# Cognitive modelling of human behaviour

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# The Challenge

- Simulation is an essential instrument for understanding complex systems
- Broadly acknowledged that realistic models cannot ignore human behaviour
- Real-world data normally does not provide insight into human decision-making mechanisms
- Which modelling approaches help us best understand complex social processes?

# Modelling agent behaviour

- Agent-based approaches capture prescriptive rules for how certain behaviours are caused
- Simple "behaviourist" models consist of collections of stimulus-response rules (and a control architecture to arbitrate between these)
- More complex models like the Belief-Desire-Intention architecture (BDI) involve memory, goals, and the ability to plan complex action

# Mars rover example

- A set of robots are attempting to gather rock samples on Mars; there is a radio signal from the mother ship to find way back
- Five rules (from top (high priority) to bottom (low priority)):
  1. If detect an obstacle then change direction
  2. If carrying samples and at the base then drop samples
  3. If carrying samples and not at the base then travel up gradient
  4. If detect a sample then pick sample up
  5. Else, move randomly

# The Belief Desire Intention Model

- Based on Bratman's philosophy of "practical reasoning":

  "*Practical reasoning is a matter of weighing conflicting considerations for and against competing options, where the relevant considerations are provided by what the agent desires/values/cares about and what the agent believes.*"

- Emphasises that agents have explicit desires (goals), and that the current situation determines which of these the agent chooses to work toward

# The BDI model

- Generic control loop for a BDI agent
  1. Revise your beliefs based on new information
  2. Re-prioritise your desires based on current beliefs
  3. Adopt your top desire as an intention
  4. Compute a plan to achieve this intention
  5. If your current intention has become unachievable or has been achieved, drop it
- Notion of intentions crucial, captures how thinking about alternatives is suspended while being committed to achieve a goal

# Mars rover example

- Agent now has a library of plan templates (or ability to plan on the fly
  - explore a certain limited area
  - go to a known sample and pick it up
  - return to spacecraft (remembers location)
- Intention formation: e.g. agent sees sample it could collect, forms goal to get it
- Intention reconsideration: e.g. while attempting to pick sample up sees other agent who will do it

# Strengths and weaknesses

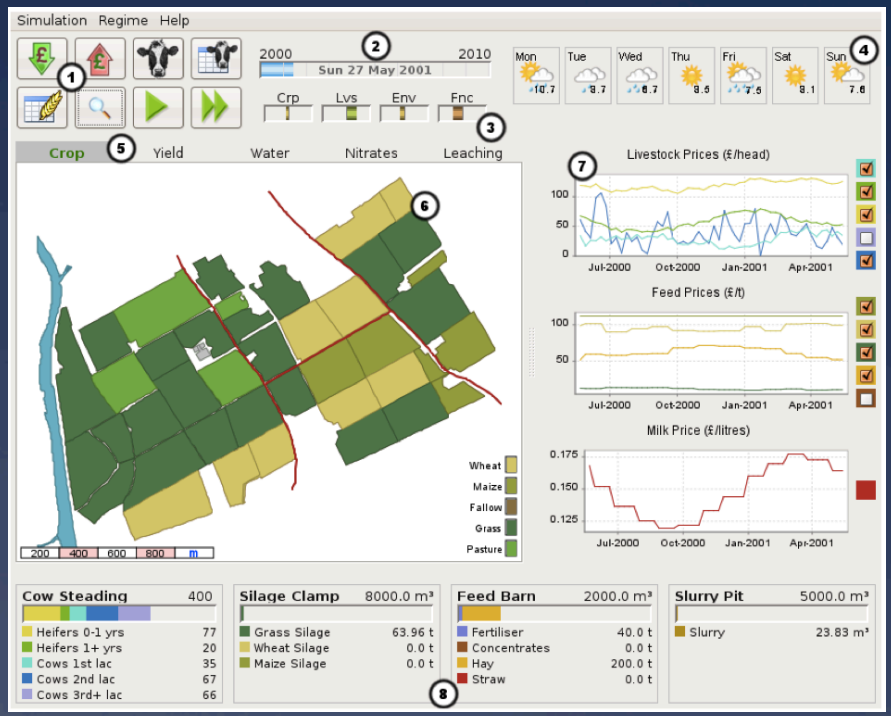
- Good for modelling situations where multiple objectives need to be balanced
- More suitable for modelling qualitative than quantitative preferences and behavioural patterns
- Computationally quite involved, needs expert user to develop implementation
- Does not specifically account for social interaction (but this can be integrated)

