1. Closed loops in pose networks

WALL-E has picked up a compressed block of trash, and forms the pose network illustrated on the right.

a. Write out $T_{LS}^G$ and $T_{LS}^W$ as compositions of the transforms above.

b. Write $T_{RH}^W$ and $T_{RH}^G$ as compositions of the transforms above.

c. Let $M$ be the composition given by

$$M = (T_{GLH}^L)^{-1} (T_{LS}^B)^{-1} T_{RS}^B T_{RH}^T T_{RH}^G$$

What must be the rotation matrix and translation vector of $M$?

2. Basic Turtlebot control in Python

Look over the finished starter code for Project 1 at

https://github.com/swatbotics/e28-f2016-project1/blob/master/scripts/starter.py

Note that the states and state transitions have been changed slightly to take account of Gabe’s suggestions in class on Thursday.

a. What are the possible states of the robot? List all values that can be stored in the the self.state member variable in this program. Hint: the self.cliff_alert variable tracks whether the robot has been picked up, and is independent of the state.

b. For each state, what are all of the ways the robot might transition into that state? For each way of getting into that state, is it automatic, or in reaction to an external stimulus?

For example, the only way to enter state ‘turn_right’ is in reaction to a left bumper hit, inside of the sensor_callback function.

c. Draw the state diagram corresponding to the finished starter code.
Two robots $A$ and $B$ are situated in the plane as depicted above. Robot $A$ is carrying a light $L$, and robot $B$ is carrying a camera $C$, both of which are rigidly attached to the robots. The relative transformations from each robot to its respective payload can be obtained by translating forward 0.25 m along each robot’s $x$-axis.

The motion of robot $A$ in the world frame is given by

$$x(t) = 0.5 + 2 \sin \left( \frac{\pi t}{10} \right), \quad y(t) = 2 \cos \left( \frac{\pi t}{10} \right), \quad \theta(t) = -\frac{\pi t}{10}$$

and the motion of robot $B$ is given by

$$x(t) = 3.5 + 0.25 \cos \left( \frac{7\pi t}{6} \right) t, \quad y(t) = 2.0 + 0.25 \sin \left( \frac{7\pi t}{6} \right) t, \quad \theta(t) = \frac{7\pi t}{6}$$

a. Define the rigid transformations $T^W_A$, $T^W_B$, $T^L_A$, and $T^C_B$ at time $t = 0$ in terms of their rotation matrix $R$ and translation vector $t$. You should explicitly write out all of the matrix and vector elements (although it’s ok to leave the cos and sin terms in).

b. Draw the pose network graph corresponding to the transforms listed above.

c. What composition of the transformations above maps coordinates from the frame of robot $A$ to the frame of the camera?

d. Write a computer program to plot the position of the light $L$ in the coordinate frame of the camera $C$ as a function of time. You should have two separate plots $x(t)$ and $y(t)$ with $t$ ranging from 0 to 5 seconds. Submit printouts of your code and the graphs.

2