Constraint Based Modeling

2-22-2005

Opening Discussion

- What did we talk about last class?
- Only 3 people have given me code for assignment #2 so far and fewer have handed me the written part.
- Assignment #3 has a complete description. The due date was pushed back two weeks.

Pulse Processes

- Your book talks about a type of model called a pulse process where you have a graph of variables that are connected by signed arrows.
- The allows give pulses to the values incrementing or decrementing them.
- Unfortunately, this discussion is a bit too vague and he doesn't take his example far enough to make the use clear.

Markov Chains

- The “Pulse Process” does look a lot like what a Markov chain should look like only the magnitude of the pulses is proportional to the value of the variables and and pulses don't propagate through the system, instead a new state is generated using only values from the old state.

System Dynamics

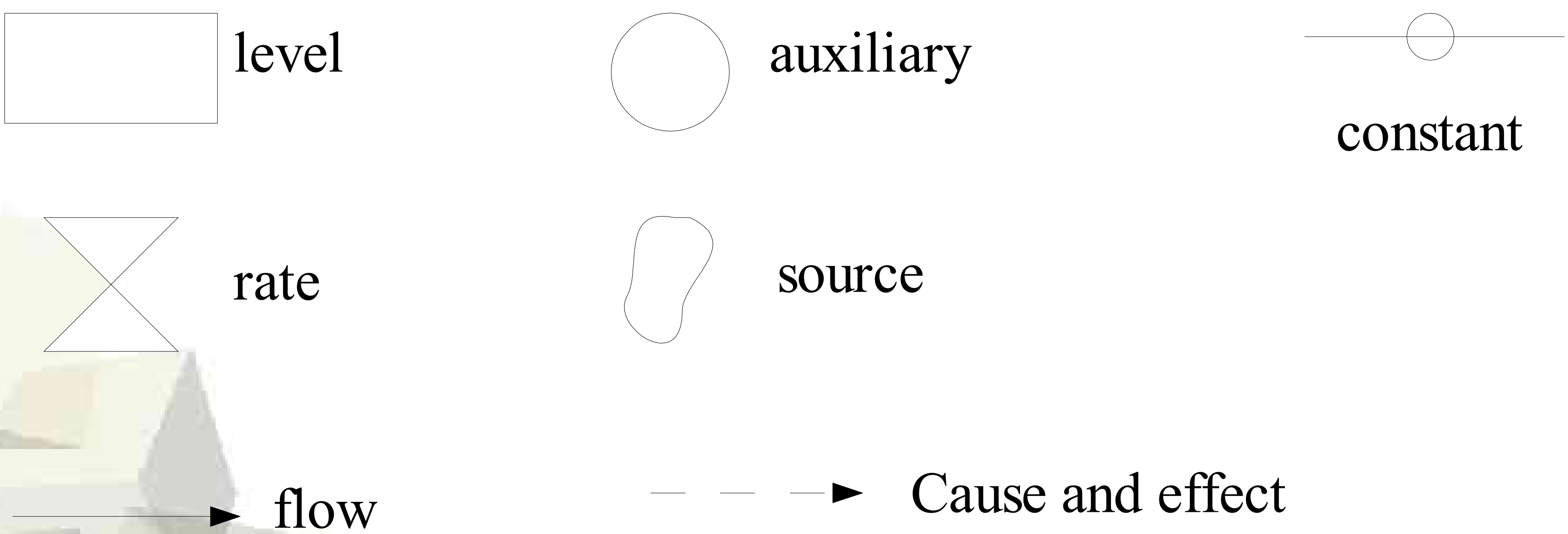
- This is a methodology for developing simulation models. You proceed through the following steps.
  - Build a causal loop diagram
  - Build a flow diagram
  - Translate to differential equations
  - Do the simulation
- The causal diagram shows arrows giving positive of negative causal relationships between concepts. Loops in these diagrams are feedback loops, positive or negative.

More System Dynamics

- The arrows in a causal diagram can be labeled with simple pluses of minuses. We can put feedback loop symbols inside of cycles in the diagrams.
- The causal graphs are then translated to flow graphs. The flow graphs are based on a hydraulic analogy of the system with icons for things like values (level of water), rates (values regulating flow), movement of values (flows), sources, etc.

Flow Graph Elements

- These are the icons we can use in flow graphs.



Finishing the Simulation

- Feedback loops occur when levels impact rates with cause and effect arcs.
- The flow graph can be nicely changed into a set of differential equations on the levels that we can easily plug into a standard DE solver to get a full simulation of the system. There are languages that are custom designed to solve these types of systems.

Compartmental Modeling

- These models are similar to flow graphs but with a little less detail on the types of things we put in them. We simplify to just having compartments that are like levels and arrows between them that signify motion from one compartment to another.

Constraint Modeling

- We have finished looking at both declarative and functional modeling. These types of models had some form of directionality to them. In declarative models we have direction of motion from one state to another. In functional models one block would send values to another.
- Constraint models are a type of model that works well when we want to preserve a balance instead of movement in a direction. This works well with laws of nature.

More on Constraint Modeling

- In nature, many things are conserved, from energy to momentum. Our models need to preserve this by modeling the transfer of something from one form to another.
- The most natural vocabularies for specifying these systems are often differential equations or difference equations.
- We will see two different types of constraint based models in chapter 6, those based on equations and those based on graphs.

Minute Essay

- What has been the most intuitive style of modeling we have discussed so far to your way of thinking? Why did you like it? What made it intuitive?