Course: Knowledge representation (MSc AI)

Subject: Qualitative Reasoning assignment
March, 11th – 22nd, 2018

1. Goals include

- Get familiar with basic concepts relevant to Qualitative Reasoning.
- Work with various notions of causality, especially with Direct (Influence, I+/I–) and Indirect (Proportionality, P+/P–) influences, and feedback loops.
- Represent and automate reasoning about dynamic systems using qualitative representations.

2. System description

Consider containers such as bathtubs and kitchen sinks, which can be filled with water (e.g. via a tab) and emptied (e.g. via a drain). What behaviours can occur with such container systems? Your assignment is to create a programme that reasons about the possible behaviours of such systems and generates a state-graph showing *all* possible behaviours.

Start with the following details:

Quantities

- Inflow (of water into the container)
- Outflow (of water out of the container)
- Volume (of the water in the container)

Quantity spaces

- Inflow: [0, +]
- Outflow and Volume: [0, +, max]

Dependencies

- I+(Inflow, Volume) – The amount of inflow increases the volume
- I–(Outflow, Volume) – The amount of outflow decreases the volume
- P+(Volume, Outflow) – Outflow changes are proportional to volume changes
- VC(Volume(max), Outflow(max)) –The outflow is at its highest value (max), when the volume is at its highest value (also max).
- VC(Volume(0), Outflow(0)) – There is no outflow, when there is no volume.

3. Assumptions

When developing the solution to this problem, you may discover that varying solutions can be postulated, depending on assumptions you make about the system. One assumption concerns the inflow which is exogenously defined. How will it behave? You may choose assumptions at your discretion. Describe your choice(s) and its/their impact in the report you submit.

4. Assignment main steps

a. Create drawings of the causal model active for this system and the expected state-graph. Show all the states with their unique value set and the state-transitions. You can use paper & pencil or a computer tool of your preference.

b. Develop and implement an algorithm that uses the details discussed above, and creates a state-graph showing *all* the behavioural states of the container system (and as envisioned in a). Important here is your representation of states and state-transitions, and how you deploy the calculi for the different dependency types.
c. Augment the algorithm such that it generates an insightful trace (a kind of explanation) of results inferred by the algorithm. Distinguish between intra-state (within a state) and inter-state (between states) conclusions.
d. Describe and submit your results. Show and explain how your algorithm works. Include the outputs, notably the trace and the state-graph.
e. You can choose to do the extra part of the assignment.

5. Extra

The details explaining the workings of the container can be represented more accurately by including column height and bottom pressure. Augment your approach by including these intermediate quantities. Start with the following details:

Quantities

- Height (of the water column in of container)
- Pressure (of the water column at the bottom of container)

Quantity spaces

- Height and Pressure: [0, +, max]

Dependencies

- P+(Volume, Height) – Height changes are proportional to volume changes
- P+(Height, Pressure) – Pressure changes are proportional to height changes

Additional issues

- Instead of volume, it is the pressure that determines the outflow
- Particular values, such as 0 and max correspond for volume, height, pressure and outflow.

6. Scoring (total 100 points)

- Self-created causal model and state-graph (A) (15 points)
- Algorithm and its output (mainly the state-graph) well described (B & D)
    - Working of the algorithm (20 points)
    - Content and characteristics captured by the state-graph (20 points)
- Assumptions well described (10 points)
- Insightful trace (explanation) (C)
    - Intra-state (10 points): Select a state from the state-graph and describe how your approach *explains* the system behaviour represented by that state.
    - Inter-state (10 points): Select two states (one state being the successor of the other state) and describe how your approach *explains* the transition of system behaviour represented *between* these two states.
- Extra details (E) (15 points)