SOCIAL BEHAVIOR INVESTIGATION OF AN INTELLIGENT VIRTUAL AGENT WITH THE HELP OF TYPICAL WORKING STUDENT'S LIFE SCENARIO MODELING

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Abstract: This paper investigates the social behaviour of an intelligent virtual agent (IVA) with PRE-ThINK architecture with the help of typical working student's life scenario modeling. The program system and the PRE-ThINK architecture, adapted for this scenario, are proposed, and their components are considered. The dynamics of the decision making process in problem situations caused by the implementation of this architecture is shown, when mixed emotions arise and the realization of what happened reflects on the agent's temper. IVA's social behavior is shown, during which in the process of communicating with the user the agent expresses *learned* from experience secondary emotions, which can be either in harmony or in conflict with the *realized* secondary emotions, resulting both from the agent's generalized condition and the events. The investigated secondary emotions are: relief, confidence, prestige, uncertainty, confirmed fear, disappointment; and also the socially expressed secondary emotions such as refrained sadness, refrained anger, businesslike manners, politeness and authoritativeness.

1 INTRODUCTION

In general, social norms are commonly believed rules in social interaction. These rules serve as a guide for human behavior, and as the basis for their beliefs and expectations about others. Without them, communication can break down easily (Si Mei, Stacy C. Marsella, and David V. Pynadath 2006).

Social interaction is accompanied by social emotions. Social emotions can be defined as one's emotions projecting on or affected by others. They are "valenced reactions", which can occur as a result of how people understand events. The first modification to the OCC model, (that define a cognitive approach for looking at emotions) is to allow for the definition of social emotions (Ortonty, A., Clore, G.L., Collins 1988).

(Damasio 1994) distinguishes at least two classes of emotions, namely, primary and secondary emotions, on the basis of his neurobiological findings. According to them secondary emotions are more dependent on the agent's cognitive reasoning abilities. The appraisal of secondary emotions depends much more on the situational context and an agent's memory than that of primary emotions. The releasers of secondary emotions might be learned based on the history of primary emotions in connection with memories of events, agents, and objects. Secondary emotions also modulate the agent's simulated embodiment, such as its general level of arousal. The agent expresses its awareness of secondary emotions verbally. Secondary emotions are based on more complex data structures than primary ones.

Recently a number of investigators distinguish between primary and secondary emotions, underlining the importance of their modeling and studying (André, E., Klesen, M., Gebhard, P., Allen, S.,&Rist, T. (1999); Pelachaud, C., & Bilvi, M. (2003).; Becker-Asano, C., & Wachsmuth (2008)).

(Rehm Matthias and Elisabeth Andre 2005) focus on synthetic agents that may express emotions that are in conflict with their appraisal processes and they put a question: how to handle situations in which the agent decides to display an emotion which is in conflict with its internal appraisal processes in social settings.

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Acording to (Benny Ping-Han Lee et.al. 2006) the emotion models and architectures for virtual agents are not yet advanced enough to be imbued with coexisting emotions but this is very important because mixed emotions, especially those in conflict, sway agent decisions and result in dramatic changes in social scenarios.

In order to contribute to further development of the described problems, this paper investigates the social behavior of an intelligent virtual agent (IVA) with PRE-ThINK architecture by means of typical working student's life scenario modeling. The program system and the PRE-ThINK architecture, adapted for this scenario, are proposed. The basic modules of the programming system and the implementation of this architecture are considered. The mechanism of arising of the agent's thoughts, as well as their assessment, are cleared out. The dynamics of the decision making process in problem situations is shown, when mixed emotions arise and the IVA's behavior changes in a way, allowing achieving all of the goals of the scenario,.

The social behavior, shown by the agent, as well as his/her generalized condition of awareness, which are not always in harmony, are explained and presented. The proposed scenario allows for modeling and expressing of both primary and secondary emotions. The social emotions, shown by the IVA, when giving answers to user's questions in the experimental on-line information site, are a mixture of primary (spontaneously caused by the current context emotions) and secondary emotions (*demonstrated* - learned from IVA's experience in a similar situation; *and realized* – caused by the IVA's self-esteem related to his/her generalized condition and by all the simultaneous events, hidden for the users).

