# Knowledge Acquisition for Simulating Complex Psychological Processes

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**Abstract.** In this paper we introduce an approach that elicits information from psychologists and transfers this knowledge in knowledge representations for a knowledge-based system. Based on SIMOCOSTS, a psychological model for simulating coping strategies in critical situations, we present a case study on a literary character that exemplifies our approach. We describe the simulation sequences in an abstract way and elucidate how we utilise the acquired knowledge. We use Eichendorff's literary character of "From the Life of a Good-for-Nothing" ("Aus dem Leben eines Taugenichts") as an example for a psychological analysis, which is transferred into a simulation scenario according to the SIMOCOSTS model.

## 1 Introduction

Artificial Intelligence (AI) has been successfully applied in various research disciplines trying to explain complex contexts. Especially when dealing with complex problems, a simulation of the problem helps to understand interdependencies between various components. When a person has to cope with a critical situation in her or his life, many reactions are possible responding this situation, so it is very interesting how the decision they made have been developed. The work presented in this paper picks up on this topic and presents an approach for simulating a person's behavior coping with critical situations. The approach has been developed together with development psychologists who have developed a psychological theory how decision making in stressful situations can be explained [1]. In this approach the decision making process is explained as a market place with various buyers and sellers. Each of them has an individual goal and they bargain with each other trying to receive its goal. The buyers and sellers in the theory are goals that have been developed over years and the result of the negotiation is a strategy how the person deals with the situation.

We picked up the idea of a market place idea where different goals meet and transfered it to an multi-agent-system that simulates the determination of a strategy. The underlying architecture of our approach is the SEASALT (Sharing Experience using an Agent-based System Architecture LayouT) architecture [2] which is based on the CoMES (Collaborating Multi-Expert-Systems) approach [3], the research vision of our group.

SEASALT consists of five components and is built around a multi-agent system containing intelligent agents providing information (Knowledge Provision). Each agent, so-called Topic Agent, is equipped with a knowledge-based system that derives it information from some kind of community (Knowledge Sources) that is pre-processed and formalized in order to be usable by a knowledge based system (Knowledge Formalization). Furthermore a Knowledge Representation component provides shared knowledge like rule sets and domain ontologies. The interaction with the user is realized via a user interface that interacts with the multi-agent system. The simulation of developing coping strategies focuses on the multi-agent- system and the according knowledge formalization which is mainly carried out by psychologists supported by intelligent graphical interfaces. By talking about knowledge based systems, we are currently focusing on case-based reasoning (CBR) systems, because CBR is an established methodology that uses previous experiences to solve new problems. Moreover, CBR already works with representative examples and thus performs well in interdisciplinary projects as ours. Experts have to provide initial examples and by using the application the figure our "wrong behaviors" and provide more examples. So, the application develops successively by integrating the new examples. In comparison to other SEASALT realizations like docQuery [4] that are focusing on co-operating topic agents where the agents deal with complex problems by dividing them into topics that are solved individually and afterwards the solutions are put together. However, in this approach we have competitive agents, because each intelligent agent has its individual goal and they are competing against each other. The knowledge acquisition is almost the same, because a knowledge engineer is supported by intelligent agents or processed developing knowledge models and cases that can further be used by the CBR systems.

The remaining part of this paper presents the SIMOCOSTS model and the briefly introduced marked place idea in section 2.2, followed by the introduction of our case study based on Eichendorff's literary character of "From the Life of a Good-for-Nothing" ("Aus dem Leben eines Taugenichts") [5] in section 3. Section 4 discusses how knowledge can be acquired and gives examples taken from the case study. The final Section 5 sums up the paper and points out the next challenges for us.

