Overview
**Materials:**

Use USB camera was attached to the ebox to detect objects in the vicinity of the robot arm. If an object of a predetermined type is detected (e.g. red pyramid) it should be picked up by the arm and moved to a designated location.

<table>
<thead>
<tr>
<th>Materials</th>
<th>Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical Arm (Lynxmotion)</td>
<td>OpenCV 2.1 Libraries</td>
</tr>
<tr>
<td>Ebox 3300</td>
<td>Ubuntu 10.04</td>
</tr>
<tr>
<td>Dynex Camera 1.3 MP</td>
<td></td>
</tr>
<tr>
<td>Mbed MCU</td>
<td></td>
</tr>
</tbody>
</table>
Object Detection via OpenCV
Displacement analysis – planar serial robots

RRR robot – reverse displacement analysis

Given: $p_{1e}, \phi_e$

Find: $\theta_1, \theta_2, \theta_3$

Solution:

\[ s_2^{(\pm)} = \pm \sqrt{1 - c_2^2} \]

\[ \theta_2^{(\pm)} = \text{ATAN2}(s_2^{(\pm)}, c_2) \leftarrow \text{answer} \]

\[ c_1 = \frac{\begin{vmatrix}
    x_{1e} - a_3 c_e & -a_2 s_2 \\
    y_{1e} - a_3 s_e & a_1 + a_2 c_2 \\
  \end{vmatrix}}{\Delta}, \quad \Delta \neq 0 \quad \text{(Cramer's rule)} \]

\[ s_1 = \frac{\begin{vmatrix}
    a_1 + a_2 c_2 & x_{1e} - a_3 c_e \\
    a_2 s_2 & y_{1e} - a_3 s_e \\
  \end{vmatrix}}{\Delta}, \quad \Delta \neq 0 \quad \text{(Cramer's rule)} \]

where, $\Delta = a_1^2 + a_2^2 + 2a_1 a_2 c_2$

\[ \theta_1 = \text{ATAN2}(s_1, c_1) \leftarrow \text{answer} \]

\[ \theta_3 = \phi_e - \theta_1 - \theta_2 \leftarrow \text{answer} \]
Displacement Analysis Simulation
Hardware Challenges

- Due to the wrong springs being shipped, they had to be removed to ensure the proper working of the algorithm. (This results in a higher current draw)

- Each servo has different offset (0 degs is not always 1ms)
- Portable battery can only operate 4 servos
OS Challenges

- Ubuntu installation for ebox (10.04)
  1. Version 9.10 and 10.10 did not work
- Network Driver r6040.ko (requires mii.ko)
- OpenCV installation (illegal instructions)

- RT response is affected by desktop Ubuntu
- SD Card installation was not successful
<table>
<thead>
<tr>
<th>Week</th>
<th>Task</th>
</tr>
</thead>
</table>
| Week 1| Ubuntu Installation  
Tried different version and settled with Ubuntu 10.10 |
| Week 2| OpenCV installation.  
Could not get CV 2.0 on ebox uses 2.1  
Getting arm to work on coordinates.  
Failed installation of Ubuntu on SD card |
| Week 3| Writing OpenCV code  
Testing and simulation |
Future Work:

- Detect objects of different colors
- Detect objects of different shapes
- Program the ebox to control the bottom motor in order to pick up unaligned objects.
- Research a way to power all the motors of the arm with a portable battery (must meet current and voltage specifications).