Artificial Societies, Theory Building and Memetics

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Abstract. A growing body of researchers from the social and computer sciences are using computational experimentation in a highly exploratory way. The work done in this area is less "simulation" and more "construction". By analogy with artificial intelligence and artificial life, this synthetic approach has become known as artificial societies.

It is argued that artificial societies can aid memetic theory building ultimately producing theories and hypotheses that can be tested in the real world.

A set of methodologies loosely based on the Popperian (Popper 1968) conception of theory refutation through the falsification of hypotheses and consequent theory development is presented. This process occurs within a deductive system (the artificial society) which due to it's complexity requires empirical investigations to refute hypotheses and generate theory.

Current work (Hales 1998c) involving construction and experimentation with an artificial society in order to aid the building of meme theory around the processes of stereotyping and group formation is outlined.

1 Artificial Societies

Computational modelling and simulation of social systems has a history of almost 40 years (Halpin 1998). Recently a speculative and exploratory form of social modelling has emerged. Termed "Artificial Societies" (ASoc), such models address "possible societies", their general processes, dynamics, and emergent properties (Gilbert & Conte 1995). In the same way that Artificial Intelligence is not limited to the accurate modelling of physiological brain processes so ASoc research does not start from some given scenario or particular social system. The aim is to model features and processes which characterise societies in general: co-operation, specialisation, group formation, hierarchy etc. Asoc work does not strive for superficial realism or direct correspondence with existing societies but for abstract logical relationships that characterise whole categories of phenomena. Generally ASoc's consist of multiple interacting agents. Each agent minimally consists of: internal state; sets of possible actions; percepts (or perceptual inputs); a shared environment and some form of decision process informing action selection. This latter component of an agent's "architecture" may vary considerably. It may consist of simple hardwired rules (e.g. the Sugerscape see below), deliberative, planning and goal directed AI systems (e.g. EOS - Doran et al 1994); inductive learning (e.g. via connectionist models - Hutchins & Hazlehurst 1992) or population level evolutionary methods (e.g. evolutionary game theory - Hoffmann & Waring 1996).

2 Artificial Societies and Cultural Evolution

One of the more recent and substantial contributions to ASoc work is the Sugarscape (Epstein & Axtell 1996). Cultural transmission in the Sugarscape is effectively an extension of Axelrod's Cultural Model (ACM) (Axelrod 1995) which can be compared to the Social Impact Theory (SIT) models of Nowak & Latané (1994). These two latter models are implemented within a Cellular Automata framework (a 2-dimensional grid of fixed agents interacting within some small spatial neighbourhood). Sugarscape, ACM and SIT work on a passive representation of culture focusing on the spread of cultural attributes.

In Scenario-3 Doran (1998) models agents with beliefs about their environment detailing the location and usefulness of resources and the friendliness of other agents. Beliefs are spatially harmonised and mutated. Societies often thrive around misbeliefs based on "cult heads" in which dead agents become universal friends increasing co-operation among "cult followers". Could such processes have contributed to the emergence and success of religious beliefs in early societies?

Gilbert (1997) uses an artificial society to model the publication trends found in scientific literature. By modelling individual papers as units of transmissible knowledge ("kenes") which compete for authors to get reproduced (cited in other papers) he demonstrates the formation of subject clusters based around seminal papers. The results of these simulations correlate with statistics detailing real publications and citations.

Gabora (1995) presents a society populated with connectionist based agents which have the ability to evaluate new memes before accepting them. Within the given scenario different creativity to imitation ratios are investigated.

Bura (1994) introduces an ASoc model of meme spread (Minimeme) which ascribes levels of confidence to memes. Confidence is mediated by a satisfaction function and a form of frequency-dependent bias (Boyd & Richerson 1985). The model was extended (Hales 1997) to include meta-memes, memes that directly effect the meme process at the individual level impacting on the agents receptivity to memes.

3 A Methodology for Aritificial Societies?

Many have recently noted that ASoc work does not fit neatly into existing experimental methodologies. Consider the following comments:

"Simulation is a third way of doing science. Like deduction, it starts with a set of explicit assumptions. But unlike deduction, it does not prove theorems... induction can be used to find patterns in data, and deduction can be used to find consequences of assumptions, simulation modelling can be used as an aid to intuition." (Axelrod 1997).

