

Agents, simulations and applications

Nigel Gilbert

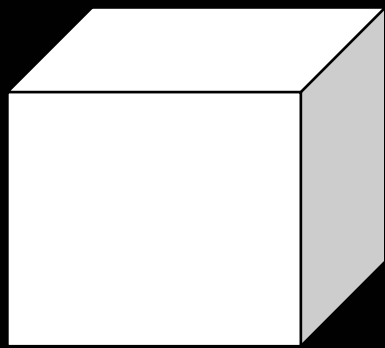
University of Surrey

United Kingdom

Outline

- Target, model, simulation
 - Innovation networks
- Static, kinetic, dynamic
 - Schelling's segregation model
- Emergence and complexity
 - Computational anthropology
- Participatory simulation
 - The Zurich Water Game
- Further reading
- Summary

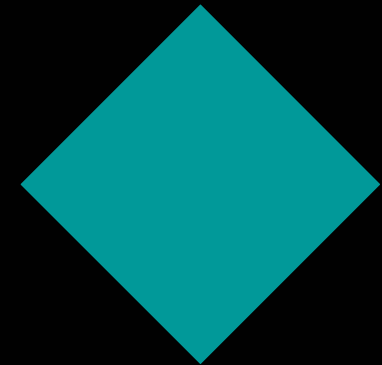
Terminology



Target
(the world)



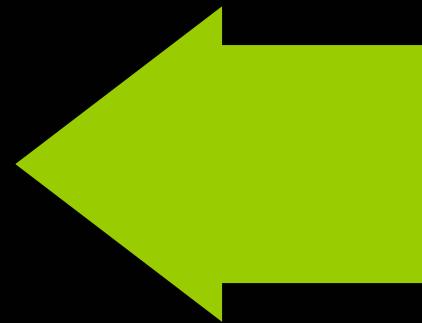
Specification
(a description)



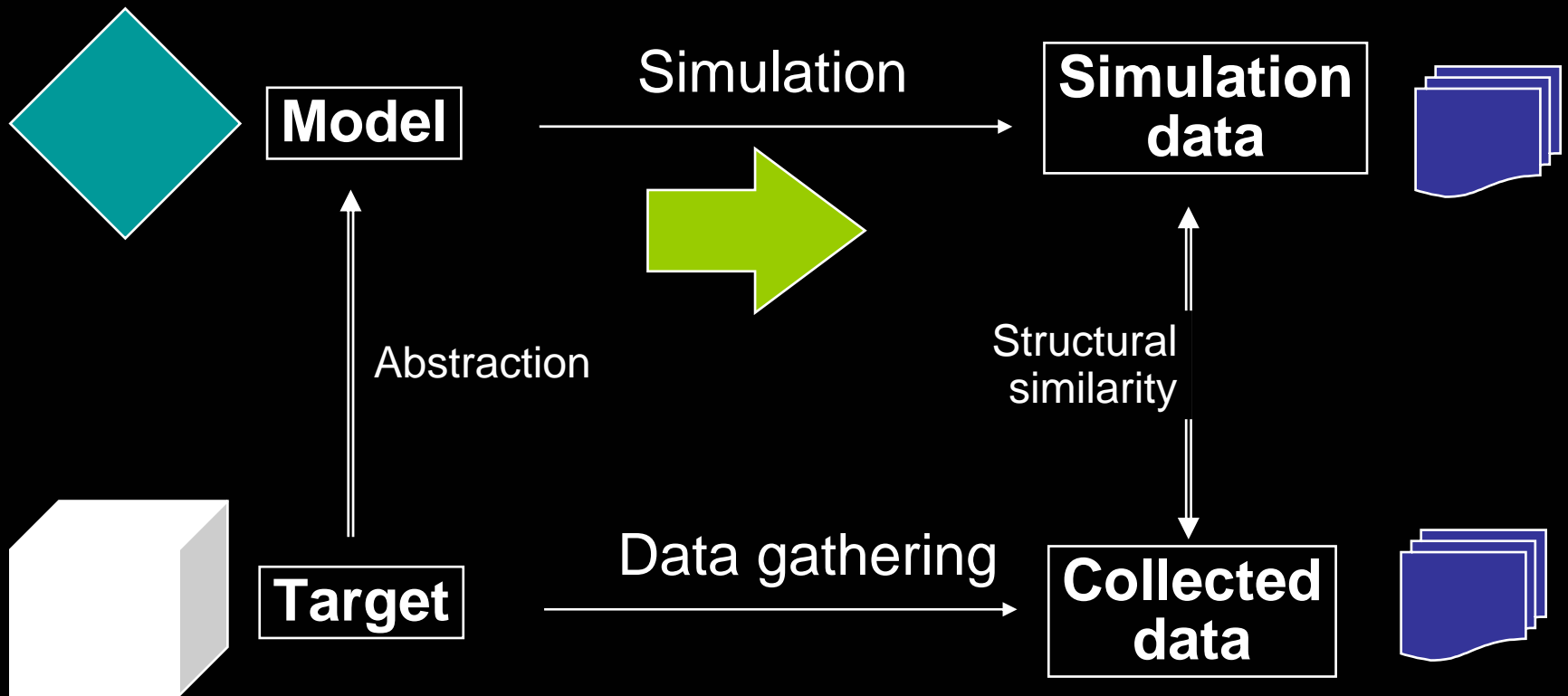
Model
(a program)