## 2 Simulating human processes

As stated in the previous section, we deal in our project with human behaviour. In this section, we will first present some psychological background that we use for the implementation of the simulation. It should be noted that we want to develop a tool that should be used only by domain experts.
Any time we have to deal with simulations, we have to know exactly which information we need and what we have to take into account. In our case, it means that we have to know which information is processed by a person while facing

a critical situation. Yet, as we all know, it is (almost) impossible to capture the complete knowledge of a human being. This due to the fact that that whole knowledge is saved in the so called *long term memory* which can, according to psychologists, store an infinite amount of information [6].
Luckily, humans never access their whole long term memory at the same moment. We instead just use our so called *short term memory*, which can be seen as a very small activated part of our long term memory. The short term memory contains information related to the situation we are actually experiencing. More on memory activation can be read in [7, 6]. That perception of memory legitimates us to just consider situation related information during our simulations. That means that we do not have to capture all kind of information that a human can have. We can restrict on the situation related knowledge in order to simulate a plausible behavior of human beings in critical situations.

Nevertheless, our simulation will be based on the theory of Brandtstädter and Greve [8]. It is based on the fact that intentions are a key part of psychological theories of action. Except for knee-jerk or automated behaviours, human actions are motivated by intentions. When somebody faces a critical situation, his actual state strongly differs from his goal state (i.e., his intentions). In order to solve the problem, the person essentially can use one of the following three forms of coping processes:

- *Assimilative processes*: the strategy here is to solve the problem by working directly on the actual state. That is, it is an active art to work through a problem, in which the person uses the available resources in a problem oriented way. The available resources can be the person's own resources or external ones.
- *Accommodative processes*: this strategy is used when the person believes he can not change the actual state (i.e. solve the problem) by himself. He then tries to adapt his goal state such that the discrepancy to the actual state can be diminished.
- *Defensive processes*: in this case, the person just ignores the discrepancy between the actual state and his goals. He can for example perform actions that diminishes the meaning of the discrepancy.

It should be noted that a person does not (normally) intentionally apply a given type of process. The person rather just try to find out, which strategy would be the best for him at the moment (depending on his capabilities, environment, etc.). The chosen strategy can then be evaluated to belong to one of the given processes by experts.

We will consider that the goals of a person play a crucial role for his behaviour. We also suppose that these goals are competitive. In fact, we will consider that human's mind is comparable to some kind of market place which contains those competitive goals.

Another question which have to be taken into account is to know which part of the knowledge of a human play a significant or even an essential role when he faces critical situations. This is actually a question that will be answered with the aid of the simulation tool, because even psychologists can not give

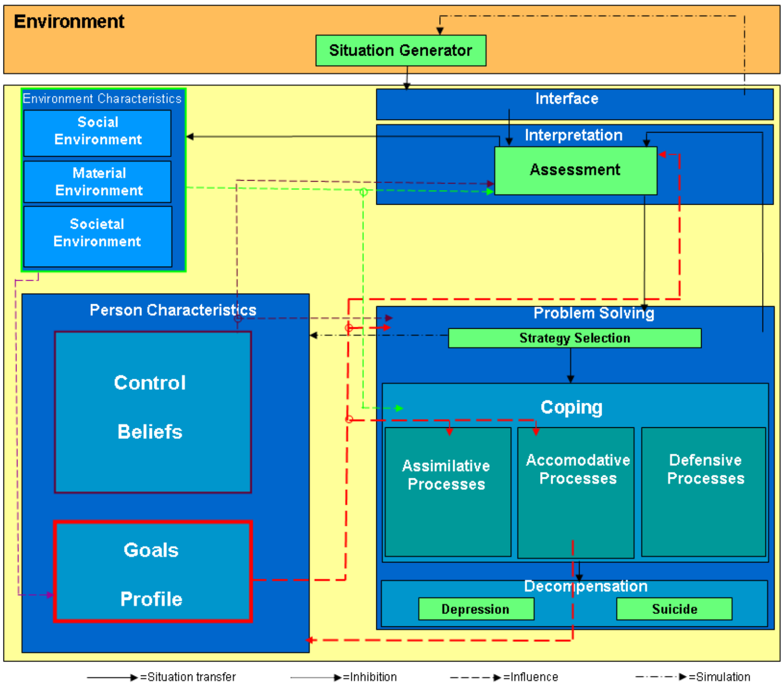


**Fig. 1.** Simplified Version of SIMOCOSTS (see [9])

a precise answer. Nevertheless, there are some parts (i.e. components) which are believed to a play a major role. To that extend, we developed a model, called SIMOCOSTS [9] (SImulation MOdel for COping STrategy Selection), in which we represent those components and also the interactions between them. A simplified version of the model can be seen on Figure 1

Yet that model can not be directly used for an implementation. We still for example have to figure out how the information is going to gathered and stored. The gathering of information will be discussed in Section 4. While dealing with human processes, many knowledge representation techniques have to be considered, because of the diversity of human knowledge. Yet we believe that humans mostly rely on past experiences (first or second hand), particularly in difficult situations. That is why we will mainly rely on Case-Based Reasoning (CBR) [10] as our main knowledge representation technique.

