Optimal Control Theory

A team-based learning project

(written by G. Blohm for NSCI 401, October 2012)

The goal of this project is to acquire theoretical knowledge about movement execution that is optimal is terms of certain computational principles.

Learning objectives: By the end of this project, you should be familiar with the following notions.

- Optimal Control Theory
- State equations and cost functions
- Kalman filter
- Forward/Inverse models

Step 1: individual knowledge acquisition

Every group member should read the papers in the **portfolio** and familiarize her-/himself with the following concepts (feel free to do some research in the library, on the internet, etc):

- Reading portfolio (online): Scott (2012), Diedrichsen, et al. (2010), Shadmehr & Krakauer (2008)
- Linear systems and state equations

Step 2: collaborative learning – problem solving

These are the questions you are ultimately required to answer in your final written report. Answer them ALL **before** you start writing your report (step 3).

- What is an internal model? Why is it useful and what does it to? What types of internal models are there?
- How does optimal feedback control work? Explain the iterative procedure.
- What is the minimum intervention principle and why does it emerge?
- What is a cost and how does the cost determine movements?
- One step in optimal feedback control theory is state estimation. What is that and how does it work?
- What can optimal feedback control do that other control schemes cannot achieve?
- Bonus question: If you could control the movement of a car in only 3 time steps (3 times you can change your control policy between start and end of movement) then what would be the optimal strategy to drive a car on a straight line from point A to point B? What would the state equation look like if you consider that the car is a point mass moving without friction? Hint, use position and velocity as state variables.

Step 3: project report

Please answer all above questions and justify your answers! Include a **1-page summary** of Optimal Control Theory. This summary should be like an introduction to Optimal Control for a naïve reader. The total project report should **not exceed 5 pages** (12pt fond size, single spaced). Please submit the report as a PDF or DOCX document before the deadline to gunnar.blohm@queensu.ca.

Important! Include your names on the report. Also, please provide a breakdown of work performed by the group (who did what?) on an additional page.