Simulation
(a running program)



The logic of simulation



Research steps

1. Define topic and problem
2. Specify hypothesis
3. List assumptions
4. Design and build model
5. Verify model
6. Validate model
7. Draw conclusions

Innovation networks

- Innovation: the successful development of new products, processes and ideas
- Network: a set of actors (people, organisations) that interact bringing together heterogeneous competencies and skills

Innovation network: a network of actors that has the goal of generating innovations (negotiating, shaping, producing)

- Two-Level Approach: knowledge and economic success (relation between new knowledge, learning, knowledge transfer etc. and success in the market)

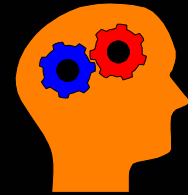


Agents

- a computer program (or, more usually, a part of a program)
- which represents some real world actor
 - e.g. a person, an organisation, a nation
- with inputs ('perception'), outputs (actions) and rules (what it should do)

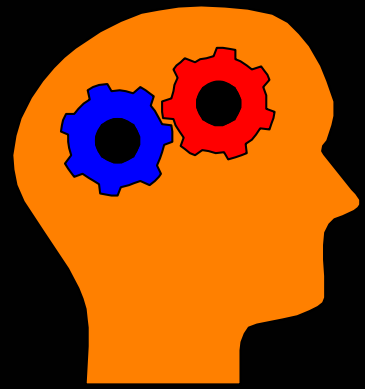
The model

- The knowledge level
 - development and exchange of knowledge
 - capabilities, abilities and expertise
 - networks of relationships
- The market level
 - trade in products and processes
 - producer-consumer relationships
- The interaction between knowledge and market levels
 - Knowledge, products and relationships co-evolve



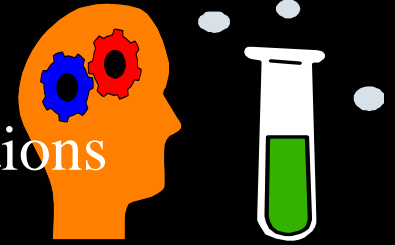
The Knowledge Level: Actors who know

- A **kene** is a structured collection of technological, political, social and economic *Capabilities*
- It is used to represent the knowledge base of an agent
- Instances of capabilities are *Abilities*
- Agents have a level of *Expertise* for each ability

