Improving the Mobility of a 3D Printed Robot for Search and Rescue Operations

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Emu Mini 2
Originally part of the Open Academic Robot Kit
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Parts:
- Raspberry pi 2B
- Open CM 9.04 Board
- Lipo Battery
- External Battery Pack
- Dynamixel Servos
- Wireless LAN Adaptor
- Bluetooth Adaptor
Standard Test Methods

Test methods measure performance of robot capabilities

Continuous Ramps
Gravel
Crossing Ramps
Hurdles
Collecting Data Procedure

Test methods measure performance of robot capabilities
Initial Data Collection

Collected by running tests on the test methods

**Meters per Minute for Emu Mini 2 on Test Methods**

- **Continuous Ramps**: 6.6
- **Gravel**: 11.7
- **Crossing Ramps**: 3
- **Hurdles**: 1.7
Modifications

Improving on the Emu Mini 2’s original design

- Pros
  - Wheel servos move reliably
  - Pretty long distance
  - Bluetooth and video streaming
  - Good camera quality
  - Accurate turns

- Cons
  - Servos are loud
  - Camera and arm servos not reliable
  - Limited view
  - Limited camera movement
  - Wheel friction

- Improvements
  - New tracks
  - Rotating arm
  - Different camera
  - Base modification
    - More space for wires
    - Put on gears
    - Better organization
    - Allows for full rotation

- Flat ground testing

- Tracks
  - Size of wheels
  - Most variables
  - Good for data collection
Re-Designs

Created new designs using SketchUp

TRIAL 4: 54 links, Radius: 88 (tighter than original) with web
New Design: Tracks

New designs created from modifications
New Design: Wheels

New designs created from modifications
3D Printing: Setup
Prepared the new designs using cura
3D Printing: Moving to the Printer

Printed the new designs using a Lulzbot Taz 4 printer
Tracks
Tracks designed to increase surface contact and traction
Wheels

Wheels designed to climb over hurdles and increase tread depth
Secondary Data Collection

Collected by running tests with the tracks and new wheels

![Meters Per Minute on Test Methods](chart)

- **Continuous Ramps**
  - Old Wheels: 10.9
  - Tracks: 11.2
  - New Wheels: 12.8

- **Gravel**
  - Old Wheels: 11.9
  - Tracks: 9.6
  - New Wheels: 10.4

- **Crossing Ramps**
  - Old Wheels: 5.8
  - Tracks: 12.8
  - New Wheels: 15

- **Hurdles**
  - Old Wheels: 3.9
  - Tracks: 9.1
  - New Wheels: 10.3
Emu Mini 2: Meet Lauren

Second Emu Mini 2 (Robot 2) created for secondary testing
# Differences Between Robots

Differences that may account for performance differences

<table>
<thead>
<tr>
<th>Robot 1 (Ralph)</th>
<th>Robot 2 (Lauren)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Controlled by Raspberry Pi</td>
<td>• Controlled by CM-530 board</td>
</tr>
<tr>
<td>• Raspberry Pi camera</td>
<td>• Mofek wifi camera</td>
</tr>
<tr>
<td>• Needs backup battery</td>
<td>• Does not need backup battery</td>
</tr>
<tr>
<td>• Arm controlled by AX-12 servo</td>
<td>• Arm controlled by MX-64 servo</td>
</tr>
<tr>
<td>• Original arm, rest, shoulder design</td>
<td>• Re-designed arm, rest, shoulder design</td>
</tr>
<tr>
<td>• Average Speed: 15.7 m/min</td>
<td>• Average Speed: 16.5 m/min</td>
</tr>
</tbody>
</table>
Track Data Collection

Collected by running tests with both Emu Mini 2 robots

Meters Per Minute Using Tracks

<table>
<thead>
<tr>
<th>Category</th>
<th>Tracks, 1</th>
<th>Tracks, 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous Ramps</td>
<td>11.2</td>
<td>11.9</td>
</tr>
<tr>
<td>Gravel</td>
<td>9.6</td>
<td>11.7</td>
</tr>
<tr>
<td>Crossing Ramps</td>
<td>12.8</td>
<td>12.3</td>
</tr>
<tr>
<td>Hurdles</td>
<td>9.1</td>
<td>9.7</td>
</tr>
</tbody>
</table>
Wheel Data Collection
Collected by running tests with both Emu Mini 2 robots

Meters Per Minute Using New Wheels

<table>
<thead>
<tr>
<th>Condition</th>
<th>New Wheels, 1</th>
<th>New Wheels, 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous Ramps</td>
<td>12.6</td>
<td>15.7</td>
</tr>
<tr>
<td>Gravel</td>
<td>10.4</td>
<td>13.8</td>
</tr>
<tr>
<td>Crossing Ramps</td>
<td>10.3</td>
<td>15.2</td>
</tr>
<tr>
<td>Hurdles</td>
<td>11.5</td>
<td>15.2</td>
</tr>
</tbody>
</table>
Conclusion
Discussion and next possible steps

• Best mobility combination: New Wheels + Robot 2 (Lauren)

• Second robot was better because of lower weight

• Actual tests are run via remote operations

• Next step: Run tests remotely and compare results between the different cameras and different robots