The rest of this paper is organized as follows: Section 2 considers similar developments; the third section presents the scenario for the goals of the experiment; the fourth section comprises the description of the programming system and the model of IVA with PRE-ThINK architecture, adapted for typical working student's life scenario modeling. Section 5 gives description of the experimental results. The sixth section includes discussion and directions for further development of the programming system; a generalization of the present work is proposed at the end.

2 BACKGROUND

There is a considerable body of work on social norms and norms in conversations in particular, including formalization of norms and obligations (Boella, G., Torre, L.v.d. 2003), how norms emerge, spread and get enforced in a society (Castelfranchi, C. 1995), levels of cooperation in social communications (Airenti, G., Bara, B. G., Colombetti, M. 1993), discourse obligations in dialogues (Traum, D. R., Allen, J. F. 1994) etc.

In Thespian's decision-theoretic framework (Si Mei, Marsella, Pynadath 2006), conversational norms enable the characters to behave human-like by making relevant responses, following natural turn-taking patterns, and having appropriate conversational flow. (deRosis Fiorella, C. Pelachaud et. al. 2003) as well as Prendinger and colleagues (Prendinger Helmut and Mitsuru Ishizuka 2001) developed agents that are able to control their emotional displays if the social situation requires it. For instance, if the social distance between an agent and its conversational partner is high, Prendinger's agent would not show anger to the full extent.

The virtual tutor COSMO (Lester J. C. et. al. 2000) intentionally portrays emotions with the goal of motivating students and thus increasing the learning effect.

In the WASABI architecture (Becker-Asano, C., Wachsmuth, I.) use their agent's cognitive reasoning abilities to model the mood-congruent elicitation of secondary emotions as well. They explain how nine primary emotions together with three secondary emotions—namely the prospect-based emotions hope, fears-confirmed, and relief —were integrated in such a way that their mood congruent elicitation can be guaranteed. They discussing results of a study on the effect of secondary emotion simulation in a card game scenario.

Many researchers model IVA behaviour aiming at establishing a trust-based relationship between the user and the IVA (Celso M. de Melo et. al. 2009, Gratch et. al 2007, Bickmore et. al.2007, Niewiadomski et. al. 2008).

In the present paper the agent with PRE-ThINK architecture proposed in (Budakova D. 2011) (abbreviation from the initial letters of the basic components making it up - Principles, Rationalities, Emotions, Thoughts, Investigations, Needs, and Knowledge) is used to investigate social behavior in typical working student's life scenario.

3 THE SCENARIO

For the purposes of the experiment the behavior of the typical working student is modeled, that have to

follows the polite form of social communication at work; fulfills diligently its duties at work; manages to pass all its exams; and manages to attend all meetings and parties, organized by its friends. According to this particular scenario the IVA is modeled to be an attractive 20-year-old blond student, giving information to the users of an experimental, especially developed for the experiment site, in the role of an on-line receptionist.

The users can only observe the IVA's behavior in its role of an on-line receptionist. The other events, related to its modeled personal identity in accordance with the modeled scenario (student's life, sleeping time, party time) as well as the course of time, remain hidden for the users of the site and are only simulated in a programming way.

The new aspect in the proposed paper is that a situation is modeled, in which the hidden/refrained emotions are caused by events that are outside the current context and not related to the current events, while the shown emotions are related to the current context but they are well considered and result from personal experience as well as from studying of social standards.

The real secondary emotions of the agent, on the one hand, could be: confidence, satisfaction with the achievements and self-belief. They result from well fulfilled tasks, passed exams, well spent time at parties with friends, high ranking by the users of the site, and they evoke at first happiness, relief and pleasure and after their rationalization they turn in the course of time into self-confidence, certainty and authoritativeness.

This can be expressed by politeness, energy, friendliness, readiness to help and understand the others, willingness to communicate and join both the others and various good causes.

On the other hand, these emotions could also be: inferiority complex, disappointment and depression, lack of self-belief, what is caused by failures at the exams, unfulfilled tasks at work, lowered ranking by the users, and they evoke at first fear and anticipation of failures, as well as confirmed fear and after their rationalization in the course of time they turn into disappointment and inferiority complex. They could be expressed by irritability, aggression, dictatorial behavior or shyness, sadness, depression and self-isolation from the others.

