Methods of artificial intelligence as analytical instruments to investigate consumers' response after a food scare

Methoden der künstlichen Intelligenz als analytisches Instrumentarium zur Analyse von Konsumentenverhalten bei Lebensmittelskandalen

Volker SAGGAU

Zusammenfassung

Der Beitrag beschäftigt sich mit einer neuen Methodik, die aus der künstlichen Intelligenz erwachsen ist und derzeit ihre Anwendung in vielen Bereichen der unterschiedlichen wissenschaftlichen Disziplinen findet. Die Methodik der Multiagentensimulation wird hier auf einen Untersuchungsgegenstand angewendet, der sich mit der Informationsausbreitung nach einem Lebensmittelskandal und dem sich daraus verändernden Vertrauen beschäftigt. Die Modellierung eines solchen Systems wird sowohl abstrakt als auch konkret beschrieben.
Schlagworte: Emergenz, Memetik, Mem, komplexe Phänomene, Informationsausbreitung.

Summary

Methods of artificial intelligence offer a rich application field in a number of different scientific disciplines. Multiagent simulations use some features of artificial intelligence. This methodology will be applied in this paper work to investigate how diffusion of information regarding a food scare influences a population of agents and their trust in this food item. The modelling of such a system will be done abstract as well as concrete.
Keywords: Emergence, complex phenomena, memetic, meme, information diffusion.

Published 2005 in the *Jahrbuch der Österreichischen Gesellschaft für Agrarökonomie*, Vol. 14, S. 99-110. Available on-line: www.boku.ac.at/oega

1. Introduction

Information diffusion and information processing are topics which have been investigated in various ways and fields in recent years. Connected with perception, trust and decision making they form a complex field which is not trivial to investigate.

There are several streamings based on its specific assumptions, perspectives and proceedings which try to find explanations for this dynamic and hard to determine part in the social and economical sciences. Neither neoclassical models nor models of behavioural sciences as well as pure information economics were able to adequately reflect the whole spectrum of this complex aspect of life.

Traditional economical modelling marked by the top-down-construction is not flexible enough to reflect the complexity of the daily life. The restrictive conditions which support this framework and the assumption of ever stable market equilibrium exclude temporal states and development perspectives. Personal interactions typically don't play a role at all in these models. But this contradicts observation in real life where interaction plays a crucial role.

The question then is "how do complex phenomena evolve?" One important issue to address is already mentioned in the question: emergence. This phenomenon is a kind of universal player. It doesn't care about the restrictions of a scientific discipline. Emergence is observable in many scientific fields. From this point of view it is no wonder that several scientists from different disciplines to address the same question, namely the force that drive emergence and the results that evolve under different conditions. Biologists, physicists, social scientists and also economists (and this list is not complete) are discussing the common phenomenon with the special reference to their own disciplinary questions.

Emergence means the evolvement of new structures or properties which evolve by the cooperation of the elements of a complex system. Emergence comes from the bottom up, so that the top-down idea is not applicable for this field to analyse.

This paper work faces on methods of the artificial intelligence which could be used to identify mechanisms which drives emergence. One of these methods will be used to serve as an example to apply such a method to a research question which aims at investigating real life

problems. A multiagent system will be presented which focuses at the information diffusion regarding food scares and their influence on the aggregate demand regarding this food item under investigation. This model is based on local interactions of consumer agents which lead to an aggregate demand given specific information releases.

2. Emergence and complex phenomena

What are complex phenomena? Complex phenomena could be decentralised markets, inductive learning, consumer societies, endogenous evolving trading networks and so on. Decentralised markets are complex adaptive systems which consist of a big number of adaptive agents which are itself connected to parallel local interactions (TESFATSION, 2002). These local interactions lead to macro economical regularities like behavioural norms which itself feedback to the determinants of local interactions. The result is a complex dynamical system of repeating causal chains which connect individual behaviour, interaction networks and social welfare.

