar.
6. Use the sonar in the sensor testing platform to find the accuracy of the sensor.
7. Design and build a chassis that was versatile and capable of handling the weight of the motors as well as the NXJ brick. This included developing a zero point turn wheel to make the robot more versatile.
8. Create a program that will cause the robot to move in basic directions. This will show whether the motors can handle the chassis and provide the type of control that is required for this project.
9. Create a program that integrates the sonar and the motors. This will show that the Lego brick is capable of taking an input signal and decide what to do with the output signal.
10. Create a quarterly report showing our progress.
11. Research similar projects to see what methods worked best. The goal is to expand on already existing methods, not to reinvent the wheel.
12. Design and build a test environment in which the robot will autonomously navigate.
13. Create a program that begins to find distances to landmarks in every direction. Having the robot make perfect turns will increase its efficiency.
14. Research the best way to have the MLC algorithms predict where the robot is located and how points will be eliminated.
15. Add MCL algorithms into the programming of the robot.
16. Troubleshoot any issues that the robot may have.
17. Optimize the robot’s programming to compensate for the issues the robot experienced in previous tests.
18. Repeat steps 15-17, working out any problems in countered for the optimization of the performance of the autonomous system.
19. Provide a full demonstration of the capabilities of the autonomous robot.

**Delegating and assignment of tasks:**

Tasks are delegated when projects can be divided and worked on at the same time. Group members who are interested in a particular task volunteer to complete it. At one point, a group member was gathering supplies for the sonar testing environment, one was trying to locate a meter stick, and another was trying to install Java onto the Lego brick. For future programming tasks, each group member will work on different solutions to the same problem. If several members are able to find different solutions, our group has a better chance of finding the best solution.

*Schedule*

**Work tasks completed—history project:**

1. Create a project objective. **– Completed 12/6/2010**.
2. Find seniors interesting in working on this project. **– Completed 1/17/2011**.
3. Research possible robotic systems that have the capabilities necessary for this project that are also cost effective. **– Completed 1/19/2011**.
4. After choosing a system, order the system. **– Completed 1/21/2011**.
5. Design and build a sensor testing platform to determine the accuracy of the sonar. **– Completed 1/31/2011**.
6. Use the sonar in the sensor testing platform to find the accuracy of the sensor. **– Completed 2/7/2011**.
7. Design and build a chassis that was versatile and capable of handling the weight of the motors as well as the NXJ brick. This included developing a zero point turn wheel to make the robot more versatile. **– Completed 2/14/2011**.
8. Create a program that will cause the robot to move in basic directions. This will show whether the motors can handle the chassis and provide the type of control that is required for this project. **– Completed 2/21/2011**.
9. Create a program that integrates the sonar and the motors. This will show that the Lego brick is capable of taking an input signal and decide what to do with the output signal. **– Completed 2/28/2011**.
10. Create a quarterly report showing our progress. **– Completed 3/7/2011**.

**Current work tasks including estimated time to finish:**

1. Research similar projects to see what methods worked best. The goal is to expand on already existing methods, not to reinvent the wheel. – Due to be completed 3/28/2011.
2. Design and build a test environment in which the robot will autonomously navigate. – Due to be completed on 4/4/2011.

**Future work tasks:**

1. Create a program that begins to find distances to landmarks in every direction. Having the robot make perfect turns will increase its efficiency.
2. Research the best way to have the MLC algorithms predict where the robot is located and how points will be eliminated.
3. Add MCL algorithms into the programming of the robot.
4. Troubleshoot any issues that the robot may have.
5. Optimize the robot’s programming to compensate for the issues the robot experienced in previous tests.
6. Repeat steps 15-17, working out any problems in countered for the optimization of the performance of the autonomous system.
7. Provide a full demonstration of the capabilities of the autonomous robot.

*Conclusion/Summary*

**Preliminary findings:**

* Java is more powerful than the software that came with the Lego kit. Installing Java was the best programming move our group could had made. It is open source and well documented. The internet is full of examples showing how to use Java to perform complex tasks.
* The Lego Mindstorm provides our group with a powerful processing unit for a relatively cheap price. This is important because if our group is able to navigate an area with low end sensors, then this method can be applied to much larger applications.

|  |  |
| --- | --- |
| 20110310125646  Figure 1 - This image shows the light weight chassis for the robot. The sonar is at the front of the vehicle to enable a clear reading. | 20110310125704  Figure 2 - This image shows the ball bearing pivot wheel. The white cylinder is a wheel hub with a marble sitting inside of it. |