Considering the organisation the knowledge, we distinguish between two types of knowledge, which differs in their accessibility for the simulated person. The first type is called *shared knowledge* and is always accessible for the person. It contains general facts about the person as well as personal characteristics. The second type of knowledge is called *unshared knowledge* and is only available for the goals. It mainly contains information about the concerned goals and strategies which can be used if there is a critical situation.

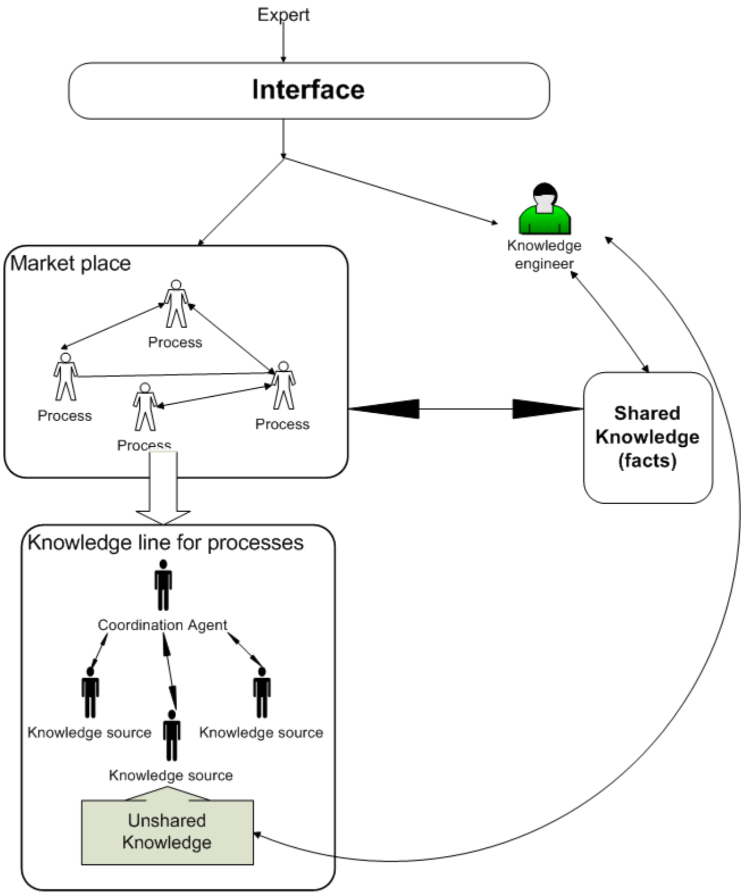


**Fig. 2.** Architecture for the Knowledge Management in SIMOCOSTS

A generic illustration of the simulation with respect to the knowledge management can be seen in Figure 2. The market place contains several processes, in our case the goals, which interact with each other and are competitive. Each process can access its own unshared knowledge which can in turn consist of multiple sources. As mentioned earlier, the knowledge sources will rely on CBR. Yet we do not rule out the use of other techniques (e.g. ontologies or rules).

This architecture actually displays the knowledge line of the SEASALT architecture [2]. SEASALT thus provides a very good platform for the organisation of the (unshared) knowledge, which can be realised with a case factory [11].

In order to give a better insight on the realisation of the simulation, we will elucidate in the next paragraph the underlying concepts and workflows used for the implementation.