"Clearly, agent-based social science does not seem to be either deductive or inductive in the usual senses. But then what is it? We think *generative* is an appropriate term... We consider a given macrostructure to be ’explained’ by a given microspecification..." (Epstein & Axtell 1996).

“We can therefor hope to develop an abstract theory of multiple agent systems and then to transfer its insights to human social systems, without *a priori* commitment to existing particular social theory." (Doran 1998).

"Our stress... is on a new experimental methodology consisting of observing theoretical models performing on some testbed. Such a new methodology could be defined as 'exploratory simulation'... " (Gilbert & Conte 1995).

Below a set of methodologies are presented which attempt to untangle and incorporate these various strands of investigation.

3.1 Artificial Society Experimentation

Asoc work can be seen as a set of assumptions (A) used to construct the society; a set of runs (R) comprising execution of a computer program which embodies (A); a set of measurements or observations (O) of the runs; a set of explanations (E) which attempt to link (A) and (O) in some meaningful way and a set of hypotheses (H) linked to (E) based on (A) and (O).

(A), (R) and (O) are formalised since (A) represents a computer program, (R) some set of executions of the program and (O) some specified measures of (R).

(E) and (H) may or may not be formalised. They are often given in a mixture of natural language using qualitative concepts and statistical or mathematical relationships. In either case the explanation aims to illuminate the dynamic processes in (R) with reference to (A) and (O) and possibly via the identification of some emergent properties.

3.2 Mix & Match Methodologies

Connecting the above components in different ways reveals several modes of inquiry, some of which are now detailed. An existence proof does not require an (E) or (H) at all. Here (A) is shown to be sufficient to produce some (O) (see fig.1). Behaviour modelling (or reverse engineering) again does not require (E) or (H). Here some existing process (R') is observed (O') and compared (possibly visually / qualitatively) against (O) and, based on divergence, (A) is revised (see fig.2). This process is continued until a satisfactory level of correspondence is observed.

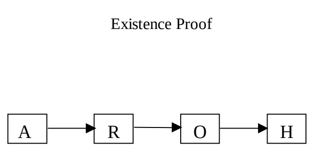

Figure 1

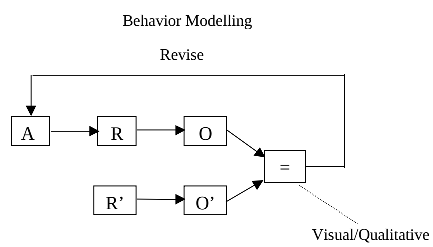

Figure 2

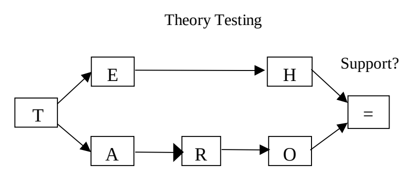

Figure 3

Figures 1-5 show some typical methodologies used in ASoc work. The feedback arrows indicate possible revision based on results obtained. See text for details.

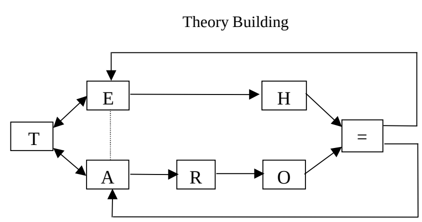

Figure 4

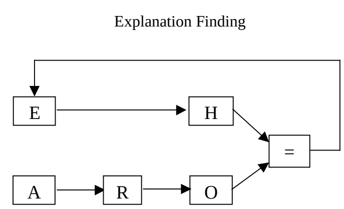

Figure 5

Theory testing involves the translation / abstraction of some existing theory concerning real social processes (T) into (E), (A) and (H) and then the testing of (H) against (O) in order to either support or refute (H) and by implication (T) (see fig.3). Theory building involves the abstraction from (T) into (E), (A) and (H) comparison between (O) and (H) and then possible revision of (E) and/or (A). Given that a state is reached in which (E), (H) and (O) correspond, (E) and (H) can then possibly be "de-abstracted" into (T) producing a theory testable against real social processes (see fig.4). Explanation finding involves iterative refinement of (E) based on comparison of (H) with (O) without changing (A) (see fig.5).

