Computer Science 148: Final Project Proposal

Master-Blaster Robot Proposal

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1. Overview

This document describes a system of two robots that will be constructed for the CS148 final project. The concept for the two robots is based loosely on the feeding behavior of bees and has been dubbed "Master-Blaster" after the characters that ran the methane plant at Bartertown in *Mad Max Beyond Thunderdome*. The Master robot will originate at a "nest" and find a path to a light-emitting coffee cup using a line on the floor. It will then retrace its path back to the nest, where it will communicate the path that it discovered to the Blaster robot. Blaster will then follow the path charted by Master, find the coffee cup using its short-range sensors, pick up the cup, and return to the nest.

The design of the robots will combine a several ideas introduced in class with a number of new concepts, such as path encoding and backtracking, path communication, and object acquisition (through hand-eye coordination) and transportation. The two robots will combine to create a reasonably complex system, but the work involved in building them and designing their software should still be manageable because of the work already done for previous assignments. The task of developing the two robots is expected to take about four weeks because of the challenges involved and the potential for error.

Figure 1: Bee performing dance to communicate pollen location to another bee.

Figure 2: Master-Blaster from *Mad Max Beyond Thunderdome*

2. Robot Description and Development Approach

The Master-Blaster system will start with a calibration phase, after which the two robots will be placed in their "nest" with their infrared ports facing each other. The Master robot will be facing in a direction such that it can find the line to follow by simply driving straight. After finding the coffee cup and returning the to nest, Master-Blaster will switch positions, and Blaster will seek to acquire the cup. A sample starting position for Master-Blaster is shown in **Figure 3**.

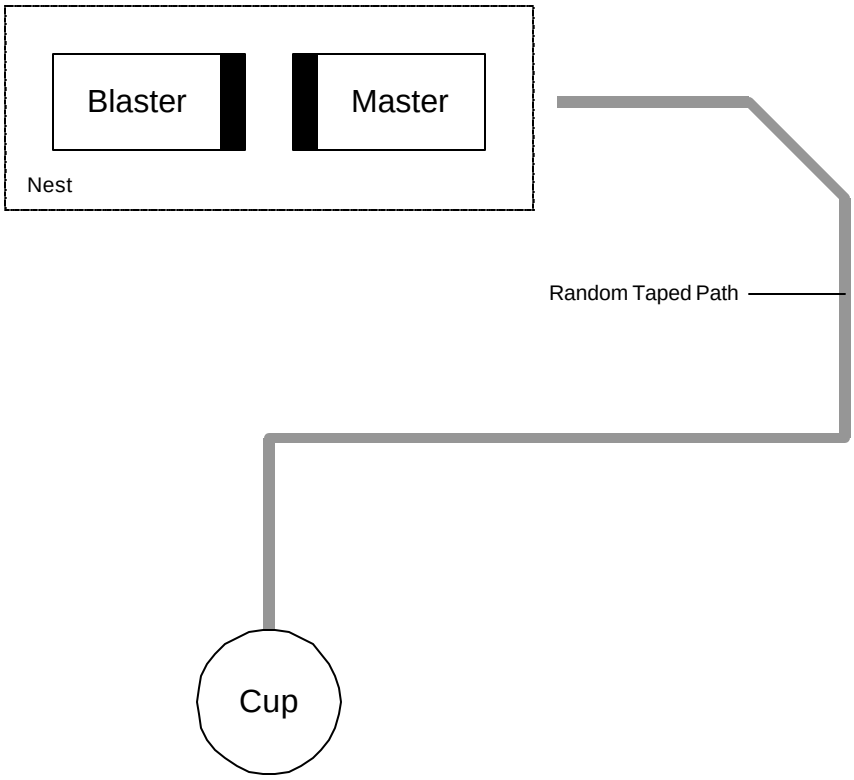

Figure 3: Sample starting position for Master-Blaster.

