Agents in the Social Sciences
Modelling of Human Behaviour

Bernd Schmidt
Universität Passau - Lehrstuhl für OR
Innstraße 33, 94032 Passau

Summary

Human behaviour is complex and many-sided. Nevertheless it can within limits be modelled and thus be made comprehensible and predictable.
Human behaviour is influenced by physical, emotional, cognitive and social factors and their interactions. Human beings are accordingly regarded as psychosomatic units with cognitive abilities who are embedded in a social environment. Approaches which regard human beings as rational decision makers are of limited value.
PECS is an agent-reference model that makes it possible to specify and model these 4 factors.
PECS stand for
P **P**hysical conditions
E **E**motions
C **C**ognitive abilities
S **S**ocial status
The basic procedure for the modelling of human behaviour is illustrated using the Group model. The Group model documents the interaction of individuals in the process of group formation, group activities and group disbandment. Application areas are e.g. team work manufacturing, co-operative organisation or tutor systems.

1 The PECS Reference Model

PECS is a multi-purpose reference model for the simulation of human behaviour in a social environment. Particular emphasis is placed on emergent behaviour which is typical of the formation of groups and societies in social systems.
Human behaviour is highly complex in its structure. It is influenced by physical, emotional, cognitive and social factors. The human being is consequently perceived as a psychosomatic unit with cognitive capacities who is embedded in a social environment.

PECS is a reference model which makes it possible to specify and to model these factors and their interactions. A detailed description of PECS can be found in Urban (1999) or Schmidt (2000).
The PECS reference model aims to replace the so-called BDI (Belief, Desire, Intention) architecture [Rao 1995]. Architectures which conceive of human beings as rational decision-makers are only to a very limited degree sensible and useful. Restriction to the factors of belief, desire and intention is simply not appropriate for sophisticated models aiming to model real social systems.
Fundamentally we may distinguish between the following two modes for the control of behaviour:

- Reactive behaviour
  This category comprises behaviour that follows fixed rules. This means that no explicit thought processes are required for the control of such behaviour.
- Deliberative behaviour
  In this case behaviour does not follow fixed rules. Instead a goal is set which has to be achieved. By means of reflection, working with models and trying and testing, a sequence of actions is established which leads to the goal.

These modes of behaviour have developed gradually in the course of evolution. Each step signifies an additional extension of possibilities and hence leads to better adaptation and to an increase in the chances of survival.
The human being as the most highly developed organism to date displays all forms of behaviour control in complex interaction.

In all forms of behaviour control the physical situation, the emotional state, cognitive abilities and social position play a role. If human behaviour is to be modelled and hence made comprehensible and predictable, the following state variables must be taken into account:

- Physical state variable
- Emotional state variable
- Cognitive state variable
- Social state variable

Not every model investigation requires consideration of all 4 classes of the above mentioned state variables. Any number of combinations is possible depending on the nature of the problem and the model. The decisive factor is that it must be possible to construct complex models which contain all four classes and do not disregard their interactions.

PECS agents provide a reference model which meets these requirements.

The basic approach adopted for the modelling of human behaviour is explained using the Group model. This documents the interplay of individuals in the process of group formation, group activities and group disbandment.
The research program is inter-disciplinary in its approach and touches the fields of human medicine, psychology, artificial intelligence and philosophy. However its true location is the field of artificial life.

2 The Learning Group Model

The learning group model shows in principle how agents form groups, how they work together in groups and how they leave groups. It includes the process of group formation when new groups are formed and the process of group dissolution when a group ceases to exist.
The example chosen to illustrate this is that of students who wish to prepare for an examination and to revise. This learning may take place in peace and quiet at home. However in some circumstances working in a group will be more efficient. In this case a student can choose an already existing group and try to join it. If this does not work out, he or she may start a new group. There is also the possibility that a student will leave his group if group work no longer seems to offer any advantages. If no student wants to join a particular group, that group will disband.
A detailed description of the Group model can be found in Schmidt (2000).

