Social Simulation: theory and practice Statistics NZ SPEAR NZSSN 23 February 2006

agent-based simulation: a very short introduction

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overview

what is it?

- why is it interesting?
- what can you do with it?
- how can you learn more?

what is it?



agent

- 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)



what can you do with it?

- models of markets
- understanding ethnic segregation

- opinion dynamics
- managing resources
- science policy and innovation
- the evolution of language

sugarscape



- agents are located on a square grid
- they trade with their neighbours
- there are two commodities: sugar and spice.
 - all agents consume both these, but at different rates
- each agent has its own welfare function,
 - relating its relative preference for sugar or spice to the amount it has 'in stock' and the amount it needs



Epstein, Joshua M and Robert Axtell. 1996. Growing artificial societies: social science from the bottom up. Cambridge, MA: MIT Press.

agent strategies

- an agent can see a few cells around it
- it can move to an adjacent cell to replenish its sugar and spice stocks
- it can also trade (barter) with an other neighbouring agent
- the price is negotiated between them
- they trade when both would gain in welfare

supply and demand from the bottom up



segregation



- Thomas Schelling proposed a theory[†] to explain the persistence of racial segregation in an environment of growing tolerance
- He proposed: If individuals will tolerate racial diversity, but will not tolerate being in a minority in their locality, segregation will still be the equilibrium situation

[†]Schelling, Thomas C. (1971) Dynamic Models of Segregation. Journal of Mathematical Sociology 1:143-186.

a segregation model

- grid 50 by 50
- 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



tipping

- unhappy dgents move along a random walk
 to a patch where they are happy
- emergence is a result of 'tipping'

If one red enters a neighbourhood with 4 reds already there, a previously happy green will become unhappy and move elsewhere, either contributing to a green cluster or possibly upsetting previously happy reds so on...

values of tolerance above 30% give a 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

emergence in time



managing resources

participatory simulation

- replace some of the computational agents by humans...
- the multi-agent system becomes a multi-user strategy game
- the benefits:
 - researchers can observe what people do in a given (simulated) situation
 - participants can learn about implications of their decisions
 - including the reactions of others



the Zurich Water Game



- a 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
- the water utility was regarded as inefficient due to high fixed costs
- demand management through pricing would allow parts of the system to be closed
 - but the tariffs are ultimately controlled by public through referenda

housing association 1



water demand

60

	statement	of events	discussions	negotiations	players	help
	diary of events					
	21 Apr					0
4	00:12 on	Event There has been an accident and the water quality has decreased by 1.				
е	21 Apr					
	00:12 on 21 Apr	Event	The politician's popularity has decreased by 3.			
em	00:12 on 21 Apr	Politician	spent€500 on ad increasing Politica			
	00:12 on 21 Apr	Politician	spent €500 on advertising resulting in decreasing Political popularity by 1 spent €500 on advertising resulting in increasing Political popularity by 1			
	23:03 on 21 Apr	politician				
÷	23:03 on 21 Apr	Politician	spent €500 on advertising resulting in increasing Political popularity by 2			
	23:03 on 21 Apr	Event	The interest rate on bank loans has changed to 24%.			
<u> </u>	23:03 on 21 Apr	Event	Because of an incident, it has become necessary to repair reservoir b.			
go	23:03 on 21 Apr	Event	Because of an incident, it has become necessary to repair reservoir b.			
	23:03 on 21 Apr	Event	The interest rate (to 25%.	on bank loans has	s changed	0
	22:26 on 02 May	Water Utility	left the game			Q
	22:27 on 02 May	Housing Association 1	joined the game			T T
watersupply	water price	water quali	ty political popu	larity lake water	quality envi	ronmental
		-			200	
40	5	7	6		L	5 leave

3 FIRMA

your rating

The FIRMA Project is supported by European Union's Framework 5 Programme for Research and Development, and by the European Commission as part of its Key Action on Sustainable Management and Quality of Water pro

methodological issues

is it qualitative or quantitative?

Multi-agent systems can handle all types of data

- quantitative attributes
 - age, size of organisation
- qualitative
 - ordinal or categorical (e.g. ethnicity),
 - relational (e.g. I am linked to him and her)
- vague
 - A sends B a message about one time in three

prediction and understanding



operationalism and realism

- operationalism
 - variables measure observable properties of actors
 - causation is inferred from correlations
 - compare an epidemiological study of a disease
- realism
 - actors and mechanisms are proposed that correspond with real actors and mechanisms
 - compare finding the bugs that cause the disease

why is it interesting?

Structure

- structure is emergent from agent interaction
- this can be directly modelled
- Agency
 - agents have goals, beliefs and act
 - this can be directly modelled
- Dynamics
 - things change, develop, evolve
 - agents move (in space and social location) and learn
 - these can be directly modelled

how can you learn more?

- journals
- textbooks
- associations
- mailing lists





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summary: agent-based simulation

- a technique for theorising
 - that is sympathetic to the complex, dynamic social world
- a methodology
 - that is essentially realist
- a practical tool
 - that can have real world utility

end