Since the Master robot will be responsible for following the line and encoding the path, it will need to use the following equipment:

- Two motors for locomotion
- One downward-facing light sensor for line detection
- Two rotation sensors for path encoding
- One touch sensor to for short-range bait detection

The robot will probably use a skid-steer drive system with two large wheels and a supporting stub. The rotation sensors will also be attached to the drive gear train using a higher gear ratio than the wheels themselves. The light sensor will be pointed downwards towards the floor and will be shielded adequately. A preliminary mechanical design for Master is shown in **Figure 4**.

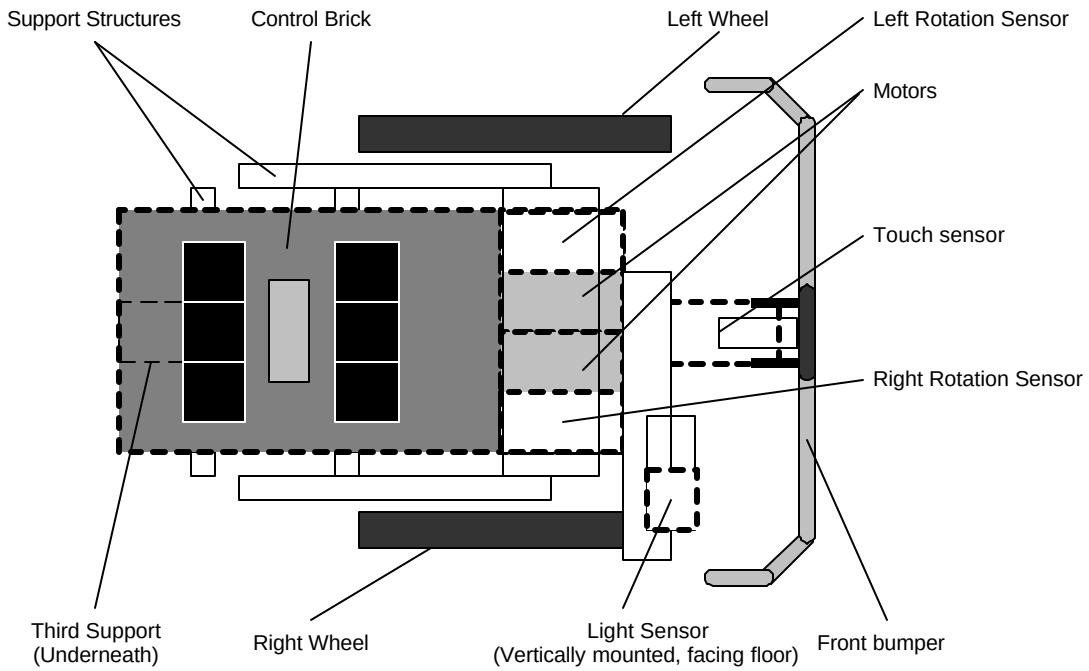

Figure 4: Master robot design, top view.