In order to reach all her goals, the IVA plans her time for studying, working, sleeping and meetings with friends, so that their optimal apportionment is achieved. The scenario allows observing how in the course of time, day by day, each deadline is met and the IVA achieves this perfect time apportionment.

4 THE PROGRAM SYSTEM DESCRIPTION

The basic modules of the program system are:
1) interface module; 2) module for simulating the course of time – days and hours; 3) module for decision making and defining the agent's actions by means of the PRE-ThINK architecture according to her goals, principles, priorities and the assessment of the generated thoughts; 4) module for initialization of the scenario, comprising the relation need – action, deadlines for achieving goals, related to the different needs and emotions, necessary number of working hours for successful fulfilling of a task, hours for passing an exam and for normal attendance of parties, as well as the agent's luck and abilities (fig.1).

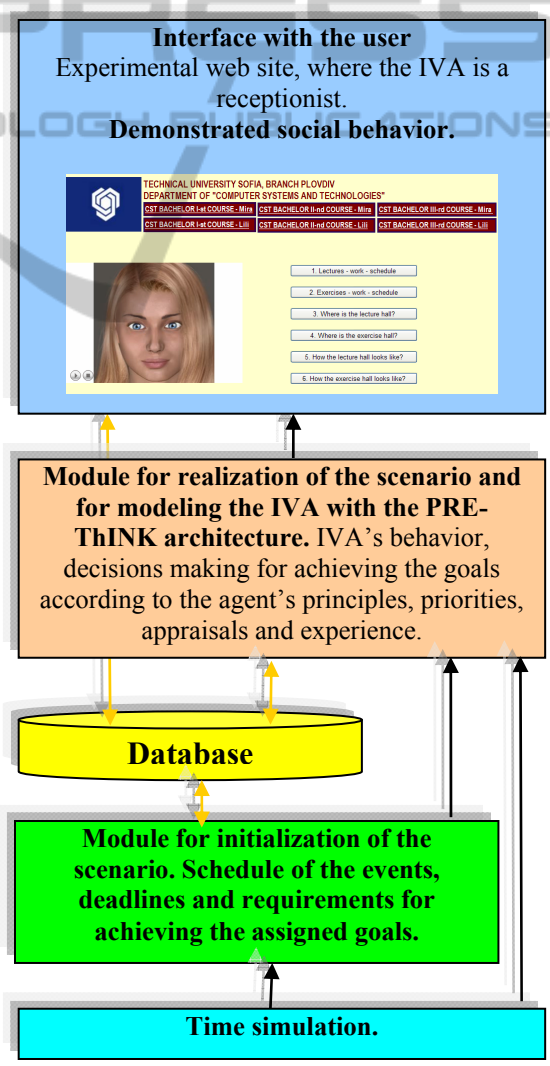

Figure 1: Structural scheme of the program system.

4.1 The Interface Module

The experimental site is divided into three frames. The first one is for choosing the topic in which the user is interested; the second – for modeling the IVA's behavior, for initialization of the scenario, as well as for simulating the course of time; and the third is for visualization of the agent's head and realization of the agent's multimodal social behavior.

The following relation is realized: a chosen question and a corresponding answer, generalized condition of the agent, temper, temperament, self-confidence, emotional but socially appropriate pronunciation of the answer by the IVA.

The user can see and ask the IVA questions by means of the site only. The rest of events and experiences from the predefined scenario remain hidden from him/her.

4.2 The Module for Initialization of the Scenario

The relation need – action is preset as it follows: physiological need – need of sleeping; need of safety – working position as an on-line receptionist; need of love and belonging – attendance at parties with friends; need of self-actualization – university course (fig.2).

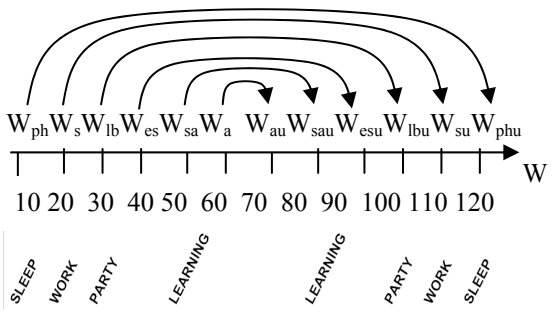

Figure 2: Arrangement of the fulfilled and unfulfilled needs in a crisis situation and their weight together with the correspondence of the relation need-action according to the considered scenario.