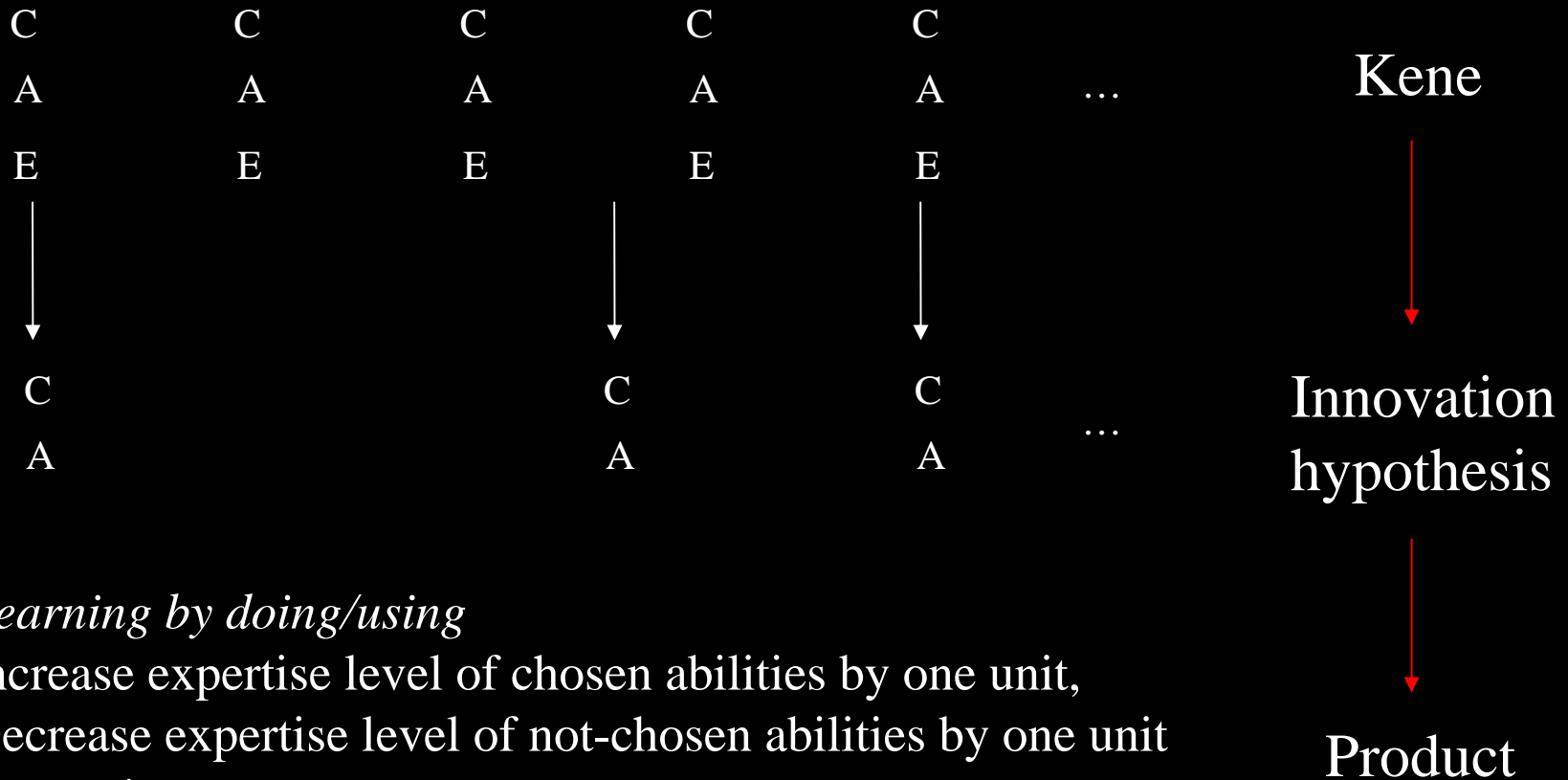


C	C	C	C	C	...
A	A	A	A	A	
E	E	E	E	E	

Innovation hypothesis



Kenes are used to produce *hypotheses* - potential innovations



Learning by doing/using

Increase expertise level of chosen abilities by one unit,

Decrease expertise level of not-chosen abilities by one unit

Forgetting

Triples with zero expertise level are deleted from the kene

The Market Level:

Actors who buy and sell



An actor's **product** is derived from its innovation hypothesis

The *product* is a number created from the capabilities and abilities of the actor

A product has a certain *quality* also computed from the innovation hypothesis (abilities and expertise)

The product needs certain *inputs* (products from other actors) to be produced. The inputs are determined by the innovation hypothesis of the actor as well.

Actors sell and buy products



step
 68

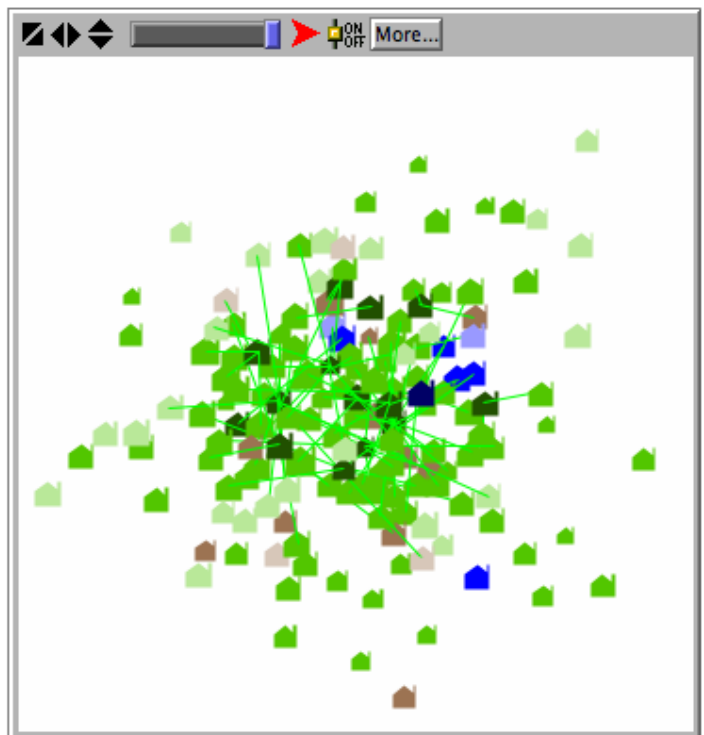
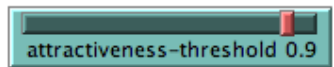
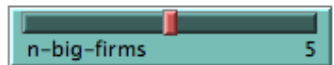
Activity
Updating plots



