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A long time ago… back in the 20th century…

I made a silly mistake and wrote a very very complicated agent-based computer model without a clear aim of what I was trying to do

I wasn't sure what to put into the model and what to leave out so I put almost everything in and parameterised the key assumptions (magic numbers) of the model

Then I realised it was so big and complex that I didn't really know how to explore the model to find interesting phenomena

This is the story of how I pulled myself out of this hole!

Aims of the talk

- Overview a quite complicated agent based model (the stereolab)
- Discuss some methods used to explored the parameter space
- Identify the outcomes of the analysis

Stereotyping

- In large human societies people have to interact with strangers all the time
- Cooperation and trust within such interactions is often required
- But with no information concerning another, how can a decision be made?

Stereotyping

- People sometimes rely on gross stereotyping based on observable characteristics
- Sometimes this might make sense but often it appears to be arbitrary
- We want to explore this kind of process abstractly

Stereotyping - assumptions

- In large complex societies stereotyping allows for “cognitive economy” simplifying the social world
- Often stereotypes are received from others via communication
- Can be generalised, specialised or otherwise changed by individuals

Stereotyping - questions

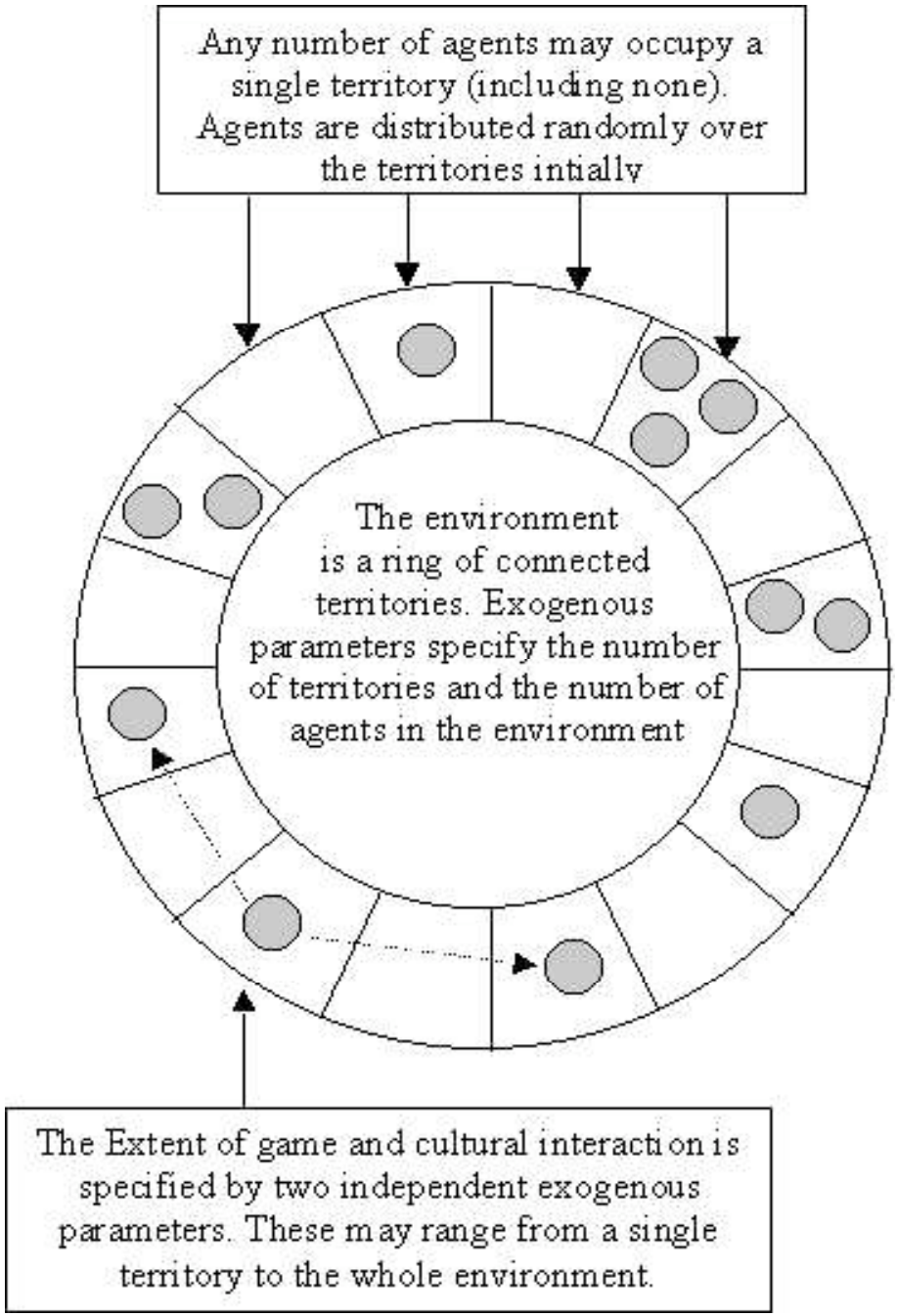
- If agents are sharing and creating “stereotypes” in a “memetic” way…
- Under what conditions (if any) can this promote cooperation
- What mechanisms produce this cooperation