First the attributes of the agents operating in the Learning Group model will be described.

2.1 The Personality of Agents

Each agent as the representative of a student will first be endowed with an elementary personality that will influence its behaviour. The personality features are as follows:

- Intelligence
- Social make-up

Intelligence and social make-up can be combined in any number of ways. Basically four different types of personality patterns emerge. An

agent may for example combine high intelligence with high social competence etc.

2.2 The Repertoire of Possible Actions

Alongside the above-mentioned personality constants, the repertoire of actions available to an agent is a decisive factor in its behaviour. The number of actions is also kept to the strict minimum. The following 6 actions are available to an agent:

- Learning
- Select group
- Join the selected group
- Start a new group
- Leave group
- Disband group

Learning is an internal action. Learning leads only to a change in the value of the internal state variables. As far as its internal life is concerned, the agent is constantly chopping and changing from learning in a group to learning alone.
The other actions relating to group membership depend on Learning alone or Learning in a group. These are external actions, observable from outside.
The life of an agent is extremely monotonous. It does not have access to particularly exciting pleasures.

2.3 The Agent's Needs

The agent in its simplicity has only two needs:

- Knowledge acquisition
  The agent wishes to increase its knowledge. It does this by learning alone or in a group.
- Social Satisfaction
  Every agent is sociable. It has the need to increase its social satisfaction. However it can only do this if it joins a group.

The agent will always arrange his behaviour so as to satisfy both needs as well as possible. However for this purpose he has access only to those actions allocated to him in section 2.2 *The Repertoire of Possible Actions*.

Depending on its internal state at a given moment, the agent will either

choose his study and private learning or group membership and group learning.

3 Internal State Transitions of the Agent When Learning

The two main state variables that determine the internal behaviour of an agent are its current state of knowledge KnowAct and its present state of social satisfaction SocAct. These state variables develop differently depending on whether the agent is learning alone or is in a group.
Learning increases the knowledge level KnowAct. This increase in knowledge will be called KnowAct´. It is described by the transfer function F, which has the form of a differential equation:

KnowAct´ : = a * KnowCap * KnowNormal * Intelligence/100 * KnowAct (Eq. 1)

KnowCap is a factor which takes into account that knowledge increase begins with a less efficient warm-up phase, then leads to higher performance and decreases again towards the end. The KnowCap factor has the following form:

KnowCap := (KnowActMax – Know Act)/KnowAct Max (Eq. 2)

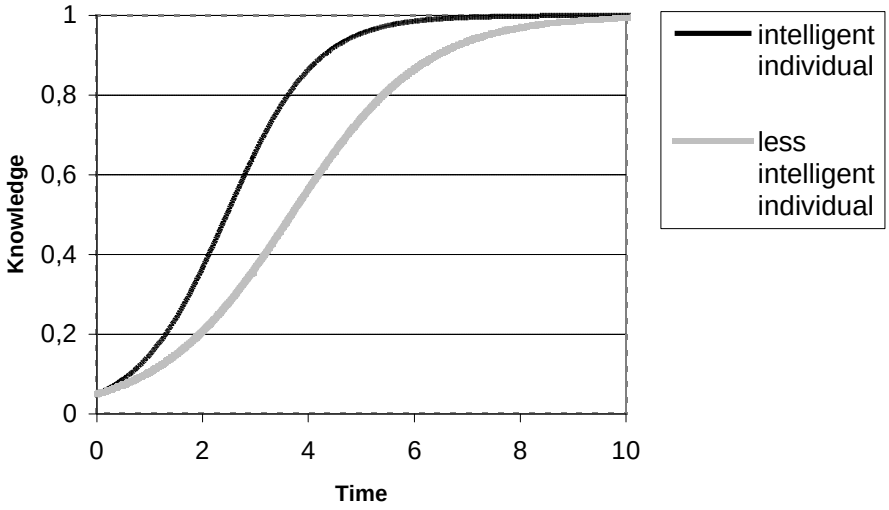

Diagram 1: Knowledge Increase When Learning Alone

It can also be seen that knowledge increase depends on intelligence. The higher its intelligence, the more quickly the agent will learn. This manifests itself in a faster increase in the knowledge to be acquired.
The knowledge KnowAct acquired in a learning phase will be shown in Diagram 1. The temporal sequence is based on the equation 1 and depends on intelligence.
When the agent is learning alone, not only its knowledge level Know Act will change but also its social satisfaction. This will decrease.

