CITS7211 Modelling Complex Systems

Lecture 5: Modelling Physical Systems

Overview

This lecture looks at the applications of cellular automata to the modelling of real-world systems. We will examine a number of common modelling solutions, and consider the modelling process in the context of a real-world problem. We will then discuss the difficult process of verifying and validating the modelling. To do this we'll look at comparisons with aggregate models and real-world data, mean-field approaches, identification of critical values, and emergent behaviour.

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Topics:

1. Rules for physical systems:
    a. Percolation models – for the spread of some phenomena that consumes a resource. E.g. bushfires and epidemics.
    b. Diffusion and Annealing Models – for modelling the dynamics of some fixed quantity in the environment. E.g. gas models, oil spills, annealing and sand piles.
    c. Agent-based models – agents (turtles) have a dynamic state, but are not fixed to one location. E.g. Ants, societies, traffic.
    d. Solid body motions – bodies are spread over several contiguous cells. E.g. vibrating strings
2. Class Exercise: Build a model for a simple epidemic.
3. Verifying the model
    a. Aggregate qualities and mean-field approaches. Cellular automata are generalizations, so they may only be accurate predicting generalized quantities and qualities. Example: traffic equations
    b. Identification of critical values. Is the theoretical value reflected in reality?
    c. Emergent Behaviour. Does the system produce comparable behaviour to the real world, relative to the simplicity of its rules.
4. Some principles:
    a. Model or verify. Never both at the same time!
    b. Models are not the real world. At best they are accurate reflections of a precise set of assumtpions.

Reading:

1. Bastien Chopard and Michel Droz. Celllular Automata Modeling of Physical Systems, Chapter 2.
2. CA Modelling Case Studies (available from the MCS webpage):
    a. *Cellular Automata Microsimulation of Bi-directional Pedestrian Flows*, Blue and Adler.
    b. *A hybrid cellular autmoata/semi-physical model of fire growth*, Sullivan and Knight.
    c. *Coastal Oil Pollution by a Tanker using Cellular Automata*, Nakana, Hagesawa and Morishita
    d. *Epidemic Modelling Using Cellular Automata*, Fu and Milne.
3. Nino Boccara, *Modeling Complex Systems,* Springer 2004, Sections 6.4 - 6.7