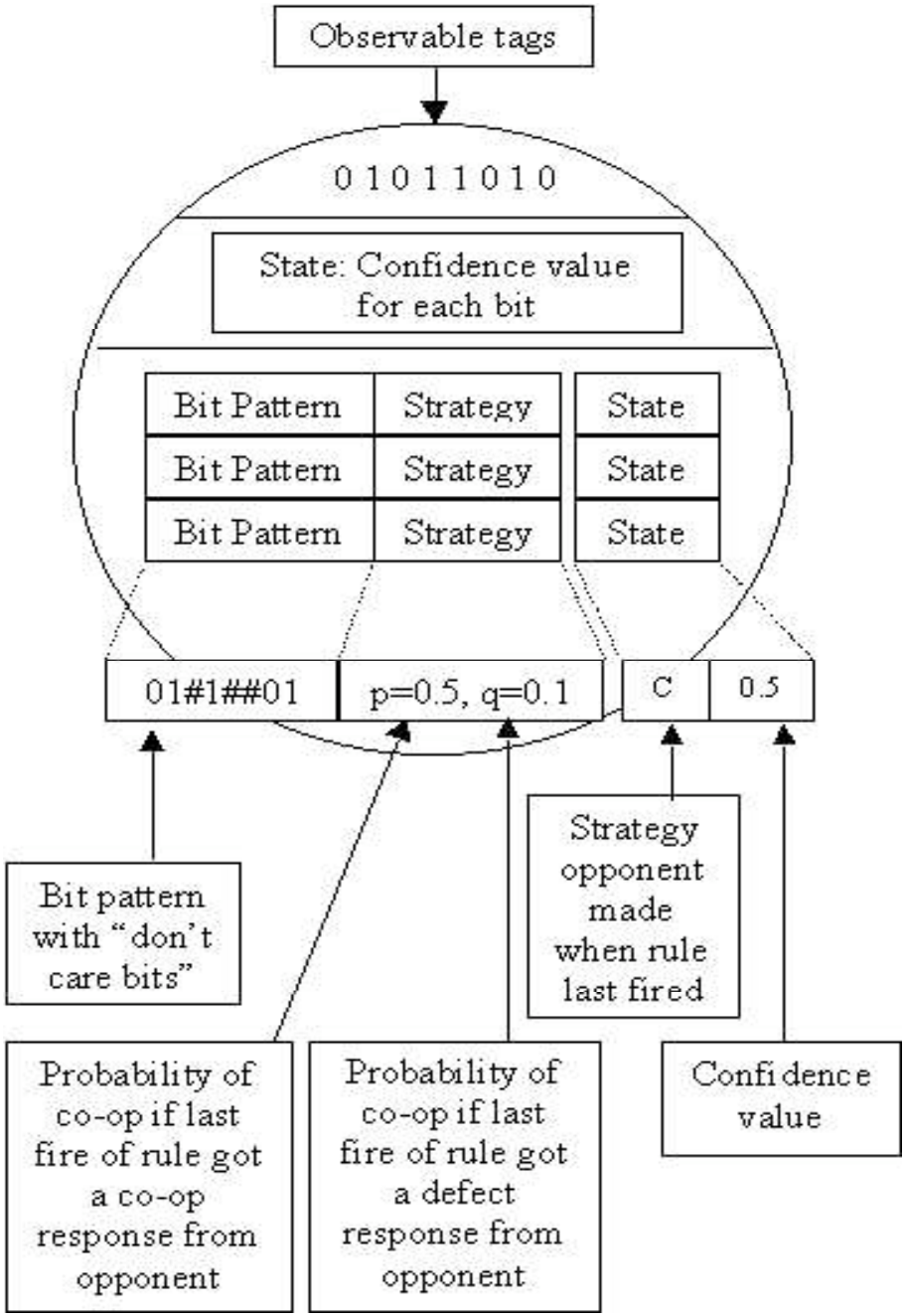
The StereoLab model

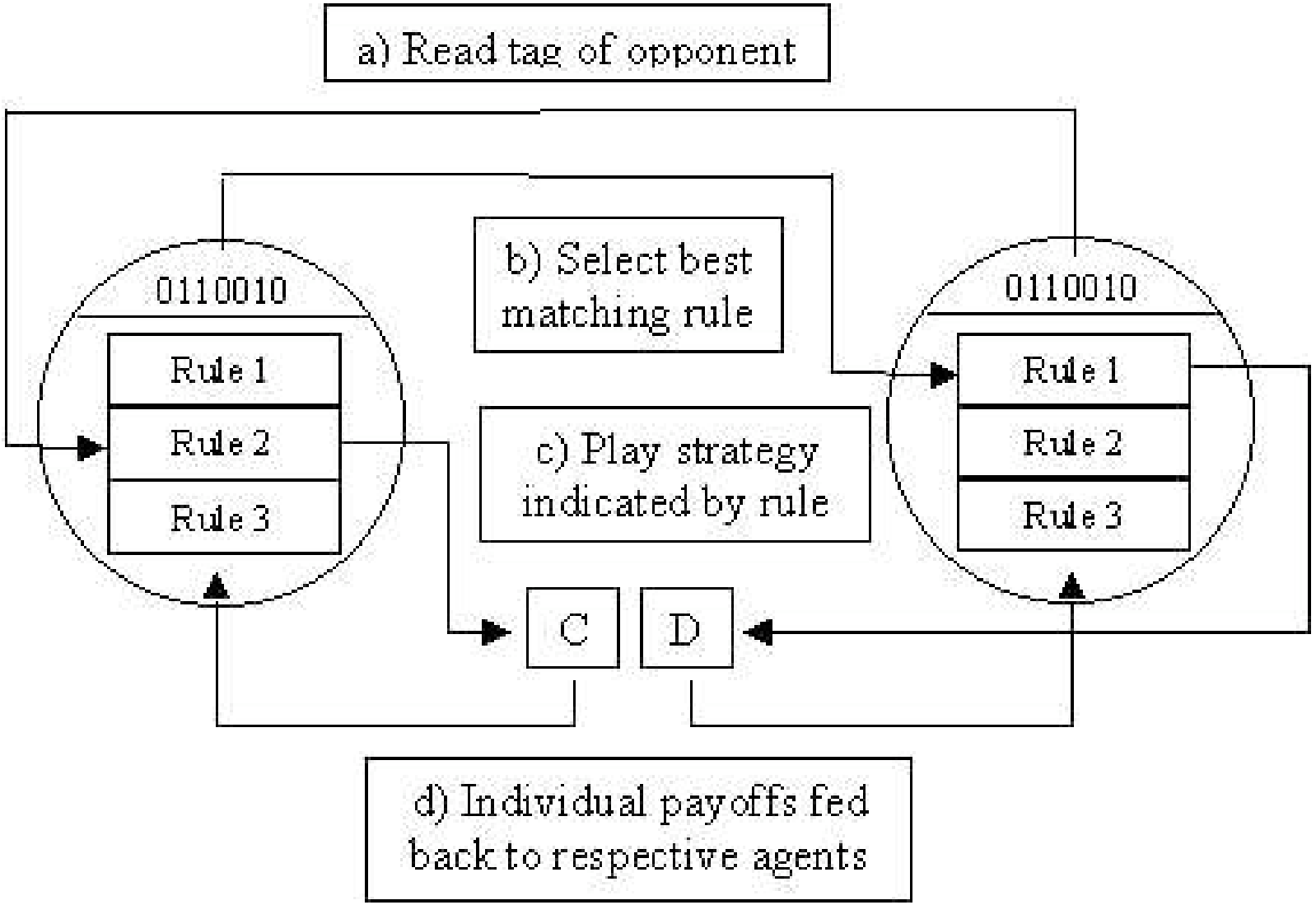
- Agent based computer simulation
- 100 satisficing agents, live on a 1D ring
- Discreet locations on the ring
- Interact culturally (memetic) and economically (PD game) with neighbors
- Many aspects of model parameterised