Many of these modes combine deduction and induction often in an iterative way. Such investigation has been termed "Ceduction" (Hales 1998a). The inductive process here is viewed as iterative observation and revision of (E) and (A). The (O) is produced deductively (computationally) from (A) but the revision of (E) and (A) is an inductive process based on observation guided by (H).

4 Altruism in the Swap Shop

Allison (1992) proposes a theory of altruism based on a "rules-eye" view of cultural evolution. Here the conception of "cultural relatedness" and the transportation of utility is used in order to explain the success of culturally learned altruistic behavioural rules. Several authors have proposed such mechanisms in different contexts (Haylighen & Campbell, Macy 1998, Evers 1998). In order to explore group formation and altruism between and within groups the ACM was extended into a resource sharing scenario - The Swap Shop (SS) (Hales 1998b). Here a theory testing method was used (see fig.3). In SS minimal meme propagation rules produce distinct cultural groupings with in-group altruism and out-group non-altruism.

5 Stereotyping and Cultural Evolution

Much work in social psychology (Oakes et al 1994) has focused on the formation and stability of culturally learned stereotypes. Stereotypes might be defined as generalisations such that certain (positive or negative) opinions are attached to individuals which have never been previously encountered. For an individual to utilise stereotypes some method of categorising other individuals is required. Ignoring fixed, assumed, deduced or imagined characteristics an ASoc has been constructed which minimally captures stereotyping based on culturally learned behavioural rules and observable features (Hales 1998c). Here a distinction is made between observable "surface memes" and non-observable "hidden memes". The stereotypes in the form of behavioural rules which map generalisations over observable characteristics are hidden whereas the characteristics themselves (representing "cultural markers" or "labels" such as form of dress etc.) are represented as surface features. Agents interact within a large population and store a number of stereotypes within their memories. Two distinct forms of interaction occur; economic (via a game of the Prisoners Dilemma) and cultural (via the exchange of memes, both surface and hidden). Many of the assumptions of the society have been parameterised. Of specific interest are the conditions (specific assumptions) that produce distinct groupings of agents with various economic relationships: e.g. where one group systematically exploits another or where groups become altruistic towards their in-group (as in the SS above). In order to explore the large parameter space of the society an automatic "hill-climbing" searching system has been developed. This implements a form of behaviour modelling (see fig.2) where the comparison is automatically made and the assumptions are automatically modified.

6 Tentative Observations

At the time of writing experimental work is at an early stage. However, the following tentative and qualitative observations can be made. Extreme spatial localisation of game interaction promotes co-operative economic behaviour whereas extreme spatial localisation of cultural interaction promotes exploitative behaviour. Group formation (defined here as sets of agents sharing all their labels) promotes co-operative economic behaviour. Interestingly, it is rare for agents to hold stereotypes which categorise themselves (a form of self-recognition). Even with extensive searching of the parameter space, societies could not be found which contained significant numbers of agents holding stereotypes which applied to themselves. This latter finding appears to refute an early hypothesis concerning the formation of in-group altruism through positive self-recognition of the in-group. But this is not the case. However, a revised hypothesis suggested by some initial results is that agents tend to hold negative stereotypes against other agents which are very similar to themselves (e.g. differing by only one label). In this way it may be possible for "groups" to form based not on positive self-recognition but on negative recognition of group boundaries. This hypothesis is currently under investigation.

7 Conclusion

Artificial societies do not aim to model real societies in any direct sense. They can be seen as an aid to intuition in which the researcher formalises abstract and logical relationships between entities. When constructed computationally they can be investigated empirically by producing explanations and hypotheses which can be refuted by observation. More interestingly, since the assumptions upon which the society is constructed can be changed there is no need to simply observe. Other modes of investigation are possible in which assumptions are changed to produce desired behaviour. Whatever the relationship between real societies and artificial ones (a problematic area) it is argued that such systems can be used as an aid to theory construction by sharpening intuition in the formulation of hypotheses which can be testable against real data.

Many of the models constructed within the ASoc mould have tended to be strictly "bottom-up" (i.e. highly skewed towards a form of methodological individualism) and consequently illuminate the micro-macro link. This skew appears for many reasons, not least that many researchers are interested mainly in this link. However, given agents inhabiting societies which maintain a meme-pool which contains ideas about the structure and form of that very society, it appears that such a skew can be alleviated. Such models can attempt to illuminate the micro-macro-micro feedback links which regulate social structures.

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