The methods of the artificial intelligence offer a big variety of tools to investigate these complicated mechanisms. Simulation runs generate results and could serve to get a deeper insight into the processes that drive evolving phenomena. Computational laboratories allow investigating under controlled experimental conditions how for example consumer populations decide. The agent population lives in an environment and forms by interaction a complex system. This is a major point: not the system itself is complex but the interaction between the single agents or particles makes the system complex.

At this point we should have a deeper look into the phenomenon "emergence". Emergence means the coming up of properties which did not exist before qualitatively different components have been merged or divided. Consider our brain which consists of a huge number of "simple" elements, the neurons. The interaction of these elements leads an evolving of patterns which make up the brain activity: one single neuron has no thought, the brain as a whole normally has. HOLLAND

(1998, 1) is of the opinion that we have to understand emergence first before we can understand life.[1]
The simulation has two goals: one is to find a constructive explanation how a global behaviour looks like and which are the processes that lead to this global behaviour and not to another. The other is what is the influence of the structure of the system itself on the result and how does a specific event like information regarding the safety of a food item changes the result.[2]

3. Modelling a multiagent simulation

The modelling starts with the construction of an economy which consists of an initial population of agents (SAGGAU, 2003). There are primary agents like consumers and there are auxiliary agents which often represent different social and model environmental objects, e.g. media agents.
First the initial state of the economy has to be specified, i.e. the agents will be equipped with their initial attributes. These attributes may be type characteristics, internal behavioural norms[3] and internal information about themselves and other agents like the network connections.
The development of the economy happens in time by interaction and updating of internal states of the agents, e.g. updating the trust value for a specific good or supplier. The simulation model should adequately reflect the development of trust respectively distrust within a population of consumer agents after a food safety incident happened.

---

[1] „Nowadays we know that genes in the seed specify a step-by-step unfolding of biochemical interactions, but only fragments of this complex process are clearly understood. Indeed, it is evident that we will not truly understand genes and chromosomes until we understand the gene specified interactions that take a seed, or a fertilized egg, to a mature organism. In short, we will not understand life and living organisms until we understand emergence.", HOLLAND (1998), 1f.

[2] This is of high importance for our EU-project. We want to evaluate different risk communication strategies regarding food safety. "Food Risk Communication and Consumers' Trust in the Food Supply Chain". TRUST – QLK1-CT-2002-02343. http://www.trust.unifi.it/

[3] This could be communication or learning modes.

3.1 The networks and the information sources

The model consists of several networks which serve as information sources for the agents (SAGGAU and PATELLI, 2004, 2f). We have decided to implement decentralized and centralized networks. Both types of networks serve as information sources for the agents. The decentralized networks are social networks which again are several networks like the demographic network or friend's networks. These networks are endogenous, i.e. the information processing is endogenous. Whereas the centralized networks are exogenous. They spread the information from one single information source to the population of agents.

An initial population of consumer agents found the basis for the simulation. They are connected to the networks. They communicate information about the safety of food and their trust regarding this food item.

We differentiate two respectively three kinds of social networks. Each network serves as an information source for the agents. The networks are differentiated by unique identifiers so that the information sources are well known to the agents.

In the demographic network each agent of the population finds its place in a family structure. The demographic network consists of three generations: the grandparent generation, the parent generation and the children generation. The agents are consistently assigned to this network, i.e. the family relations are kept, and there are no inconsistent states.

The demographic network can be varied by changing three parameters: the population size, the average number of offspring in the second generation and the average number of offspring in the third generation.

Each agent can also be part of a friend's network. The connection to other agents can be chosen differently. It's possible to choose between different distributions of the links to the friends.

Agents can be related in groups respectively clusters, where the nodes or agents are interconnected in a bidirectional way. Some agents have links to agents which are outside of the cluster but again in another cluster. In this way the friend's networks can be created. Colleague's networks are technically similar, but they have a different weight.

