Graph-Based Constraint Models

3-3-2005

Opening Discussion

- What did we talk about last class?
- We need to vote on when the first exam will be. Will it be Tuesday or Thursday or next week?
- Assignment #4 has been posted in an initial format. More details will be added soon.

Finishing Coding

- Let's finish the code that we started last class and quickly use the integrator to solve one of the example problems.
- It should be pointed out that damped systems, including the Lorentz equations, don't technically fit the authors definition of constraint systems. However, this chapter is really broader in than the initial billing.

Graph-Based Constraint Modeling

- No chapter would be complete if we couldn't draw some pictures in it.
- Graphs for constraint based systems are very different from our earlier graphs because they notion of directionality is different. They have a balance in them and things don't so much flow/jump from one part of the graph to another. Instead, the state of the entire graph is solved for at once.

Electrical Circuits

- The most well known type of constraint based graph is that used for analog electrical circuits. These diagrams are very commonly used in Engineering work.
- In these diagrams we draw lines that represent wires and have other symbols for other circuit components such as resistors, capacitors, inductors, voltage sources, and ground.
- These translate into equations on voltage, V, and current, I.

Basics of Solving Electrical Circuits

- To solve an electrical circuit we follow some basic rules.
- V=IR gives voltage drop across a resistor.
- Kirchoff's Laws (these are why this fits under constraint modeling)
  - The sum of all currents entering or existing a node is zero. Entering currents have positive sign and exiting ones have negative.
  - The sum of the voltage drops around a loop is equal to zero.
- Capacitors and inductors have time dependent behaviors we use equations for.

Parallel Between Electrical and Mechanical

- It happens that electrical circuits make very nice analogies for physical systems and the equations are identical.
- Resistors play the same role as drag from dashpots.
- Capacitors are just like springs.
- Inductors work like masses in motion.
- This parallel can be interesting, but has been expanded and put to use.

Bond Graphs

- Bond graphs were developed in 1959 and they are a general method for modeling the behavior of systems in many different areas.
- Bond graphs are based on the the general ideas of effort and flow. What those terms mean depends upon the type of system. In electronics they are voltage and current. In linear motion they are force and velocity. In angular motion they are torque and angular velocity.

More Bond Graph Basics

- In all bond graph systems energy is effort*flow.
- In addition to effort and flow, bond graphs also mention the time integrals of these which are called P and Q and have the same meaning as those letters in Hamiltonian dynamics.
- Bond graphs are very formal and have a small set of allowed connection and node types. This formality means that there are tools that can translate them.

Elements of Bond Graphs

- Your book is a bit lacking in the discussion of bond graphs, but I found a nice web site with an introduction to them that I have linked to on the course web page.
- Let's go look through that site a bit so you can get some of the flavor for bond graphs.

Minute Essay

- What do you think about formal graph modeling that can be translated directly into equations and solved?