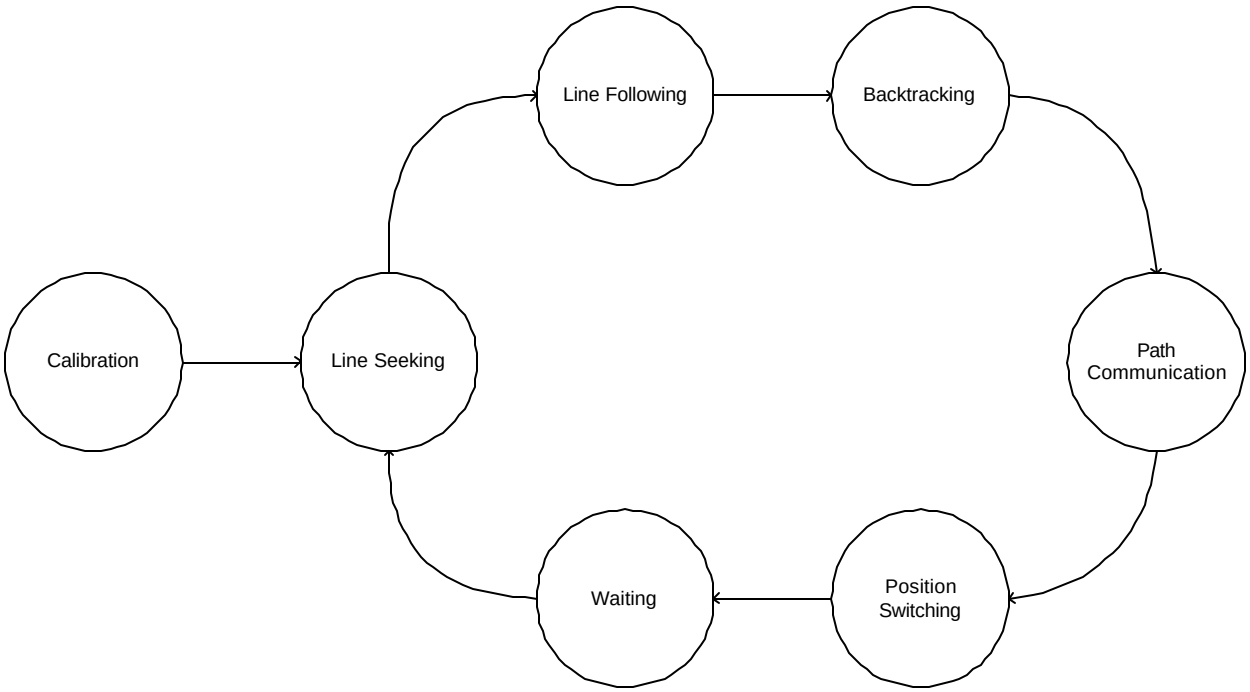

Figure 5: Master software state machine.

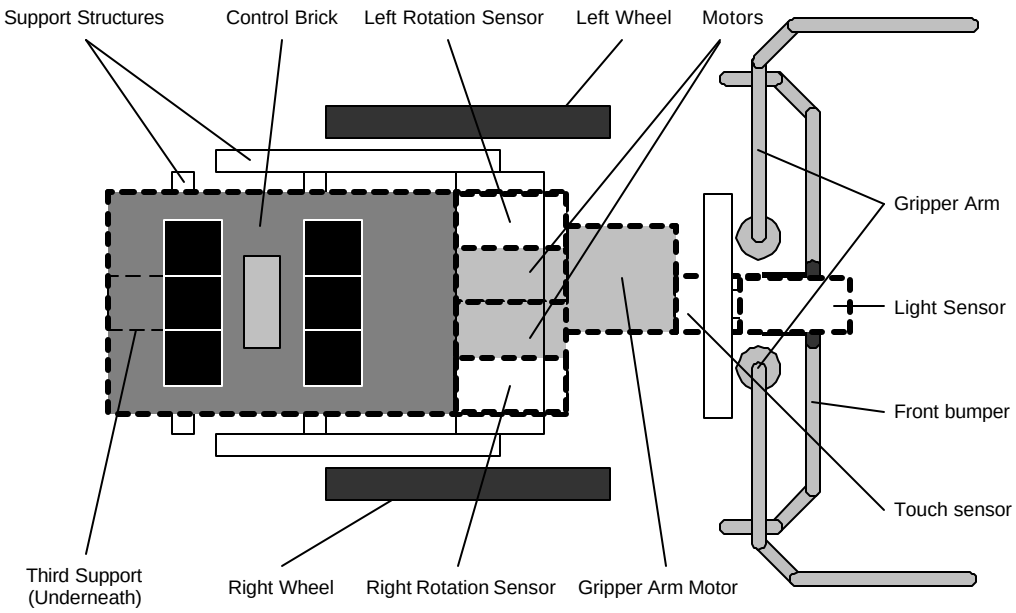

Figure 6: Blaster robot design, top view.

