Assignment 4

1. Read the “Miniature Robos for Space and Military Missions” article in Section 10 of the Bulkpack. Identify three common technological needs of space and military robots.

   a) Autonomy in navigation: Planetary robots must be autonomous because of the long communication time. Military robots because the soldier cannot afford to be caught up with the task of controlling a robot. 1 command per 100 m. traveling at 1 m/sec. Planetary robots are much slower, but the communication time is proportionately higher.

   b) Traversal of uneven, unstructured (i.e. no roads) terrain: decimeter-scale rubble and 25 cm steps for military robots. Similar terrain (except for steps) for planetary robots.

   c) Packaging constraints: Size, weight, and power source constraints dominate the design of both types of robots.

2. Mobile Robot Design Space

   a) Draw a two-dimensional graph with the following axes:
   - Size (characteristic length, or if you prefer, volume or mass)
   - Degree of intelligence/autonomy

   b) What units could be used for the intelligence/autonomy axis?

   c) Plot the following mobile platforms on the graph
   - Your car
   - Nanorover: http://robotics.jpl.nasa.gov/tasks/nrover/homepage.html
   - Urbie (referred to as “TMR Prototype” in figure 7 of the article) http://www.isr.com/research/urban.html
   - Two other examples of mobile robots you find appropriate.

![Intelligence in Vehicles](image_url)

<table>
<thead>
<tr>
<th></th>
<th>Size (kgs)</th>
<th>Intelligence (KB/sec.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>1000</td>
<td>1</td>
</tr>
<tr>
<td>Sojourner</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>Nanorover</td>
<td>0.1</td>
<td>100</td>
</tr>
<tr>
<td>TMR Urby</td>
<td>20</td>
<td>5000</td>
</tr>
<tr>
<td>Helpmate</td>
<td>50</td>
<td>10000</td>
</tr>
</tbody>
</table>
3. Suppose a mobile robot has a top speed of $S$ (m/s) and can brake at $B$ (m/sec$^2$, $B<0$). We want to design the obstacle avoidance system so that, when the robot is cruising along and its sensors detect an impassable obstacle ahead, it can slam on the brakes and stop short of hitting the obstacle. How far ahead does the sensor system need to look?

**Solution**

The time for the mobile robot to come to a complete stop is $\Delta T$ given by:

$$S = B \Delta T$$

Clearly the distance traversed in this time is:

$$D = S \Delta T - 0.5 B (\Delta T)^2$$

<table>
<thead>
<tr>
<th></th>
<th>$S$ (m/s)</th>
<th>$\Delta T$ (secs.)</th>
<th>$B$ (m/s/s)</th>
<th>$D$ (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVHS (cars)</td>
<td>24</td>
<td>4</td>
<td>6</td>
<td>48</td>
</tr>
<tr>
<td>Urby</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Demo III</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td>9</td>
</tr>
</tbody>
</table>

4. Wheeled platforms perform well on relatively smooth terrain. For rough terrain, what alternative mobility mechanisms could be considered? For each of the following, identify a terrain for which it is particularly well suited.

- Your car
- Urbie: [http://www.isr.com/research/urban.html](http://www.isr.com/research/urban.html)
- Dante walking robot: [http://img.arc.nasa.gov/dante/dante.html](http://img.arc.nasa.gov/dante/dante.html)
- All terrain wheelchair: [http://www.cis.upenn.edu/~venkat/wheel.html](http://www.cis.upenn.edu/~venkat/wheel.html)

5. Read Arkin’s view of intelligent mobile robot control: Chapter 16 [SN 99]. What is the main difference between symbolic and reflexive control? (See Figure 1 and the discussion surrounding it). What kind of control would you use

- For automated highway driving or automated landing and takeoff of unmanned aircrafts or helicopters?

Given the unstructured environment, it is vital to have a reactive component. Keep in mind that the reactions to changes in environment have to be really quick. This in turn means that you cannot afford to spend time on computations and building models. Points to reactive behavior or symbolic control. However, there is a nominal plan that may be based on symbolic control.

- For AGVs required to deliver parts to machines and transport finished products to the automated storage and retrieval system?

The trajectories can be completely preplanned and therefore symbolic (deliberative).

- For an autonomous mobile robot with sensors that you might employ to guard the perimeter of a warehouse against intruders.

Assignment 6

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A combination of deliberative and reflexive. There maybe a deliberative component to the beat of the sentry that depends on the model of the environment, but a reactive component that might let it investigate an intruder or a breach of security.

Assume flat terrain in all cases.