partnership-strategy
conservative

On Off open-system

On Off collaboration

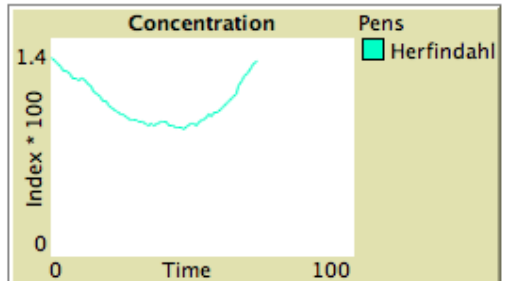
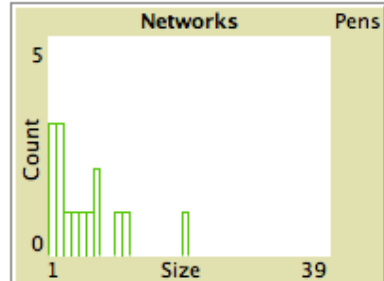
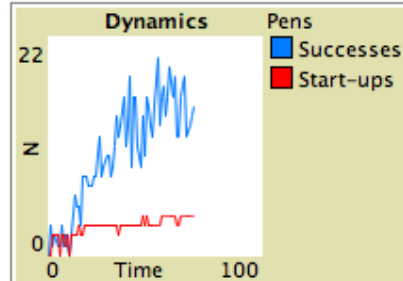
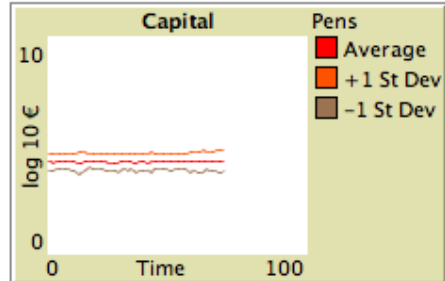
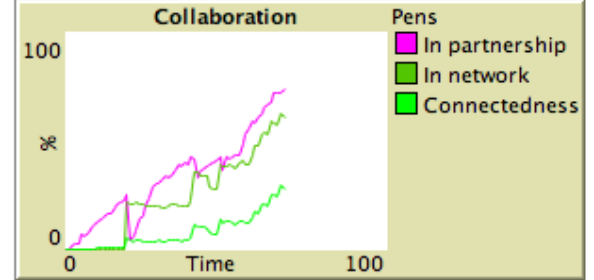
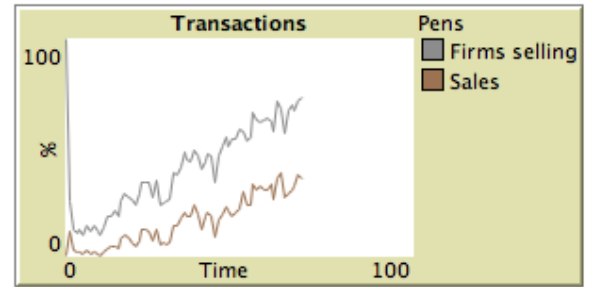
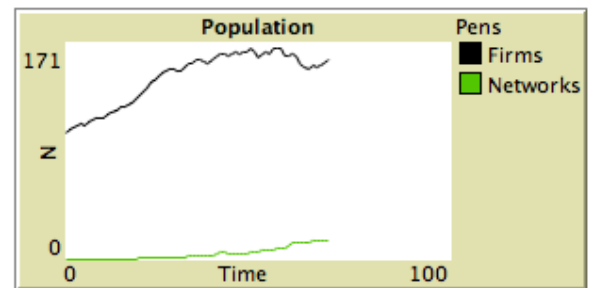


Brown factory: raw material Green factory: firm Blue factory: end-user
 Blue line: supplier-customer Red line: partnership Green line: network

On Off showSales

On Off showPartners

On Off showNetworks



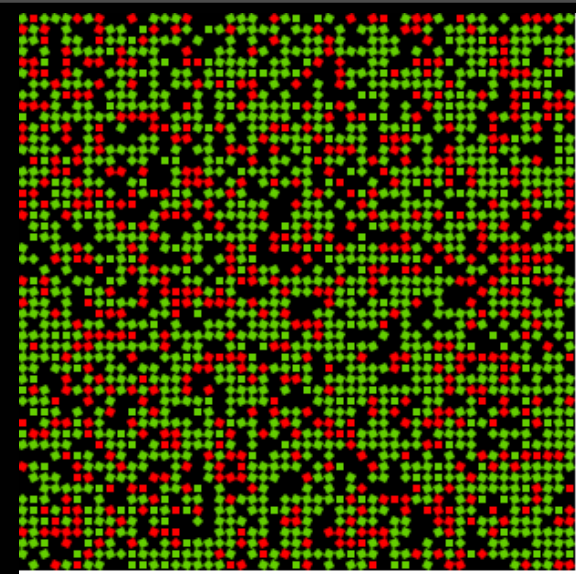
Command Center

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Static, kinetic and dynamic models