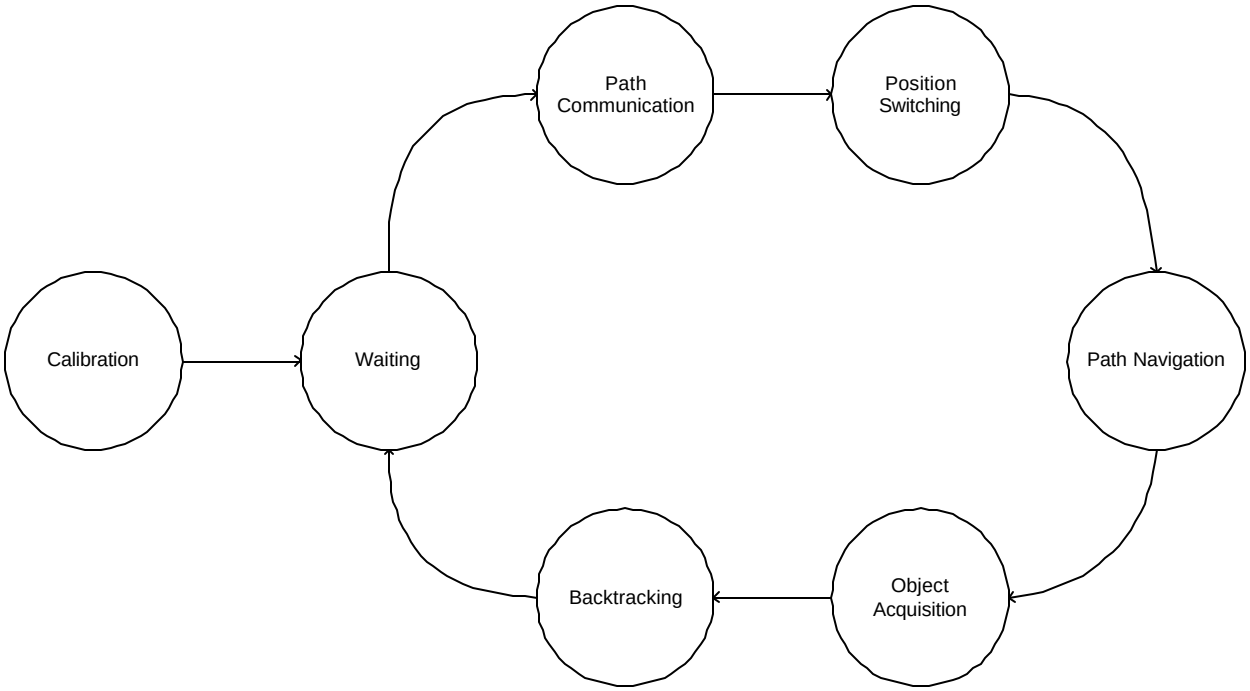

Figure 7: Blaster software state diagram.

The Master robot software will probably be designed around a state machine. A possible state machine is illustrated in **Figure 5**. The code will include algorithms for locomotion, line following, path encoding, object detection, backtracking, error correction, and communication. The path encoding algorithm will probably involve the largest amount of work. The designers currently plan to use a data structure consisting of a large array or linked list of individual instructions. The instructions would consist of either going straight for a certain distance or turning right or left by a certain number of degrees.

In order to carry out its responsibilities as the retriever of the cup, the Blaster robot will need to use the following equipment:

- Two motors for locomotion
- Two rotation sensors for path decoding
- One motor for opening and closing gripper arm
- One forward-facing light sensor for short-range bait detection
- One touch sensor for short-range bait detection

To make path encoding and decoding more straightforward, the motor and rotation sensor placement on Blaster will be identical to the motor and rotation sensor placement on Master. The motor for opening and closing the gripper arm will probably be placed near the front of Blaster, and the light and touch sensors will be placed near the gripper arm so that can be well-suited to help with the task of gripping. A preliminary mechanical design for Blaster is shown in **Figure 6**.