According to Maslow's theory the needs in normal human development are arranged as follows: physiological (ph), safety (s), love and belonging (lb), esteem and self-assessment (es), self-actualization (sa), aesthetics (a). In the architecture considered here the needs are associated with weights Wneed corresponding to their priority: Wph, Ws, Wlb, Wes, Wsa, Wa.

When, because of the occurrence of an event, one or more needs prove to be unfulfilled, i.e., there is a crisis situation, then the needs rearrange so that the unfulfilled ones receive first priority. The unfulfilled needs arrange in an order, opposite to the order of needs weights in a normal state of the agent. The unfulfilled needs are denoted by W_{phu}, W_{su}, W_{lbu}, W_{esu}, W_{sau}, W_{au}. This concept is illustrated in fig.2 where the predetermined (according to the scenario) simplified relations of the type need – action are denominated both for a normal and for a crisis situation.

The **dates** of the exams, the dates of fulfilling the working tasks and the dates of the parties are predetermined. The **hours** necessary for the agent to get ready for the exams, the hours for a task to be fulfilled successfully, the sleeping hours and the hours to enjoy a party are also predefined.

The IVA's **luck** and **abilities** are predetermined as well and they can facilitate or slow down the fulfillment of a task, they can lead to a failure at an exam, they can ruin one's sleeping or his/her time at a party. The **thresholds of dissatisfaction** for each task, related to a particular agent's activity are also predefined.

An **initial schedule** for realization of the IVA's goals is predetermined. It defines the initial apportionment of the hours in the agent's day and night. This is the exact initial apportionment of the time which changes in the course of the events in the agent's life and their optimum arrangement is a goal of the algorithm for decisions making by the IVA. The IVA's aspiration/goal is to succeed in each of the directions, to be in good spirits and have self-confidence.

The course of time is simulated by means of the component Timer. Every hour is counted out and the sequence of the morning, the noon, the evening and the night is controlled; it is also controlled what is the IVA supposed to do according to the initial schedule in each particular moment; the real agent's behavior and actions in a moment are also controlled and the activities from the schedule and the real behavior according to the decision taken are compared. All the agent's activities are saved in the database. The IVA knows how many tasks remain to be fulfilled, how many his successes and failures are, to which activities they are related.

4.3 Modelling of the IVA with the PRE-ThINK Architecture and the Process of Decision Making for Defining the IVA's Behavior

The IVA takes its decisions based on its principles.

