Hybrid systems
PDEEC
HW#6

1. Download SHIFT from:
   SHIFT, Hybrid systems simulation language, http://path.berkeley.edu/shift/
   PC-SHIFT, http://path.berkeley.edu/~vjoel/pcshift/
2. Run the 4 examples from the SHIFT tutorial http://path.berkeley.edu/shift/tutorials.html and present the results from the simulations.
3. Automated highway system. Develop the following simplified versions of (http://path.berkeley.edu/smart-ahs/DSL97.html):
   a. Single lane highway with a single source and a single sink. The source creates cars at random. Each car is initialized with an initial velocity and speed profile. When the a car comes to within 3m of the car ahead it switches to the follower mode; in this mode it just tracks the velocity of the leader. Each car is removed from the simulation when it reaches the sink.
   b. Weather conditions. The weather conditions change with time. There are two types of weather: sunny and foggy. The weather information is available to all cars. When the weather is foggy each car reduces the velocity by 50%.
   c. Multiple sinks. There is a set of sinks (destinations). Each car is initialized (randomly) with a destination. When the car comes to within 10 m of the destination it is removed from the simulation.

Automated highway systems[1]

The AHS is a distributed and hierarchical control system that aims to increase highway capacity, safety and efficiency without building more roads. Due to its size and impact on everyday life, the design of a safe, efficient and practical AHS has been the source of challenges leading to the development of control, communication, traffic flow theories and enabling sensor and actuator technologies.

Traffic is organized into groups of tightly spaced vehicles called platoons. A simple calculation shows that for an average platoon size of 20 with inter-vehicle spacing of 1m the capacity of the highway increases by a factor of 4 with respect to free-flow traffic. Furthermore, this approximation is conservative in that a large inter-platoon spacing of 60m is assumed. The tight inter-vehicle spacing also accounts for increased safety and efficiency. The former is due to a small relative velocity in the event of a collision (it is assumed that the 60m inter-platoon spacing is sufficiently large to avoid collisions between vehicles in separate platoons) and the latter due a reduction of average aerodynamic drag experienced by a vehicle.

The benefits of the AHS are accounted by the tight formation of vehicles in a platoon travelling at relatively high velocities. It is clear that control policies beyond those of human drivers are needed to realize such platoon configurations. The AHS envisions full automation.

A typical scenario under full automaton is illustrated as follows. Say you are the driver and are in a manual lane. You drive your car into the transition area where it is validated, registered and queued by the AHS entry/exit system. You place your car under automatic control and the car merges into the automated lane. Until your car reaches its destination it performs a dynamic sequence of maneuvers such as joining/leaving platoons, changing lanes and yielding to other vehicles that may merge on to the AHS. At your destination exit the control of your vehicle is returned to you.

In August 1997, the National Automated Highway Systems Consortium (NAHSC) demonstrated AHS technologies, including an eight-vehicle platoon system, on I-15 in San Diego, CA.

The AHS introduced several challenges that led to the development of tools, techniques and theories for hybrid systems.

[1] Excerpt fro:m T. Simsek, J. Borges de Sousa and P. Varaiya, "Communication and control in hybrid systems", Tutorial session, Proceedings of the American Control Conference, Washington, US, July 2001.

The salient feature of the AHS control architecture proposed at Berkeley is that it breaks down AHS control into a self-contained hierarchically organized functional layers [1]. That is, it provides us with a semantic framework in which we extract sub-problems from AHS and reason about them in self-contained theories.

For example, consider again the AHS scenario described above. Assume there is a prescribed set of ideal conditions. Under these conditions the AHS is said to be functioning in the normal mode of operation. The assignment of a vehicle to the enter, exit, or yield operations is a control action taken by the link layer. This action is broken down into a sequence of join, split and lane-change maneuvers by the coordination layer. This sequence of maneuvers is then carried out by closed-loop feedback laws at the regulation layer. For the normal mode of operation the functions of these three layers are described using self-contained theories. The functions of the regulation, coordination and link layers are described using the theories of continuous-time feedback control, Finite State Machines (FSMs) and fluid flows respectively.

[1] P. Varaiya. Smart cars on smart roads: problems of control. IEEE Transactions on Automatic Control, 38(3):195--207, February 1993.