The speed at which social satisfaction diminishes will be called SocAct´. SocAct´ is described in the differential equation (Eq. 3), which is as follows:

SocAct´ : = -b * SocCap *SocNormal *SocMake-Up/100 *SocAct (Eq. 3)

here SocCap: = (SocActMax – SocAct) / SocActMax (Eq. 4)

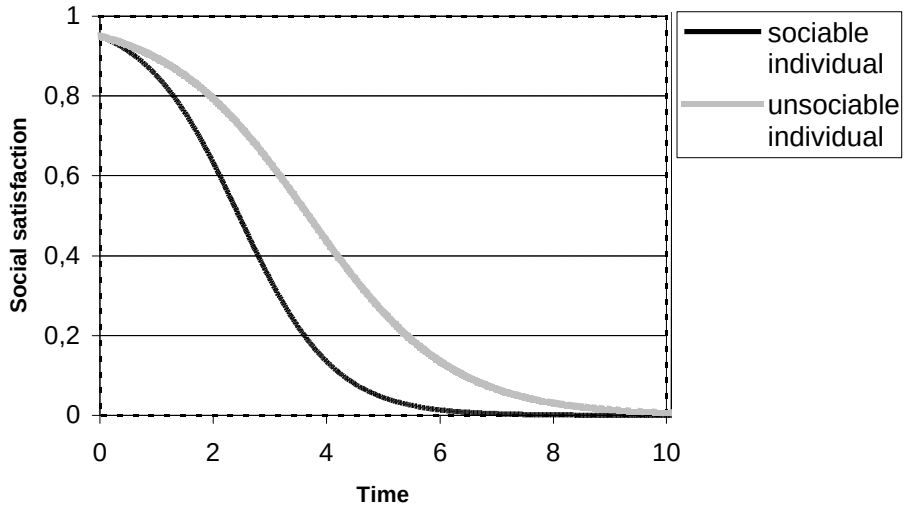

Diagram 2: The Decrease in Social Satisfaction When Learning Alone

Learning in a group takes a different course from learning alone. The decisive difference results from the group quality QualityG. General quality QualityG here influences both knowledge increase KnowAct´ and the increase of social satisfaction SocAct´ of the individual agent.

The equations 1 and 3 can now be expanded in the following manner:

KnowAct´ : = a * KnowCap * KnowNormal * Intelligence/100 * KnowAct * QualityG (Eq. 5)
SocAct´ := b * SocCap * SocNormal * SocMake-Up /100 * SocAct * QualityG (Eq. 6)

In each equation the QualityG factor has been added. It takes account of the fact that learning behaviour and social satisfaction develop differently in the group than in the case of learning alone.

4 The Behaviour of an Agent

So far the temporal development of the two internal states KnowAct and SocAct have been described. The next task is to show how these internal states manifest themselves externally as behaviour. The output function g is responsible for describing external behaviour.
As far as the relation to groups is concerned, an agent's behavioural repertoire includes the following actions:

- Select group
- Join the selected group
- Leave group
- Disband group

For every one of these actions it must be clearly stated under which conditions one of the actions is chosen, passed on to Actor and executed by Actor.

4.1 Select Group and Join Selected Group

An agent will want to end his solitude and look for another group when the following situations occur:

- Knowledge KnowAct has reached a certain level when the agent is studying alone. Not much more can be achieved by learning in private. The stimulation and encouragement that group work brings are required.
- Social need has exceeded a certain limit. The agent feels so lonely that it looks for sociability in a group.