# Useful for modelling socio-environmental domains?

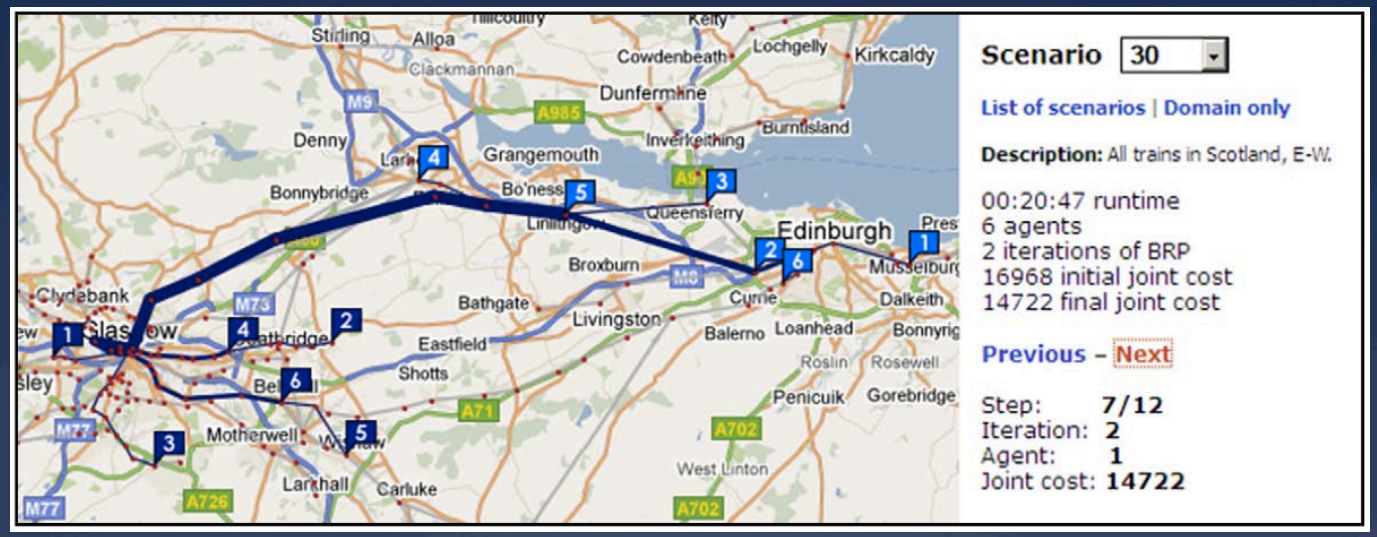
- Main advantage: transparency, explainability, explicit modelling of knowledge and belief
- Main weakness: how to elicit these models from actual users
- Two examples:
  - Modelling land use change through participatory simulation game
  - Modelling potential trip sharing using strategic multiagent planning and commuter data

# Gamification

- Conrad Rider's PhD: Elicit decision-making models from real farmers using a participatory simulation game
- BDI models derived from observed patterns and user self-description
- Crowdsourcing such models in combination with sensing may be a useful method
- Beneficial side-effects: exchange of expertise, co-creation of knowledge



# Data + decision making




- Jan Hrncir's MSc project: calculating trip sharing routes based on UK public transportation/commuting data
- How can travel routes be calculated in such a way that they benefit all participants (assuming pricing incentives)
- Rational choice in terms of pure preferences, but weights of comfort/price etc can be adjusted
- Data- and model-driven approaches are not mutually exclusive, lots of opportunities in combining them

# Conclusions

- Agent-based models that account for agent's decision-making mechanisms explicitly are useful
- But not easy to implement, and require expert knowledge to convert elicited knowledge into actual models
- To promote their use, better tools for non-expert users are needed
- Use of crowdsourced data in combination with sensing and open data opens up new perspectives

# Questions?