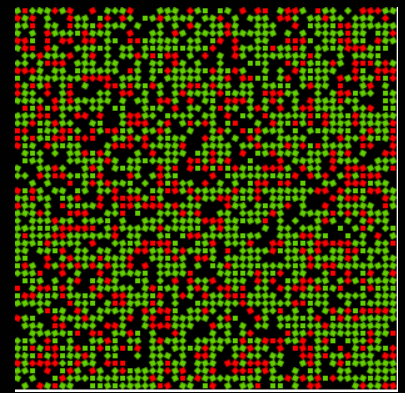
- Static
 - E.g. equilibrium models
- Kinetic
 - They move but it is an external agency that is doing the moving
- Dynamic
 - Autonomous, perceiving, acting and (possibly) intelligent

A segregation model



- Grid 500 by 500
- 1500 agents, 1050 **green**, 450 **red**
 - so: 1000 vacant patches
- Each agent has a *tolerance*
 - A **green** agent is 'happy' when the ratio of **greens** to **reds** in its Moore neighbourhood (i.e. in the 8 surrounding patches) is more than its tolerance
 - and vice versa for **reds**

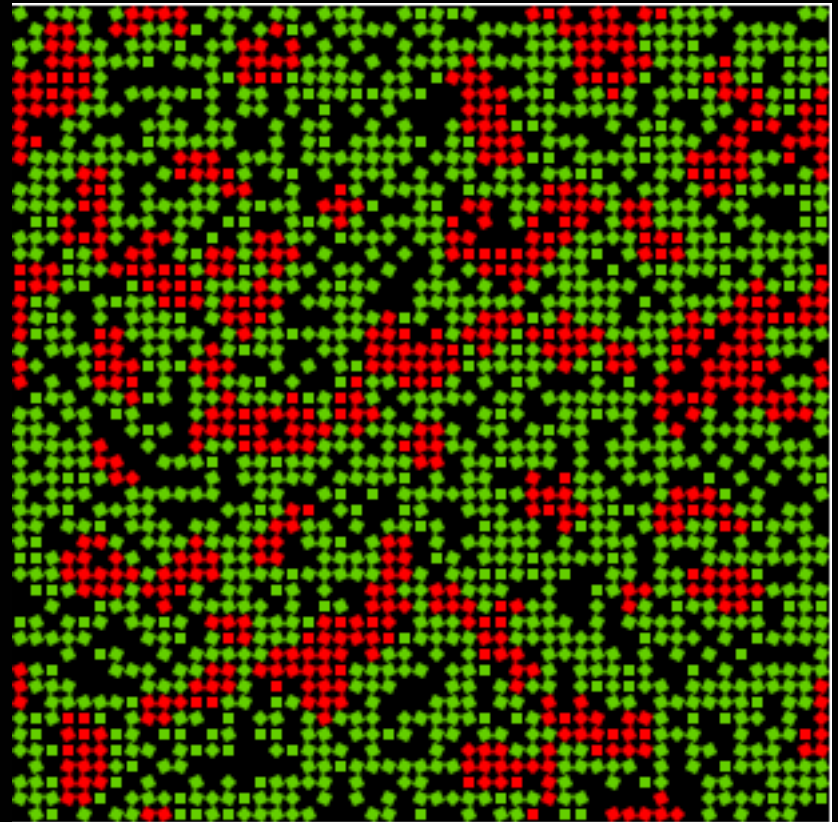
Aggregation



- Note: With a tolerance of 40%, an agent is happy even when up to 60% of its neighbours (a slight majority) are the other colour
- Randomly allocate **reds** and **greens** to patches
- Then the *average* number of neighbours of the *same* colour is **58%** (about 5)
- And about **18%** of the agents are **unhappy**

Emergence

- The Schelling model is used as a standard example of emergence
- Values of tolerance above 30% give clear display of clustering: 'ghettos'