The Blaster robot's software architecture will probably be extremely similar to that of the Master robot, and it will probably even share some of the same code, such as the functions for locomotion and backtracking. A possible state machine for Blaster is shown in **Figure 7**. That code will include algorithms for communication, locomotion, path decoding, error correction, object detection, and object acquisition through hand-eye coordination. The path decoding algorithm and the hand-eye coordination algorithm will probably involve the largest amount of work. The path decoding algorithm will use the same data structure as the path-encoding code on Master. The hand-eye coordination code will probably involve a large amount of empirical work. A preliminary mechanical design for Blaster is shown in .

3. Demonstration Milestones

The Master-Blaster project will seek to meet two separate demonstration milestones: a **preliminary demonstration** and a **final demonstration**. The development schedule will be structured so that both robots will have been built by the date of the preliminary demonstration. In addition, the robots software will incorporate the following functionality:

- **Line-following**: By the date of the preliminary demonstration, Master will be able to calibrate its light sensor, seek a line on the floor, and follow it until it senses the coffee cup on its bump sensor.
- **Backtracking**: Master will also be able to retrace its steps backwards, returning to within a foot of its point of origin after an arbitrary journey of reasonable length. The same code will also be used in the Blaster robot.

- **Distance measuring**: Both robots will have rotation sensors attached to their motors, which they will use to make sure that they travel the same distance, regardless of relative motor speeds and battery levels.
- **Path communication using infrared port**: After returning from seeking, Master will be able to locate the IR port of Blaster using its bump sensor or its IR port. It will send Blaster data about the path that it traveled.

By the final demonstration, Blaster must also be completed. In addition to the tasks listed above, the final demonstration will demonstrate:

- **Position switching**: Configuring Master and Blaster to switch positions before having Blaster seeks the coffee cup will be an algorithmically simple but empirically vigorous task.
- **Path following**: Blaster will be able to follow the path sent by Master.
- **Error correction**: Both Master and Blaster should be able to follow the line fairly accurately based on the path first charted out by Master.
- **Object acquisition and hand-eye coordination**: After following the path charted out by Master, Blaster should be able to find the coffee cup with its bump and light sensor, grasp it using its robotic arm, and transport it back to the nest using the Backtracking mode. If it is unable to find the coffee cup, it should be able to find its way back to the nest empty-handed.
- **Goal acknowledgement**: After returning to the nest, Blaster will signal Master, which will either play a tune indicating success or play another tune indicating failure.

4. Potential Problems

The designers expect to run into several possible problems during development, including:

1. **Path encoding difficulties**: Irregularities in the environment and sensor inaccuracies may make it difficult to encode the path accurately and follow it without veering. Small deviations may multiply over the course of the path, resulting in large cumulative errors. Hopefully, the error correction algorithms in the robot will eliminate this issue.
2. **Precise locomotion**: Because of the importance of path following and backtracking in the system, the locomotion of the two robots will have to be controlled extremely carefully. Addressing this issue will require a large amount of empirical testing.
3. **Additional weight of object, and weight difference between Master and Blaster**: The additional weight of the coffee cup may have strange effects on the backtracking code, since it will make Blaster at least a little slower than Master. Hopefully, the rotation sensors will be able to measure the distance traveled accurately.
4. **Infrared communication**: Relying on infrared communication may be tricky. If Master deviates from its path during backtracking, it may not be able to find Blaster again, and vice versa. The error correction code should limit the risks involved in seeking infrared ports.

5. Additional Equipment Needed

In addition to the items included in the original kit, the Master-Blaster project will need the following Lego pieces:

- Additional control brick
- Three additional motors
- Two additional rotation sensors

The project will also need a light-emitting coffee cup that's reasonably heavy. This can probably be constructed by punching a hole in a coffee cup and putting a small light inside.

6. Requested TAs

The designers would like to request Colin's guidance in this project. If Colin is unavailable, Chris would be a fine alternate. Either of the other two TAs would also be great.