Adding Behaviour to Microsimulation Models

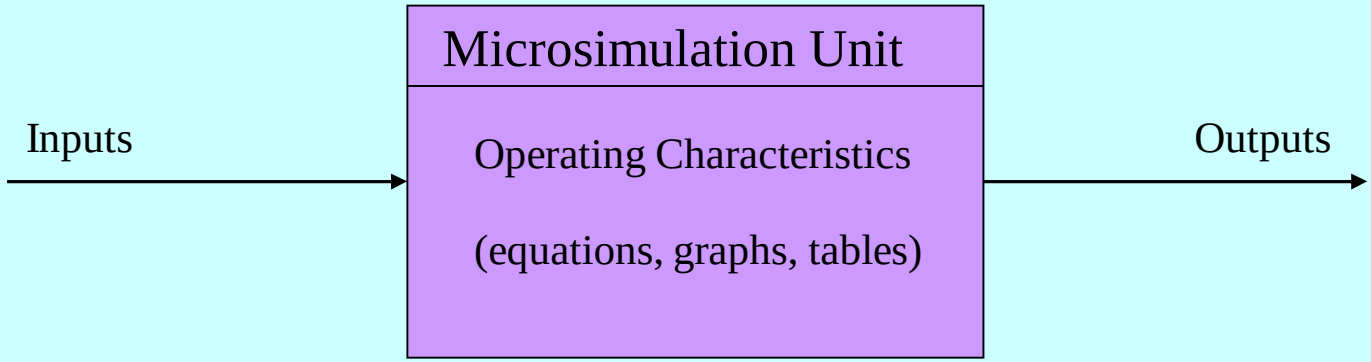
- A lot of interest in adding behaviour to microsimulation models
- Agent based models can produce emergent behaviour
- Agent based modellers are interested in basing their models on data

- Origins and development of microsimulation and agent based modelling - reasons for their divergence
- Underlying similarity of agents and microsimulation units

- Demographic model with behavioural expenditure module
- Technically, not difficult to add behaviour
- Biggest problem is in having enough understanding of a system

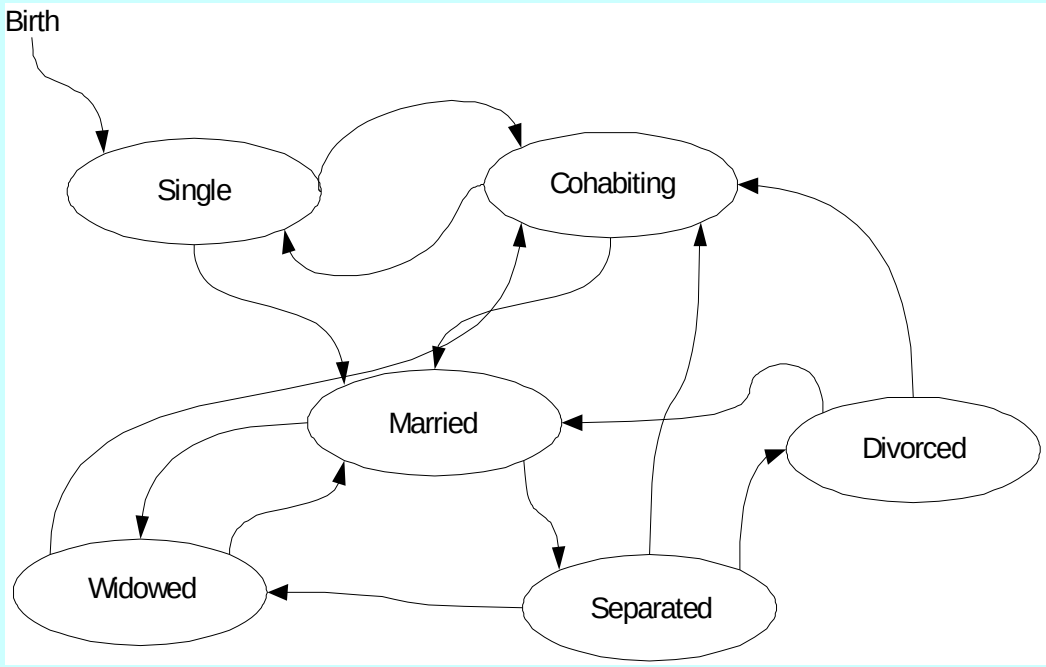
Microsimulation

- Based on Orcutt unit (Orcutt 1957)
- Inputs - things acting upon the unit
- Outputs - stem from the unit
- Operating Characteristics