### 2.1 Concepts of the Simulation

**Person** The main concept is the person itself. As can be seen on Figure 2, the person can access a so-called general knowledge, which contains for instance general facts about the person. These general fact include psychic as well as physical facts. It means that we assume that we know how the person feels physically and which abilities he has as well as the personality of the simulated person. We use several psychological theories in order to represent all those facts. In the style of the personality theory developed by Asendorpf [12], we describe the psychological facts among other things with the self-concept of a human by using adjectives defined by Müskens in [13]. These adjectives are grouped in several classes which include for example happiness and creativity. The physical abilities are similarly represented by defining the hard skills of the simulated person.
We thus represent all those attributes of the person with attribute value pair in which the attributes display the characteristics and the values whether and to which extend they are existent.

**Situations** In our simulation, a situation is a description of a state. It might for instance be the description of the actual state of the person, thus indicating how the person feels. We use situations to model two important parts of our architecture.

**Events** An event is a situation which may have an impact on the characteristics of the person. Events represents the situation that the person faces which might affect him. The simulation therefore starts with the (external) generation of an event with is then passed to the person.

**Goals** Goals, as stated earlier, are things that the person wants to achieve. They are thus concrete specification of situations that the person wants to achieve. Goals might have priorities which show their importance for the simulated person. An accommodative strategy to achieve is then capable to change the goal or adjust the its priority.

**Strategies** Strategies are the plans that can be used by a person in order to achieve a certain goal. These plans can consists of several steps which affect either the actual situation (assimilative) or the concerned goal (accommodative).

### 2.2 Workflows of the Simulation

A simulation run consists of five main steps:

1. The generated event is compared to the goals of the person in order to find out whether we have a critical situation.

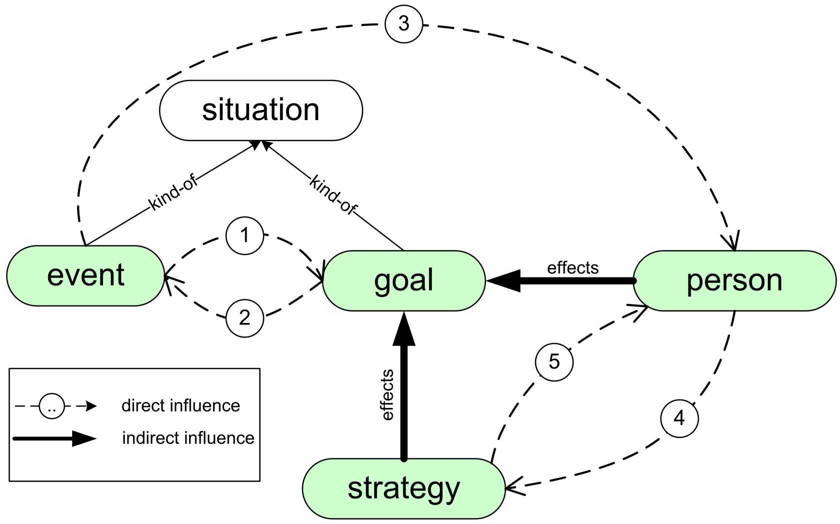


**Fig. 3.** Correlation between the concepts and illustration of the workflows

2. The goals gives a feedback of that evaluation to the event. That feedback contains a so-called influence factor vector which indicates how the event actually affects the person.
3. The influence factors are applied on the personal characteristics.
4. The best strategies for the affected goals are computed.
5. The influence factor generated by the strategies is applied on the characteristics of the person.

Afterwards, the psychologists analyse the state of the person after the run and also have the possibility to start a new run with different parameters. These workflows are illustrated in Figure 3

## 3 Case Study

In this section, we will present an example to illustrate the architecture. We decided to stick with an literary example because the (important) information is given and accessible for everyone. Another reason is the fact that we also have the output that our simulation tool should give. It is hence a good way to tune our implementation.

Our example is a literary character of "From the Life of a Good-For-Nothing", a novella of Joseph von Eichendorff [5]. It is the story of a young man, called Good-For-Nothing, who is very lazy (hence the name). He likes to sing and play the violin. Because he does not like to work and does not help at home, his father send him to the wide world. His adventure starts there. Although he is quite happy at the beginning, because he likes journeys, he faces several difficulties during his adventure. Nevertheless, he always finds a way to come through, even if he is sometimes lucky.