Clusters remain even when agents come and go

5% of agents 'die'
and are replaced with
agents of random colour
every timestep



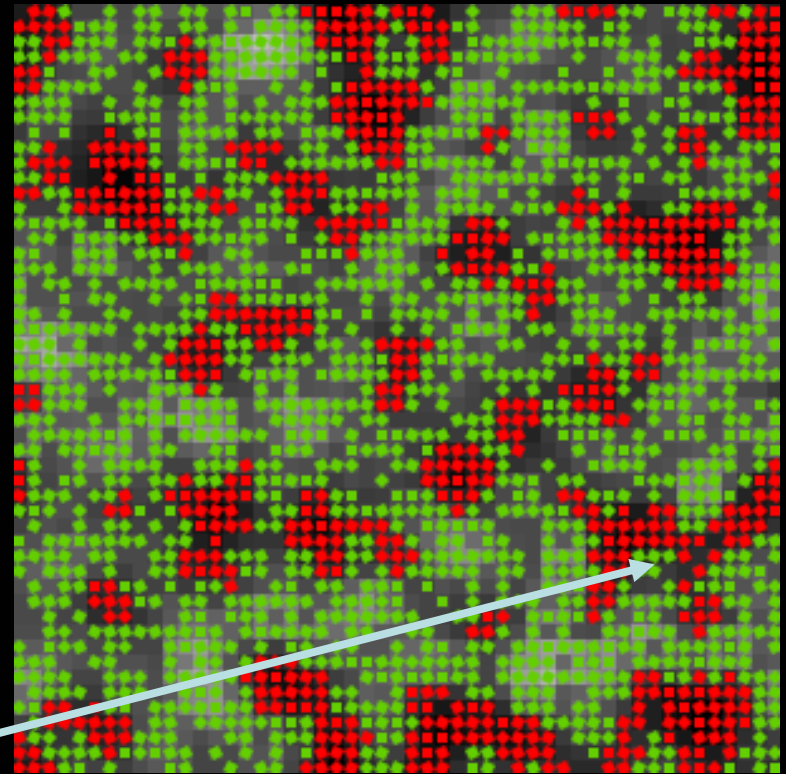
Downward effects



- Assume: Predominantly **red** areas have higher crime rates
 - Crime rate: a macro-level attribute
- As a result, property within such areas is cheaper
 - Assume property price $P = (9 - \mathbf{R}) / (9 - \mathbf{G})$
 - Where
 - **R** is the number of red neighbours
 - **G** is the number of green neighbours
- An agent can only move to a spot where the property price is less than or slightly above the agent's current property value (its wealth)
 - Agent can move if $P_{\text{current}} + 1 \geq P_{\text{new}}$

Consequences

- Reds that are surrounded by other reds are poor because they are in high crime areas and so have cheap homes
- Reds surrounded by greens are wealthy, but want to move to red areas
- Greens surrounded by reds are poor and can't move to desirable green areas
- Greens surrounded by greens are rich and don't want to move



Recognising emergent features

- While the observer can see the emergent features, the agents can't
- But in human societies, people can recognise (and act on) emergent features
- Their reactions can in turn affect those features
- Thus, *second-order emergence*
 - also called
 - The double hermeneutic
 - Immergence

Learning how to budget

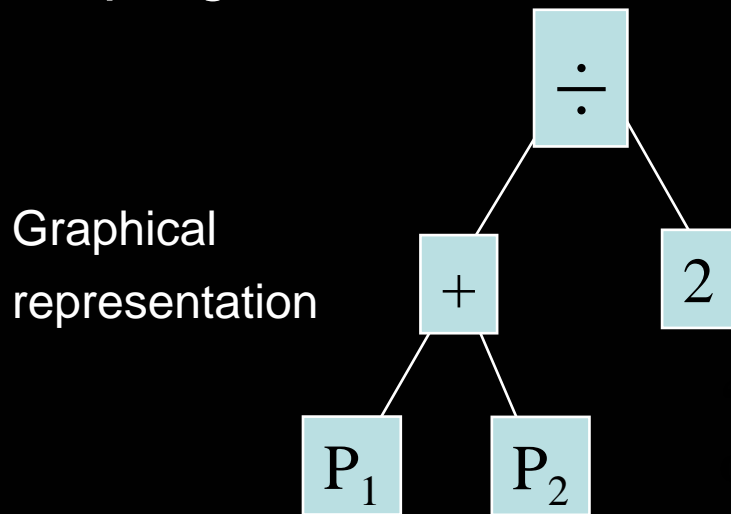
- How do people manage their finances, in the face of
 - many opportunities for spending
 - bills which arrive irregularly and for varying amounts
 - varying incomes
- Economic models of consumption generally do a poor job of predicting individual budgeting behaviour

Assumptions

- People learn how to budget:
 - from their own experience
 - from imitating others (lifestyle)
- By interviewing people who have had a recent substantial change in income, we can find out how they budget (for others, budgeting is tacit/habitual)
- *Genetic programming* can be used to formalise and check our understanding of the budgeting process

Genetic programming

- GP represents solutions, not as bit strings, but as programs



- The program's fitness is measured according to the quality of the answer it computes