Operating Characteristics

- Change the state of the unit
- Transition probability



State transitions in a typical demographic microsimulation

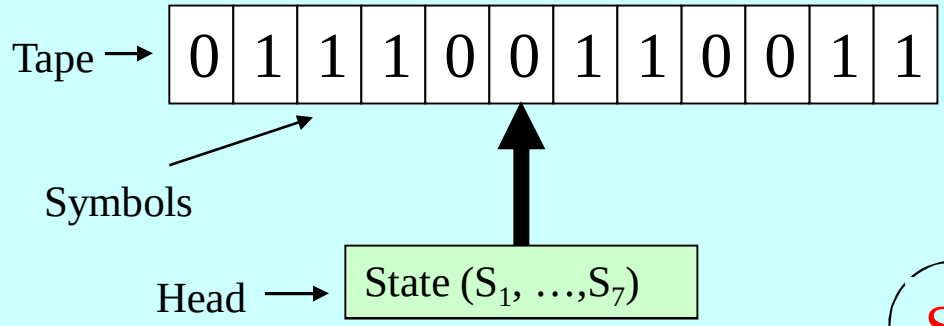
Transitions depend on probability

Non-deterministic

More than one exit state

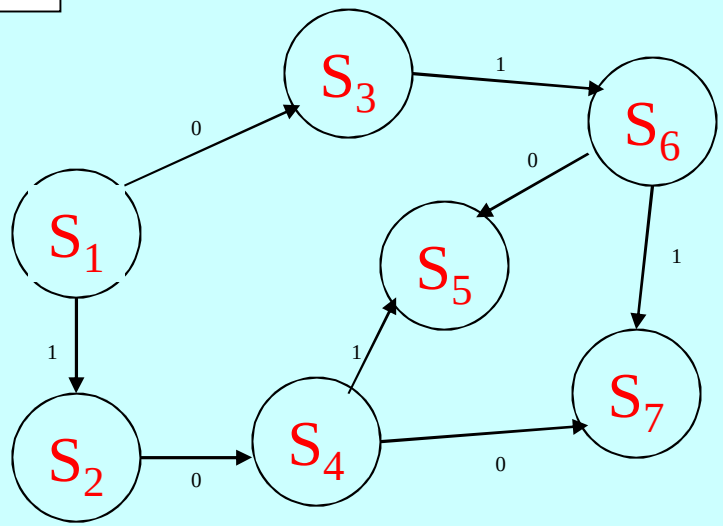
Agent Based Modelling

- Turing Machine (1936)
- Developed to investigate limits to computation



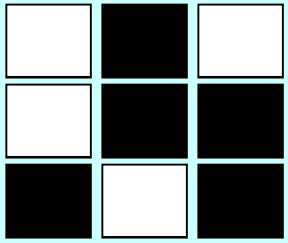
Only one exit state

Deterministic transitions



Cellular Automata

- Von Nuemann & Ulam
- Conway's Game of Life
- Grid of Cells which can be on or off
- State at next step depends on current state and state of neighbours



Game of life Rules

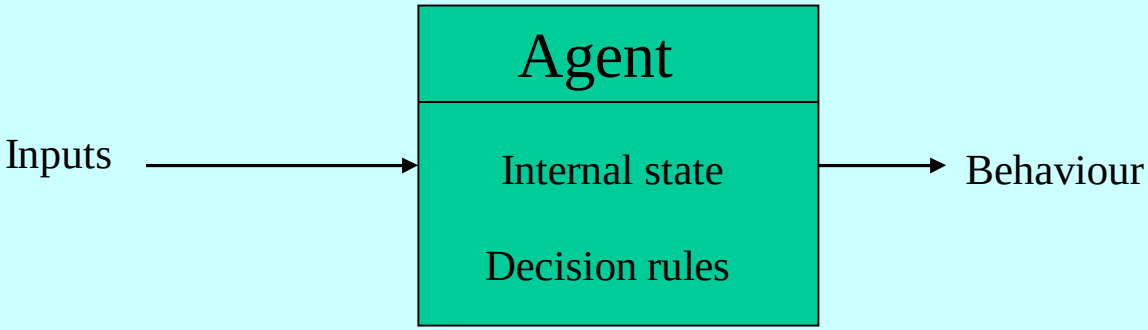
Any live cell with fewer then two neighbours dies, as if caused by under-population