The centralized networks can be the shops, the media, the government etc. Here each agent is connected to these networks. We call it centralized because everybody receives a message which is released by these information sources. Whereas the social networks are decentralised, i.e. only the members of the single social networks will be informed. The intensity of the information received from the different networks is also different, depending on the information type, the information source (the weight of the network) and other environmental influences.
Since we look at information which is related to food scares we have to consider negative and positive information. Bounded rationality is an aspect which has to be taken into account when looking at consumers which have to take decisions. The Prospect Theory of KAHNEMAN and TVERSKY (1979) refers to that issue. Consumers evaluate negative information relative to a reference point higher than positive information, i.e. negative information has a higher weight than positive information. This point has to be taken into account with respect to information releases by centralized information sources.

3.2 The agents

We use a Bayesian updating process which BOECKER and HANF (2000) have applied to investigate how new information influences trust in two kinds of suppliers. One supplier type is reliable (supplier *A*) while the other is not (supplier *B*). P_J in equation 1 is the probability of supplier *J* to be reliable. This is seen as the trust value before new information appears. P_{PJ} is the probability of supplier *J* to be reliable after new information was taken into account. Negative information activates equation 1.

$$P_{PJ} = \frac{P_J P(G \mid A)}{P_J P(G \mid A) + (1 - P_J) P(G \mid B)} \tag{1}$$

The updating of positive information displays equation 2. $P(G \mid A)$ is the probability to buy a defected good of supplier *A* while $P(G \mid B)$ is the placeholder for the probability to buy a defected good of supplier *B*.

$$P_{PJ} = \frac{P_J (1 - P(G \mid A))}{P_J (1 - P(G \mid A)) + (1 - P_J)(1 - P(G \mid B))} \tag{2}$$

We use this method to update trust as an internal processing mechanism in each agent when new information is available. The decision function of the agents is based on this model. There are three steps: The agents collect information, they revise their P_J and they diffuse their P_J to their related agents.

Like stated above, each agent is part in at least one network, the demographic network, but can also be part in other networks. The agent is registered in the networks where it belongs to. It can go through the networks and ask for information.

The agents have internal updating algorithms. These algorithms aim at the information on the one hand side and at the decisions taken by the related agents in the networks on the other hand side. In each step of the simulation run the basic agents' internal step method will be invoked. This method goes through the list of related agents, looks up what the trust value is, evaluates it and it also goes through the list of information sources in order to get information and to update its own information state. In each iteration there will be three steps performed.

Step 1 - Information Collection and Processing:

The agents collect in each time step information from their neighbours, i.e. from the decentralized information sources, and also from the centralized information sources (media, gov., shops ...).

Step 2 - Bayesian Updating:

After the information collection the agents update their P_J according to Bayesian updating (see above). The old P_J enters into the equation and revises P_{PJ} which then again is the next value which enters in the following updating and so on.

Step 3 - Trust Communication (P_J):

The third step is that the agents collect the P_Js from their related agents and aggregate the value according to an aggregation rule (mean, max, min).

3.3 Information strategies and the aggregate demand

One of the initial questions referred to the impact of different information strategies. Since we investigate food scares and the corresponding changes in the demand, we focus on information strategies starting with negative information releases regarding the food item under investigation followed by positive information releases by lobbies like

producer organisations, political stakeholders or others using the media to spread information.
The distribution of the information releases by the centralized media can be chosen by the user of the simulation. We consider in our case first a negative information release in the sense of observing a product failure regarding the food item under investigation. The centralized objects spread negative information over the network respectively the population, so that each agent receives this negative information signal. When time continues, here the iterations of the communications steps, the intensity of the information release decreases. It follows an exponential distribution. In a certain point in time, we call it break-point, the information release changes from negative to positive information. It also follows an exponential distribution, beginning with a high intensity and decreasing the intensity when time continues.