The StereoLab

- Agents store, communicate and mutate two kinds of meme
- Observable tags and behavioral rules
- The rules are stereotypes indicating how cooperative an agent should be with other agents based on generalisations over tags

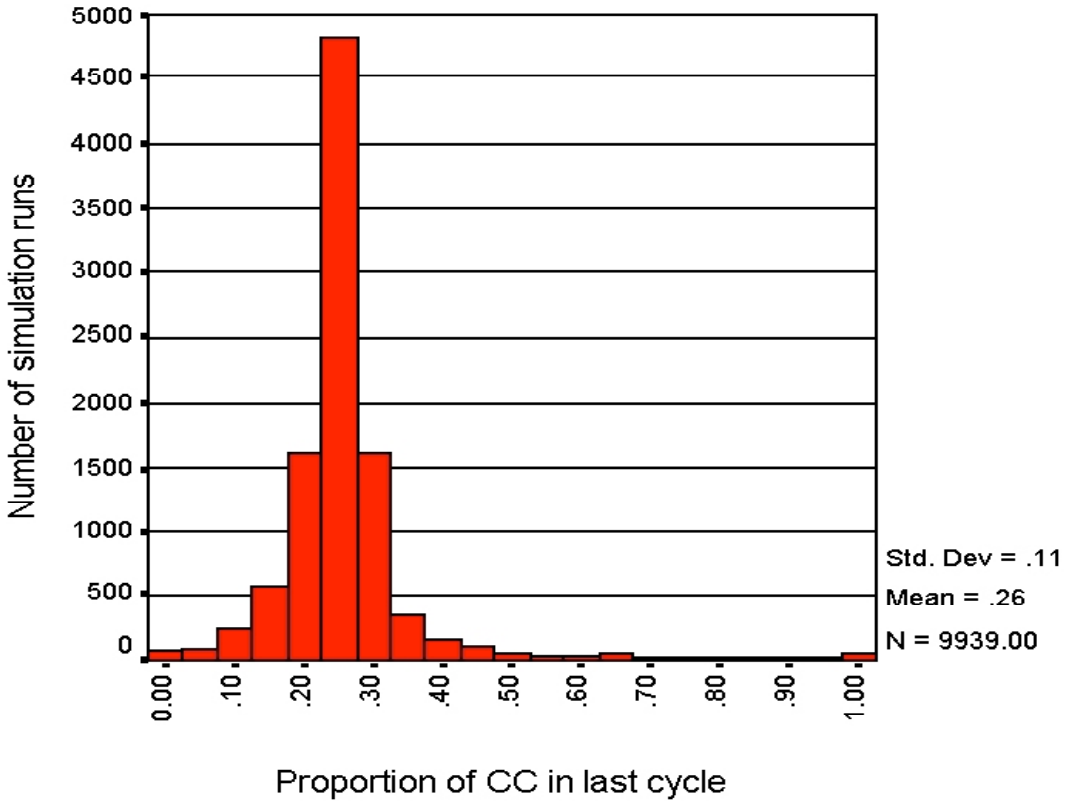

Any number of agents may occupy a single territory (including none). Agents are distributed randomly over the territories intially
The environment is a ring of connected territories. Exogenous parameters specify the number of territories and the number of agents in the environment
The Extent of game and cultural interaction is specified by two independent exogenous parameters. These may range from a single territory to the whole environment.