Any live cell with more than three live neighbours dies of overcrowding

Any live cell with two or three neighbours lives on to the next generation

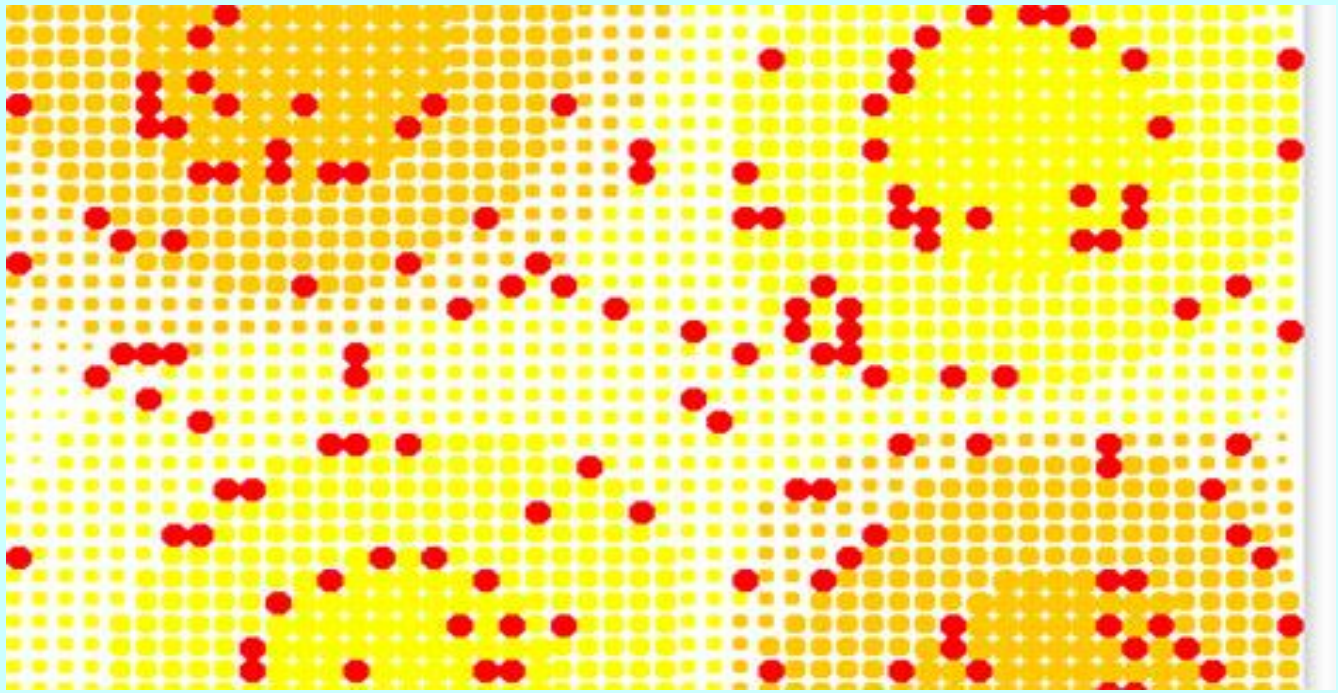
Any dead cell with exactly three live neighbours becomes a live cell