4. Memetic – a different view on the things

At this point follows a different try to explain how human beings could be influenced by information. Why has the information "BSE" dominated all other food safety incidents? This question will be addressed in the following by applying a different approach towards information processing.
The same question but in another context was asking Bryan Arthur himself when he was thinking about "increasing returns". WALDROP (1992, 35) described in his book "*Complexity*" how Arthur discovered several examples of increasing returns in the economy. The question was "why do some ideas survive while other die out?" These ideas came into path dependencies. One explanation is that successful ideas could evolve by emergent processes and follow then a path dependency. „Consider the Beta versus VHS competition in the mid-1970s. Even in 1979 it was clear that the VHS videotape format was well on its way to concerning the market, despite the fact that many experts had originally rated it slightly inferior to Beta technologically. How could this have happened? Because the VHS vendors were lucky enough to gain a slightly bigger market share in the beginning, which gave them an enormous advantage in spite of the technological differences: the video stores hated having to stock everything in two different formats, and consumers hated the idea of being stuck with obsolete VCRs. So

everyone had a big incentive to go with the market leader. That pushed up VHS's market share even more, and the small initial difference grew rapidly. Once again increasing returns" WALDROP (1992, 35-36). Back to the question why the information "BSE" has such a strong effect on the consumer population. Information will be diffused by people who actively communicate. But there may be an additional aspect – the concept of the Memes. What does it mean?

Some methods of the artificial intelligence research were created by copying nature's methods. Nature often serves as a blueprint which could be adopted to technical problems like weight problems in engineering new aggregates for cars. Artificial neural nets for example were created in the same way as their natural originals but much easier structured. DAWKINS (1976), a biologist, developed the concept of the memes. He claimed that information has its own will. He worked with genes. Genes are information which are stored on amino acid. They have just one will – they want to survive. One information unit which does not have such a will, will disappear from this world when its host will be gone. A variant which wants to survive has to produce permanently copies of itself in order to avoid the continuous decay. For this reason the genetically information has invented a lot of mechanisms. This information has created cells which divide themselves over and over again so that they were able to populate the whole world. Information which can not do reproduction will disappear at some point in time. This is a different perspective of the Darwinian evolution theory. Human beings, animals and plants make copies of themselves so that their inheritance information not dies out. This inheritance information is egoistic and only keeps track of its own presence in time.

Marketing uses this phenomenon as a tool in order to make a product or a service known to a lot of people. This is called viral marketing.

DAWKINS (1976) transferred the concept of the egoistic Gene to all other information, even those which we have in our minds. Memes are ideas, imaginations, rituals, advices of behaviour or thoughts, or all kinds of information which we have in our spiritual world and which we communicate. These memes try like genes to survive and to overcome others of their species.

BRODIE (1996) marked the Memes as viruses or parasites which settle down in our brains and try to convince people to talk about themselves

so that others also got these Memes. In this sense one can be a victim of trends or even culture (BLACKMORE, 2000). The ideas and thoughts spread themselves over the society hoping to find empty brains in which they can survive. Like genes, memes have also created tricks in order to settle down in a brain unrecognised. Memes convince the potential host of its non existent advantages, and then they try to go from that point on further and further. That seems to be trivial but nearly every religion uses these mechanisms to survive spatially and in time. On the one hand side it speaks about the paradise in heaven on the other side it speaks about missionary. The one, who does not want to play this game, will come to hell like it says. The more successful an idea is, the better are its tricks to convince.

Is the information "BSE" a strong meme?

The memes move supply and demand relations to that point where they aren't supposed to be according to rational thinking. In this sense one can speak about bounded rationality. Considering the BSE-crisis we can observe that a lot of people are influenced by the information "BSE". The effective rate of infections with the Creutzfeld-Jakob-Disease is n-times less than the perception in the minds of the people. This may lead to the question if the information "BSE" is a strong meme. Memes often influence economical parameters. People sometimes buy things or do sometimes not buy things anymore. If we look at the demand of beef after the news releases about mad cow disease, we can observe that the consumption level of beef went down rapidly. Coming back to the question if the information "BSE" could be a strong meme - such an explanation cannot be excluded, i.e. it may be possible that the viral effect of the information "BSE" respectively the meme "BSE" could be strong enough to lead to some kind of herding effect which implies that a number of consumers don't buy and eat beef anymore, at least for some time.