Our aim is to simulate the main character, Good-For-Nothing, in different situations. For this example, we will concentrate on the psychological facts about the character, because the physical facts do not play an important role in his decision making. The only hard skill that can be mentioned is his ability to play violin. As for his self-concept, Good-For-Nothing is a positive and preponderant lucky person. He is also authentic, candid, unorderly, educated and creative. Furthermore, he can be seen as a sentimental person and in need of affection.

He has several goals as the story goes on. First, as he leaves his father's home, he soon realizes that he has to earn his keep. This situation is a difficult one because he doe not like to work. Later he gets to know a girl, yet she does not seem to like him at fist sight. Moreover, he has the goal to go to Italy because he heard many good things about the country. Because of his laziness, Good-For-Nothing often applies accommodative strategies to overcome his critical situations. That means, he just changes his goals or at least their priorities. Most of his assimilative strategies are based on luck.

## 4 Knowledge Acquisition in SIMOCOSTS

With the previous example, we can see that there are many information that should be given before an initial simulation run can be made. Because the tool should be used by domain experts, we have to deal with the knowledge acquisition from experts. Two main problems arise. First, the expert has to give many different information before the start. He does not only have to give a complete and detailed description of the person (i.e. characteristics), he also have to provide the goals, strategies to achieve these goals and also events, which should be evaluated by the person (as critical situations or not).
The second main problem concerns the amount of information needed for each part of the simulation. In order to avoid a trivial simulation, we do not only need decent algorithms, but also enough information. Because of the fact that we intend to use CBR as main knowledge representation technique, we need for example many strategies the person can rely on before we can start simulation runs. These two points lead to the fact we need a good knowledge acquisition methodology. That methodology should of course also take into account that the experts, in our case the psychologists, often have a different perception of the underlying model and the simulation than computer scientists. Furthermore, they want to able to have non trivial simulation runs, which is necessary in order to be able to develop (psychological) theories.

The basic idea of our approach is based upon the fact that the domain expert should not be overwhelmed by the amount of information that has to be entered.

In our concrete example, we aim at having as few input masks as possible. For that purpose, we try to gather similar information in one step instead of

getting each kind of information in different steps. This leads to the need of an intelligent combination of similar information inputs. Determining the appropriate combination is of course a highly domain dependent process. Another point that has to be considered is the use of information extraction techniques. The domain expert should be able to enter the needed information in his preferred form, because this might encourage him to give more input. It is therefore a necessity to use information extraction techniques, in order to be able to structure the given information in our case-based simulation tool.
For our simulation we will have two input masks. The first one allows the expert to give information about the person. That means that the experts do not only give general facts about the person, but also his goals. In the second mask, the expert should be able to enter information about the events as well as some strategies which can be applied in order overcome the critical situations. This is advantageous for the experts because the can give events as well as solutions which should adapted and applied on the event. We should remark that the specification of strategies does not trivialise the simulation, because it is important to find out which factors play a role for the adjustment of the strategies.

With both input masks, we will be able to gather information about the four knowledge areas in our simulation (namely personal characteristics, goals, events and strategies).

### 4.1 Discussion

We are still implementing the approach. Therefore we can not provide an evaluation yet. Nevertheless we strongly think that it would facilitate the knowledge acquisition from the experts.

If we consider the case study from the previous section, the experts would have to provide in the first mask the characteristics mentioned (lazy, candid, etc.) as well the goals of Good-For-Nothing (e.g. earn his keep or have a relationship with the girl he loves). The second mask offers the possibility to enter events which will start the simulation and also strategies sketches for the event. The experts thus can provide information for several knowledge bases in the same iteration.

## 5 Summary and Outlook

We presented in this paper an architecture for the implementation of the simulation of complex processes. Our generic approach for the simulation is applied in a psychological realm, namely the simulation of human behaviour in so called critical situations. The developed is intended to be used by domain experts (psychologists) with the aim to develop and test theories. The simulation tool is currently been implemented while using the SEASALT architecture.
One major problem for our simulation is the knowledge acquisition. We gave an approach and elucidate how we intend to cope with that problem. Further steps towards realising our simulation tool include the implementation of both approaches and an evaluation of the tool.

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