Agent Based Model

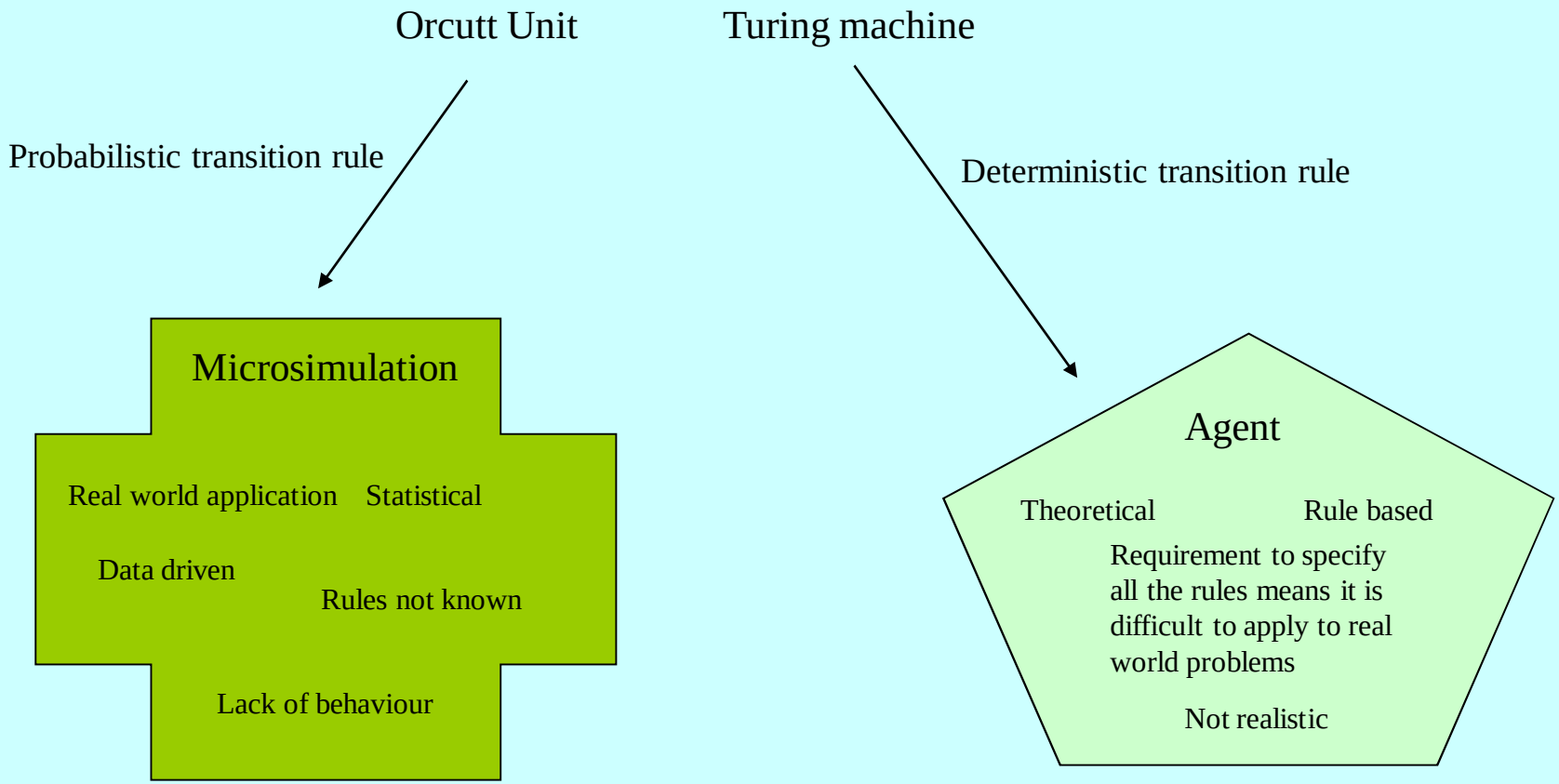


Sugarscape

Epstein & Axtell 1996



Two Islands


Orcutt Unit
Turing machine
Probabilistic transition rule
Deterministic transition rule
Microsimulation
Real world application
Statistical
Data driven
Rules not known
Lack of behaviour
Agent
Theoretical
Rule based
Requirement to specify all the rules means it is difficult to apply to real world problems
Not realistic

A Bridge

- An agent based model is a microsimulation model with all the transition probabilities equal to one
- A hybrid model can contain some deterministic transition rules to generate behaviour like an agent based model and some probabilistic transitions where there is incomplete information like in a microsimulation model
- age = age + 1

A Practical Example

- Expenditure module
- Standard demographic microsimulation (birth, mortality, partnership)
- How do households react to a change in income?
- If they have more or less money or if there is a change in circumstances, will they spend more or less on food, utilities, recreation, clothing etc?
- Behavioural rule - copy the expenditure pattern from a similar household that already has the new income

Expenditure Model

- Load in data
- Run annual cycle
- For each household
  - make demographic changes
- For each household
  - set new income
- For each household
  - copy expenditure pattern from a household of the same demographic type whose income last year is the same as the current household's new income
- Update results

Household Types

1. One person non-pensionable
2. One person pensionable
3. Two adults with no children
4. Two adults with children
5. One adult with children

Application to Homeworking

- British Telecom asked if there was a large shift towards working from home instead of commuting, what would be the effect on household spending patterns?
- How much of the savings on fuel would be offset by increases in utility bills?

- Households and individuals read in from the British Household Panel Survey
- Model chooses some individuals from the population to work at home
- This changes the household composition for some households
- If there has been a change, copy the expenditure pattern from a household with the same number of homeworkers
- Controlled for income & number of children and adults

Effect of Increasing Homeworking

Homeworking increased from 2% to 40% in 4 years

	Food	**Mortgage**	**Commuting**	**Rent**	**Utilities**
2%	£65.70	£47.36	£15.91	£10.55	£14.85
40%	£65.71	£51.77	£13.75	£10.01	£15.20
Difference	**£0.01**	**£4.42**	**£-2.16**	**£-0.54**	**£0.43**

Changes per Commuter	
Food	3p
Mortgage	£11.67
Commuting	£-5.70
Rent	£-1.43
Utilities	£1.14

Conclusions and Limitations

- Example of a microsimulation model that includes a behavioural rule
- Could have an agent model with probabilistic rules
- Only a partial solution because the most difficult part is to have enough understanding of the rules to make an accurate model.
- If we do not know what the rules are then we have to resort to probabilistic transitions