Budgeting and GP

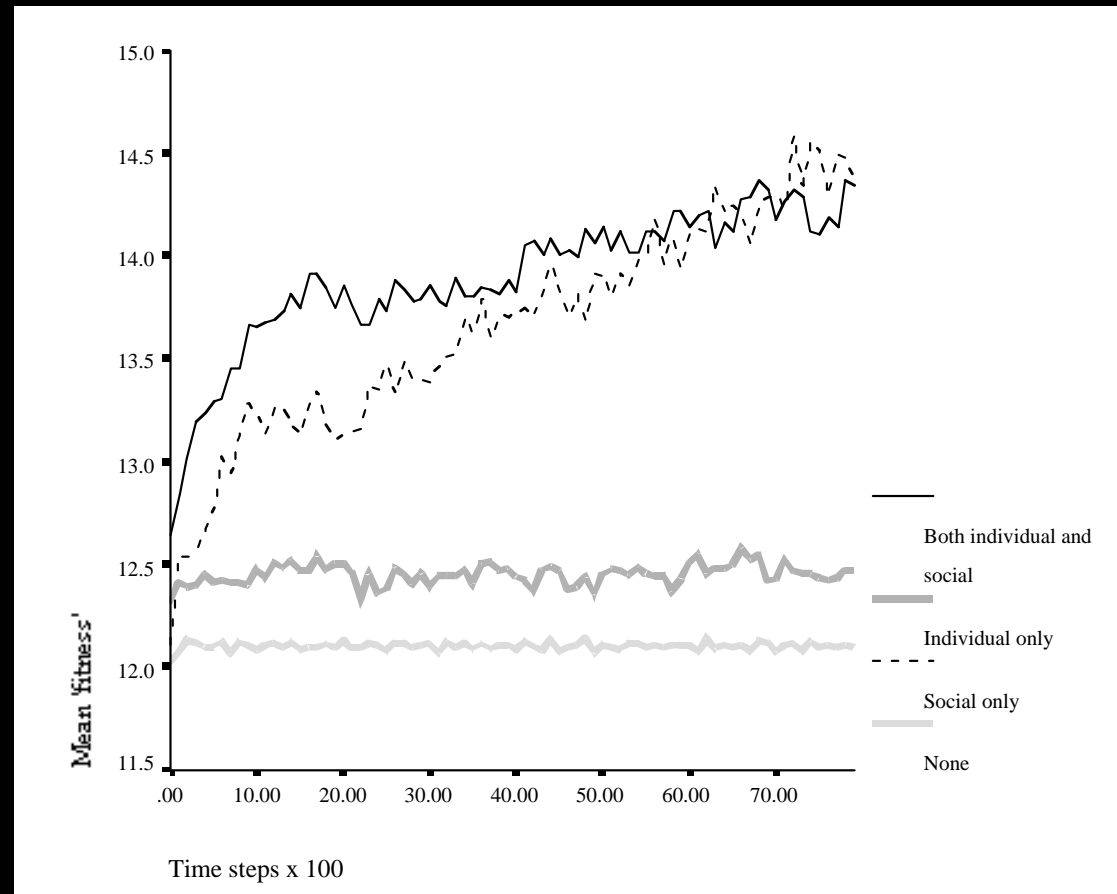
- Each agent aims to carry out a series of activities which require resources (food, petrol, rent...)
- Successfully carrying out an activity gives the agent a quantity of 'joy' (!), different for each activity
- An activity can only be carried out if there are sufficient resources in stock, so the agent has to go shopping
- The agent has only a limited amount of money and it comes in an (irregular) flow, week by week
- The task is to find a program which specifies how much of which goods to buy when, in order to maximise 'joy'

Terminals and operators

- Terminals:
 - S, the current stock level of resource R
 - F, *forecast* level of resource needed over a future period (70 days) if every planned activity is carried out
 - P, price of resource R
 - U, ratio of joy to price
- Operators
 - +, -, *, %, CMP
 - %: 'protected' division
 - CMP(a b): -1 if $a < b$; 0 if $a = b$; +1 if $a > b$

Individual and social learning

The budgeting agents could either try to learn from managing on their own, just learn from their neighbours, or do both



Computational anthropology?

The project is concerned with **emergence** and **complexity** in socially-inspired artificial systems.

The main goal of the project is to realize an **evolving artificial society** capable of exploring the environment and developing its own image of this environment and the society through cooperation and interaction.

We will work with virtual grid worlds and will set up environments that are sufficiently complex and demanding that communication and cooperation are necessary to adapt to the given tasks. The population's resource to develop advanced skills bottom-up consists of individual learning, evolutionary learning, and social learning.

One of the main innovations of this project is social learning interpreted as passing knowledge explicitly via a **language** to others in the same generation. This has a synergetic effect on the learning processes and enables the society to rapidly develop an "understanding" of the world collectively. Then we will **probe** to learn how the agents perceive the environment, including themselves, and what skills and procedures they have developed to adapt successfully.

New and Emergent
World Models Through
Individual,
Evolutionary, and
Social Learning

★ QuickTime™ and a
★ TIFF (Uncompressed) decompressor
★ are needed to see this picture.
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The challenges

1. The Kula Ring

A complex system of visits and exchanges among the Trobriand Islanders of the western Pacific.

2. Herders in a semi-arid area

Nomadic herding to deal with variable and uncertain shortages.

3. Central place theory

The theory predicts that settlement size will follow the rank size rule. It works well for human settlements.

4. Status distinctions

Agents have characteristic sensible attributes ('tags').

The challenges

1. The Kula Ring

A complex system of visits and exchanges among the Trobriand Islanders of the western Pacific.

Food is distributed in spatial patches and the amount of food in a patch varies over time. The overall quantity is more than enough to feed the population, but there may be short-term local shortages. Food is perishable and so agents need to find and consume a constant supply of food in order to survive. Food needs long term cultivation for it to grow.