Required hours for studying in order to pass the exams and sleeping hours needed from date to date.	Required hours for studying for successful fulfilling the working tasks and sleeping hours needed from date to date.
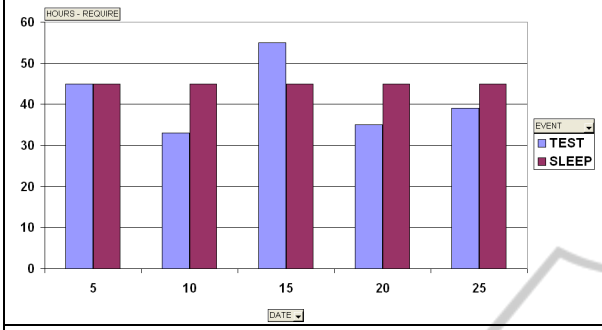	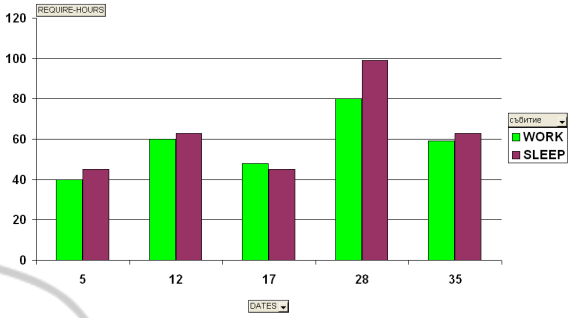
Fig. 3a)	Fig. 4a)
Really used hours according to the IVA's schedule for every exam preparation as well for sleeping from date to date. The sleeping hours are less when the IVA has been to parties during the considered time interval.	Really used hours according to the IVA's schedule for working tasks fulfillment as well as for sleeping from date to date. The sleeping hours are less when the IVA has been to parties during the considered time interval. interval.
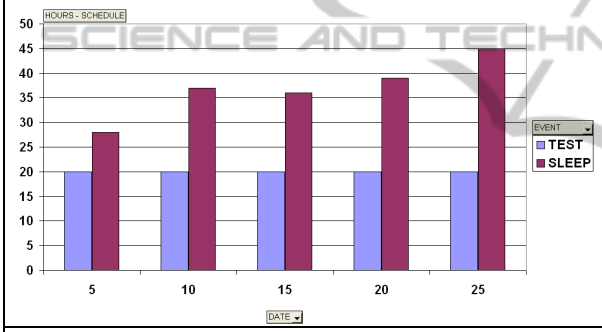	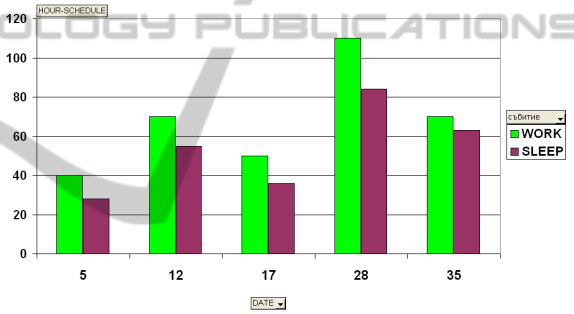
Fig. 3b)	Fig. 4b)
Hours used for studying and sleeping with the use of the PRE- ThINK architecture mechanisms.	Hours used for working and sleeping with the use of the PRE- ThINK architecture mechanisms.
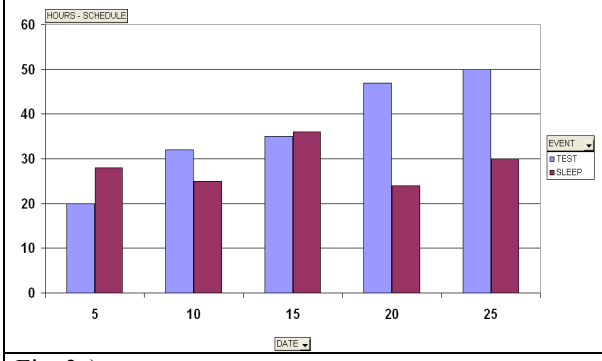	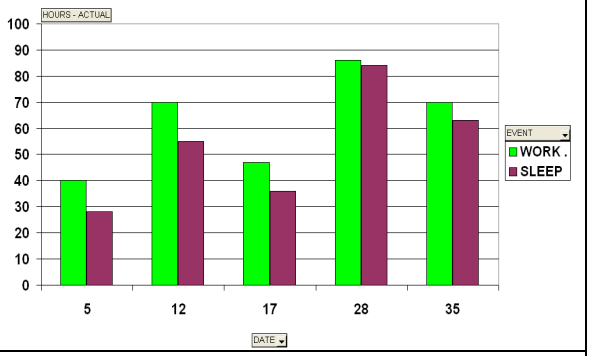
Fig. 3c)	Fig. 4c)

Figure 3 and Figure 4: Experimental results.

The following IVA principles have been modelled: "Choose the better possible action"; "Neglect the basic needs until reaching a definite threshold of dissatisfaction, giving priority to the highest-order needs", "Follow a polite form of social behavior regardless of your personal successes or problems". The IVA starts following her initial schedule and realizes whether she manages to cope with the

assigned tasks or not. She also realizes how many tasks from each activity remain to be fulfilled, e.g., how many exams to pass, how many working tasks etc. According to the principles if the IVA does not pass her exams, for example, she will try to reallocate more hours for studying at the expense of the sleeping hours at first; if this does not help, then the new arrangement of hours is done at the expense of the working hours; and, last, at the expense of the time spent with friends. If all of these measures do not help and her physiological need – her needs of safety and friendship are seriously threatened, then, according to her principles, realizing Maslow's theory and according to the predetermined at the initialization very simple relation need-action, the IVA will stop her studies in order to redress the balance of the more basic needs, sacrificed in the name of her assigned highest need/goal in this scenario.

