Homework: v-rep Assignment 2 Solutions

1. A v-rep simulation scene with the RR manipulator is at:
   `http://crrl.poly.edu/EL5223/RR_vrep_scene.ttt` .

   Code to interact with v-rep can be written in any of the programming languages supported by v-rep; the v-rep remote API is essentially the same in any of the languages. For example, codes in Matlab and Python to interact with the RR manipulator are linked below:

   - Matlab: `http://crrl.poly.edu/EL5223/vrep2_matlab.zip`
   - Python: `http://crrl.poly.edu/EL5223/vrep2_python.zip`

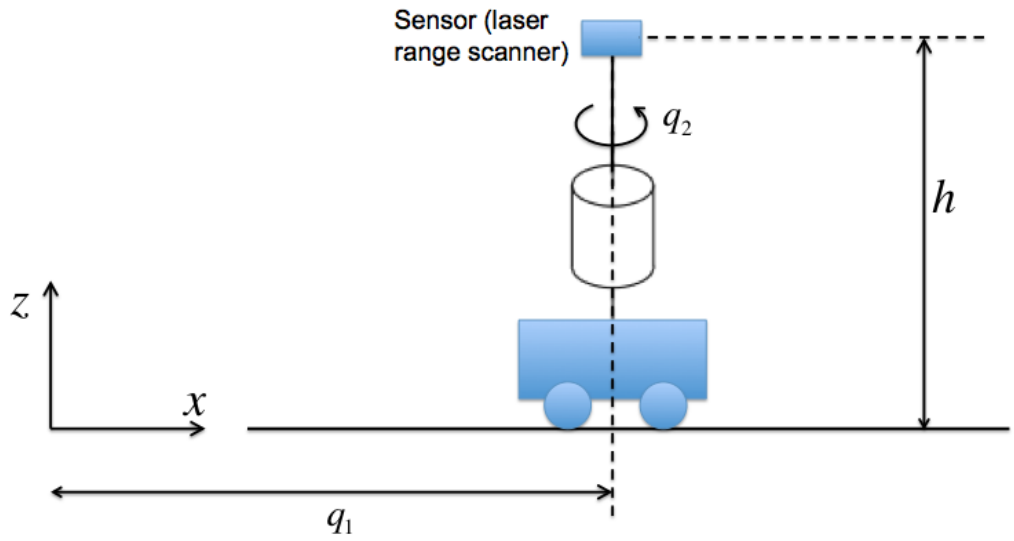
   In each of these languages, v-rep provides API support files (remApi.m and remoteApiProto.m for Matlab; vrep.py and vrepConst.py for Python). Also, v-rep provides a dynamically loaded library (.dll or equivalently a .so file in Linux and a .dylib file in Mac OS X) to interact with v-rep. See the README.txt files in each of the zip files linked above for the Matlab and Python versions.

2. Since the measured point locations are relative to the sensor, they need to be converted to a world frame (i.e., frame 0 or base frame) to build an environment map. If the sensor provides a three-dimensional reading of a point location in the environment relative to the sensor as $p^s = dv$, then this point representation can be converted into world frame as $p^0 = H_s^0 p^s$ where H_s^0 is the 4×4 homogeneous transformation matrix from the sensor-attached coordinate frame to the world frame. Here, if the sensor-attached coordinate frame has Z axis pointing up and X axis parallel to the base frame X axis when $q_2 = 0$, then we have

$$H_s^0 = \begin{bmatrix} c_2 & -s_2 & 0 & q_1 \\ s_2 & c_2 & 0 & 0 \\ 0 & 0 & 1 & h \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{1}$$

   where $c_2 = \cos(q_2)$ and $s_2 = \sin(q_2)$.

   If a sequence of measurements $p_i^s, i = 1, \ldots, N$, is available from the laser range scanner over a time horizon, then if the time stamp of each reading p_i^s is t_i and if the joint angles at time t_i are q_{1i} and q_{2i}, then the set of points converted to world frame would have coordinates $p_i^0 = H_{s,i}^0 p^s$ where $H_{s,i}^0$ is the homogeneous transformation matrix from (1) with $q_1 = q_{1i}$ and $q_2 = q_{2i}$. This set of points would provide a world map constructed using the sequence of sensor readings over a period of time.



3. A Matlab program to build a map of the environment is at:
   `http://crrl.poly.edu/5223/sim_manipulator1.m`
   `http://crrl.poly.edu/5223/run_sim.m`

   The Matlab program `run_sim.m` calls `sim_manipulator1.m`. Hence, running `run_sim.m` is sufficient. The simulation must be started in v-rep before running this Matlab program.

   The constructed environment map is shown in the 2-D and 3-D plots below.