HW4: MOTOR EXPERTISE

Vempati Anurag Sai
Y9227645

Of the various instructions discussed in 2011 HW on "Instructions for a robot to write with a pencil", the following 2 seemed particularly too complex to be achieved by a present day robot:

1. Rotate point of contact between I-affector and object, about axis defined by line passing through points of contact of M and T affectors (with object), by an angle such that P-axis lies at perpendicular distance of 'r' from 'source point'

   For a robot with rigid actuators, it's highly impossible to apply a torque on the pencil and achieve relative motion wrt the actuators. If the grip is slightly loosened for this purpose, it would slip from the actuators. It was found to be lot easier with soft actuators (For eg, tightly packed water packets).

2. Applying pressure of 2psi, along -ve Z-axis, trace locus defined by image/characters to be written on the plane of the paper, using Move function for each image/character.

   Once the wrist position is locked on the X-Y surface, the finger joints have to move in a complex way to achieve this problem. It can be seen as a control problem where the force to be applied by each of the joints has to be estimated such that the pressure along the –ve Z-axis is maintained at 2psi and trajectory defined by characters is traced.

In Kalakrishnan et al. 2012, Positions and orientations of the hand are initialized from a kinesthetic demonstration of the task. So the trajectory to be followed is known which can be thought of as **explicit knowledge**. But the robot still doesn't know the forces it has to apply at each of its joints to achieve the task of 'pen lifting'. They initialize the system with 'zero forces' state and define reward proportional to the amount of time it has been able to hold the pen. Now the robot initializes the force profile randomly and tries to learn the profile that helps in improving the reward. They use PI^2 reinforcement algorithm for learning the optimal profile.

Now, this entire process is very similar to the human way of learning. Initially like any other amateur, it tries out random profiles and the 'behaviours' which led to increase in the reward are primed with higher probability in the next iteration. Once it turned into an expert, it doesn't rely heavily on the feedback (For eg, Rules like "If the pen is slipping from the hands, apply greater force" etc.). It implicitly comes up with a profile that suits best for that particular scenario. The 'chunks' can be seen as processing the observed patterns (like in the Kalakrishnan's paper, inputs from a 6 DOF Force-Torque sensor) and giving out force profiles. This entire process can be seen as post-conscious/goal dependent automaticity as discussed by Bargh et al.

As pointed out in the video “My Brilliant Brain”, expert fire fighters just observe the pattern of the fire and carry out the ‘optimal’ (the one that maximises the reward) task. Unlike a novice, they don’t wait for the effects of their action, to take next step. They rely very little on the feedback. They rather observe the present world state and act accordingly. This process of identifying crucial patterns can be attributed to implicit learning.

REFERENCES:

[1] Agrim, Hemangini & Vidur, “Instruct a robot to write with a pencil”
http://www.cse.iitk.ac.in/users/se367/11/se367/hgini/hw2/

[2] Kalakrishnan, Righetti, Pastor, Schaal, 2012. “Learning Force Control Policies for Compliant Robotic Manipulation”.
Video: http://www.youtube.com/watch?v=LkwQJ9_i6vQ

[3] Video: “My Brilliant Brain”
http://www.youtube.com/watch?v=yn64a248qq4

[4] Bargh, Schwader, Hailey, Dyer, and Boothby, 2012. “Automaticity in social-cognitive processes”