Both reasons together can cause an individual to apply for membership of a group. The importance of the cognitive and social aspects can be established by means of weighting factors.

4.2. Leave Group and Disband Group

An agent will not always remain in a group. It will leave the group when it sees no further advantage in staying in it. This will be the case when in a new learning phase it learns better on its own for a while and when its social satisfaction has reached such a high level that it no longer needs social contacts. This means:

- Knowledge KnowAct has reached a relatively high value in group learning. Not much more is possible through learning in the group. Concentration and individual reflection are necessary to familiarise oneself with new material.
- Social satisfaction has also reached a relatively high level. The agent no longer needs any further social contacts. It can manage for a while on its own.

These two reasons together can cause an individual to leave a group. The importance of the cognitive and social aspects can be expressed by weighting factors. The same behaviour occurs that already regulated the decision to join the group.

5 Model Experiments

A number of experiments can be carried out using the learning group model. Parameters can be varied at will and the resulting consequences can be studied.

The three following problems may be studied as an example:

- Group size for three selected groups
- The number of agents in the solitary learning phase and in the group learning phase
- The number of currently active groups

During a simulation run the learning group model will display a lively dynamism. Groups will form anew and will then disband. The agents will join these groups and will then leave them again. The following diagram show this development.

A possible experiment shows the number of agents in the solitary learning phase and in the group learning phase over a period of time. Diagram 3 shows the sequence.

It can be seen that the red curve falls. This curve represents the number

of agents learning alone. At the same time the number of agents in the group learning phase increases correspondingly.

Further experiments are described in Schmidt [2000].

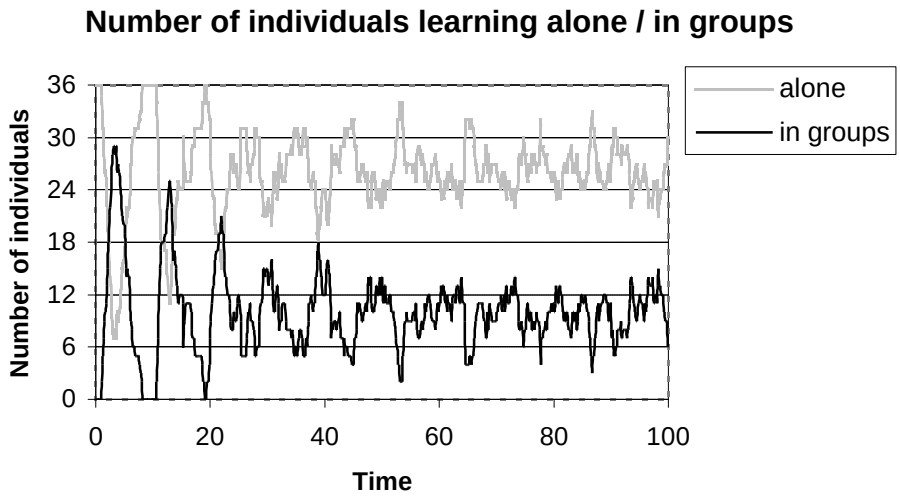

Diagram 3: The Number of Agents in the Solitary Learning and in the Group Learning Phase

6 Results

PECS describes in the form of a reference model an agent architecture for the modelling of human behaviour. By means of PECS it is possible to construct a wide range of models for agents whose dynamism is determined by physical, emotional, cognitive and social factors and who display behaviour containing reactive and deliberative elements.
This program continues and develops work begun by Moffat [Moffat 1997], [Dörner 1999], Sloman [Sloman 1996] and Velasques [Velasquez 1997].
The Learning Group models show in exemplary and prototypical fashion the procedure to be followed in the modelling of complex human behaviour.
A further application of the PECS reference model is described in Ohler (1999).

Bibliography

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