2. Herders in a semi-arid area

Nomadic herding is another human solution for dealing with variable and uncertain shortages.

Food is randomly distributed with the mean level of food just sufficient to support the population. The rate of food growth randomly varies over time. Food is perishable. Some food must be left uneaten on each patch since subsequent growth is proportional to amount of food left uneaten.

3. Central place theory

The theory predicts that settlement size will follow the rank size rule. It works well for human settlements.

The distribution of types of food is such that agents need to trade food with other agents. The food types vary in their transportability. Agents can move to find the best location to maximise their income from trade.

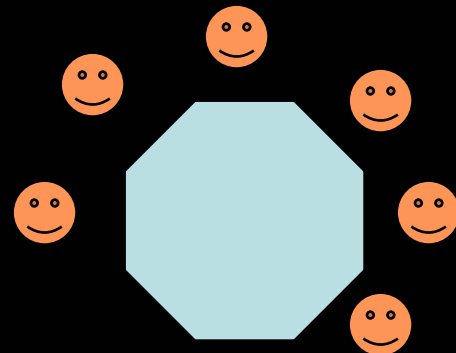
4. Status distinctions

Agents have characteristic sensible attributes ('tags'). Agents seek to locate other agents with a similar or identical set of tags (through movement and communication), but this search is expensive. Agents are able to create additional tags (the brand) by collecting tokens and carrying them around.

Agents either generate one additional tag or specially distinguish an existing tag and this becomes a linguistic category that labels agents and leads to differences in behaviour towards those agents that are labelled and those that are not.

Participatory models

- Conventionally, agents are computational agents
- Why not replace some or all by human agents?
- The simulation becomes a multi-user strategy game
- Benefits
 - Researchers can observe what people do in a given (simulated) situation
 - Participants can learn about implications of their decisions
 - E.g. business games



An example: ZWG



- Drought in summer 1976 led to a shock to Zurich's water supply system
 - Capacity increased to guarantee a secure supply
 - But over-supply leads to risk of stagnant water
 - Water demand has since fallen as a result of water saving technology and changing business behaviour
- Water utility regarded as inefficient due to high fixed costs
- Demand management through pricing would allow parts of the system to be closed
 - But tariffs ultimately controlled by public through referenda

housing association 1

state and age of houses



actions (click ? for details)

get quotes for a sanitary system

? Normal Water saving

advertise (select topic)

Political popularity

borrow from the bank €

reason for action



bank statement
diary of events
public discussions
private negotiations
other players
help

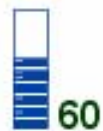
diary of events

21 Apr 00:12 on	Event	There has been an accident and the water quality has decreased by 1.
21 Apr 00:12 on	Event	The politician's popularity has decreased by 3.
21 Apr 00:12 on	Politician	spent €500 on advertising resulting in increasing Political popularity by 2
21 Apr 00:12 on	Politician	spent €500 on advertising resulting in decreasing Political popularity by 1
21 Apr 23:03 on	politician	spent €500 on advertising resulting in increasing Political popularity by 1
21 Apr 23:03 on	Politician	spent €500 on advertising resulting in increasing Political popularity by 2
21 Apr 23:03 on	Event	The interest rate on bank loans has changed to 24%.
21 Apr 23:03 on	Event	Because of an incident, it has become necessary to repair reservoir b.
21 Apr 23:03 on	Event	Because of an incident, it has become necessary to repair reservoir b.
21 Apr 23:03 on	Event	The interest rate on bank loans has changed to 25%.
02 May 22:26 on	Water Utility	left the game
02 May 22:27 on	Housing Association 1	joined the game

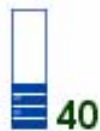
your rating



water demand



water supply



water price



water quality



political popularity



lake water quality



environmental awareness



leave

Further reading...

Journals

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<http://www.soc.surrey.ac.uk/JASSS/>

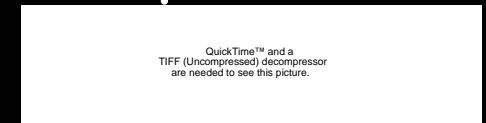
Paper stuff



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News and events

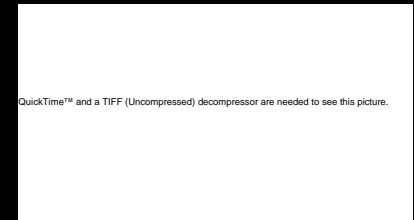
- North American Association for Computational and Organisational Simulation



- <http://www.dis.anl.gov/naacsos/home.html>

- European Social Simulation Association (essa)

- <http://www.essa.eu.org/>



- news

- <http://www.jiscmail.ac.uk>
- and then subscribe to 'simsoc' list

Summary

Words for later conversations:

- Target, model, simulation
- Static, kinetic, dynamic
- Emergence, complexity
- Second-order emergence
- Computational anthropology
- Participatory simulation

end