Observable tags
0 1 0 1 1 0 1 0
State: Confidence value for each bit
Bit Pattern
Strategy
State
Bit Pattern
Strategy
State
Bit Pattern
Strategy
State
01#1##01
p=0.5, q=0.1
C
0.5
Bit pattern with "don't care bits"
Probability of co-op if last fire of rule got a co-op response from opponent
Probability of co-op if last fire of rule got a defect response from opponent
Strategy opponent made when rule last fired
Confidence value


a) Read tag of opponent
b) Select best matching rule
0110010
Rule 1
Rule 2
Rule 3
c) Play strategy indicated by rule
0110010
Rule 1
Rule 2
Rule 3
C
D
d) Individual payoffs fed back to respective agents

	Description	Rng
B	Number of bits in tag string	4..8
M	No. stereotypes agent s tores (mem. size)	2..10
S	Number of locations in env ironment	101
N	Number of agents in the soc iety	101
T	Satisfaction threshold	3
PM	Probability of meme propag ation	0..1
P	Probability of satisfaction test	1
MT	Mutation rate	0..1
CI	Factor by which t o increase conf idence	0..1
CR	Factor by which to decrease conf idence	0..1
MS	Mutation size for strategy parts	0..1
FG	Prob. of game -interaction in a time unit	0..1
FC	Prob. of cultural interaction in time unit	0..1
FM	Prob. of rand. agent movement in time unit	0..1
BF	Proportion of tag bits that are fixed	0..1
BG	Req. prop of tag shared for game -interac.	0..1
BC	Req. prop. of tag shared for cult. -Interac..	0..1
TG	No. refusals before forced game -intera c.	1..10
TC	No. refusals before forced cultur al-intera c.	1..10
VC	Size of cultural interaction window	0..1
VG	Size of game -interaction window	0..1
PP	The P payoff from the PD matrix	1
PT	The T payoff from the PD matrix	5
PR	The R payoff from the PD matrix	3
PS	The S payoff from the PD matrix	0
PP	The P payoff from the PD matrix	1
PT	The T payoff from the PD matrix	5
PR	The R payoff from the PD matrix	3
PS	The S payoff from the PD matrix	0

A random sample



Exploration with C4.5

- C4.5 is a decision tree induction algorithm
- Feed in parameter values (input vector) and output categories (e.g. high or non-high cooperation) for each run
- C4.5 recursively splits the input vector based on information gain in the output category

Region found

- MT > 0, CR > 0, VG = 0, FM <= 0.1
- 150 points, 80% high cooperation
- Meme mutation is non-zero
- Agents reduce confidence in their memes if they are not satisfied
- Game-interaction limited to a single territory
- The frequency of agent movement between territories is low.

Region Found

- MT>0, CR>0, VG >0, PM >0.4, FG<=0.1, FC>0.1
- 284 points, 44% “high cooperation”
- Meme mutation is non-zero
- Agents reduce confidence in their memes if they are not satisfied
- Game-interaction NOT limited to a single territory
- Cultural interaction events are, at least, one order of magnitude more frequent than game-interaction events.

Hill-climbing & cluster analysis

- 100 random points
- Local hill-climb for 100 steps
- Search for global maximum – 100% cooperation
- 39 points found
- Cluster those points using k-means method

Clusters

- Cooperation high when game-interaction is limited to single territory (as before)
- Cooperation high when BG and TG were high and BF was low - biasing of game-interaction towards those sharing similar tag bits is high and the low value for BF indicates that the majority of tag bits are culturally learned
- What process produces high cooperation from such biasing?

The tag process (again)

- Tags combined with biasing create “game-interaction groups” sharing the same tags
- Cultural learning can change tags
- Hence agents “move” between tag groups
- Unsatisfied agents change tags (hence groups)
- Groups satisfying their members (via cooperation) tend to stabilise and recruit
- Groups that do not satisfy tend to dissipate
- Hence cooperation is promoted

The “tag” process is general

- Single round PD (economics / biology)
- Generalised exchange (sociology)
- Self-organising networks (engineering)
- Symbiosis / specialisation (biology)
- Swarming attack drones (military)

Conclusions

- Large parameter spaces can be explored using semi-automated methods (C4.5 & hill-climb + clustering)
- Regions of interest can be located and examined
- From these specific runs general mechanisms / processes can be identified (hand-waving, black art)
- Exported to a number of disciplines by applying it to their “pet” problems