The memes live in our uncertainty. They move supply and demand relations to positions which are not rational.

A more general view on this context can maybe contribute to the problem of bounded rationality BREITENSTEIN (2002). Memetic could serve to explain a central contradiction in economical theory: Economical decisions will be done because of rationality according to the theory. Human beings try to maximise their utility. This concept was criticised in many ways because reality often does not support this

idea. It is argued that the people do not have all relevant information to do a rational decision. That is right, they just have information which was settled down in their minds until the point of decision. They decide on the basis of memes which have been egoistic and successfully enough to settle down in the minds of the people. If the BSE-meme was able to influence its host not to buy beef then this is a successful and strong meme. To survive the memes create for its host a reality which leads to a decision that let the memes live on. In other words this implies that doing irrational actions means that human beings do not do what their will/intention is. If they would decide according to their real interest they would decide and act rational. When the human being does irrational things, the interest of the memes to reproduce themselves becomes obvious.
For the economical science this implies that besides the interest of the human beings also the interests of the memes have to be considered. This seems to be problematic because the memes are not obvious, but on the other hand Adam Smith argues with the invisible hand which is also powerful, in that sense economical science has already its experience with transcendental effects (BREITENSTEIN, 2002).

5. Conclusion

Information plays a crucial role in economics. NEFIODOV (1996) considers information as the 6th Kondratieff. This force will drive the economy and the development of societies in a sustainable way. In this sense it's worth considering different approaches of information processing. The reason is simply to use different perspectives to reach a better understanding of the things which are going on. Artificial Intelligence offers a rich field for this purpose, together with techniques of the social sciences this is a promising approach for the science of the future.

References

BLACKMORE, S. (2000): Die Macht der Meme. Heidelberg-Berlin.

BREITENSTEIN, R. (2002): Memetik und Ökonomie – Wie die Meme Märkte und Organisationen bestimmen. Münster: Lit-Verlag.

BRODIE, R. (1996): Virus in the mind – the new science of the Meme. Seattle.

BÖCKER, A. and HANF, C.-H. (2000): Confidence lost and – partially – regained: consumer response to food scares. Journal of Economic Behavior & Organization, 43, S. 471-485.

DAWKINS, R. (1976): Das egoistische Gen. Oxford.

HOLLAND, J.H. (1998): Emergence – From Chaos to Order. Cambridge, Massachusetts: Perseus Publishing.

KAHNEMAN, D. and TVERSKY, A. (1979) Prospect Theory: An Analysis of Decision under Risk. Econometrica, 47, 2, S. 263-291.

NEFIODOV, L.A. (1996) Der sechste Kondratieff. St. Augustin.

SAGGAU, V. (2003): Use case oriented modelling of heterogeneous agents in economics – modelling consumer response to food scares according to Bayesian updating. Beitrag zum "8th Annual Workshop on Economics with Heterogeneous Interacting Agents" WEHIA03, 29. bis 31. Mai, im Institut für Weltwirtschaft in Kiel. http://www.bwl.uni-kiel.de/vwlinstitute/gwrp/wehia/index.htm.

SAGGAU, V. and PATELLI, P. (2004): Information diffusion and decision making in artificial consumer societies. Vortrag, Second Conference of the European Social Simulation Association, ESSA'04, 16.-19. September in Valladolid (Spanien). http://www.insisoc.org/ESSA04/.

TESFATION, L. (2002): Agent-Based Computational Economics: Growing Economics from the Bottom Up. Department of Economics, Iowa State University: ISU Economics Working Paper No. 1. Ames, Iowa.

WALDROP, M.M. (1992): Complexity – The Emerging Science at the Edge of Order and Chaos. New York: Simon & Schuster.

Affiliation

Dipl.-Volkswirt Volker Saggau, M.Sc.
Institute of Agricultural Economics
D-24098 Kiel, Olshausenstr. 40
Tel.: +49 0431 880 5153
eMail: vsaggau@agric-econ.uni-kiel.de