Each thought of the agent is related to an emotional (positive (+) or negative (-) sign), rational and need value and receive the weight of this need. Each thought is addressed to the situation s be denoted by Th_s. If the importance of the thought Th_s is denoted by I_{Th_s}, the weight of the need, related to this thought is expressed by W_{needTh_s}, , the emotion implied by this thought is marked by $E_{emot.Th\_s}$, then, following the formulae for calculating the assessment value of the thought O_{Th_s} corresponding to the situation s will be (Budakova D., 2011):

$$O_{Th\_s} = E_{emot.Th\_s} * W_{needTh\_s} * I_{Th\_s}$$

If a thought is partially related to more than one need then the sum of the weight percentages of the needs to which it is related is taken into account in the formulae.

Each thought is related to an action. The assessment values of the thoughts related to one and the same action in one and the same situation are put on the one basin of the "thoughts balance". The assessment values of the thoughts for the same situation, but related to another action, are put on another basin etc. Our "thoughts balance" will have as many basins as the alternative actions considered by the agent in the particular situation are. (Budakova D., 2011).

The described mechanism for decision making is adapted for the purposes of the considered scenario. Instead of choosing the action from the basin having the highest assessment value, the action with the lowest ranking is sought for here, i.e., the less important for the moment. The hours used for it will be reduced in order to spare time for other more important activities and, respectively, for achieving other dissatisfied goals.

4.4 Mechanism of Origination and Assessment of the IVA's Thoughts

The IVA's thoughts are generated in 24 hour each clock round and they are related to the events from the agent's schedule, to her generalized condition, to the successful or unsuccessful fulfillment of the goals, as well as to the possibilities for action. Each thought, related to achieving a goal/action, is assessed from emotional, rational and need-related point of view.

I can increase my hours for studying at the expense of reducing the sleeping time. Emotion (+); weight of the need for sleeping 10; rational assessment – easy and safe 1; general assessment of the thought related to this action **(+10).**

I can increase my hours for studying at the expense of reducing the working hours. Emotion (+); weight of the need for work 20; rational assessment – easy and safe 2; general assessment of the thought related to this action **(+40).**

I can increase my hours for studying at the expense of reducing the hours for meeting friends. Emotion (+); weight of the need for meeting friends 30; rational assessment – easy and safe 2; general assessment of the thought related to this action **(+60).**

In addition to choosing an action for improving her generalized condition, the agent also generates thoughts about her social behavior at her working place.

5 THE EXPERIMENT

The first experiment illustrates the consequences for the IVA if she follows the schedule without changes. They are given in figure 3b for the exams and figure 4b for the working tasks. Having the graphs 3a and 3b compared, it can be seen that the IVA studies less than needed and correspondingly she fails at the exams. When comparing the graphs 4a and 4b it can be seen that the working time turns out to be sufficient for fulfilling the tasks and duties perfectly. The sleeping hours are also sufficient and from the graphs 3b and 4b it can be seen that the IVA does not miss a party. The second experience shows how the agent tries to cope with her problems at the university by increasing at first the hours for studying at the expense of the sleeping hours and

then, at the expense of the working hours (fig. 3c и fig. 4c).

The results from the graphs 3a and 3c should be compared here to see whether the actually used hours are sufficient. The results from the graphs 4a and 4c should also be compared to see if the actual hours for coping with the working tasks are sufficient to lead to success.

It can be seen from the graphs that, after she fails at her first exam, the IVA increases the time for studying at the expense of the sleeping time. After the second failure she reduces the sleeping time even more in order to study harder. After the third failure she reduces the working time, too, and this is how she manages to pass the fourth and the fifth exams. The success turns out to be sufficient for bringing back her happiness and self-confidence.

6 CONCLUSIONS

The paper investigates the social behavior of an IVA with PRE-ThINK architecture. A scenario is proposed, allowing for clearing out and revealing the following: the agent's decision making mechanism; the mechanism of origination and assessing thoughts, related to the alternative actions for each situation; the mechanism for achieving optimal time apportionment in order to achieve the best possible coping with the assigned tasks. The origination and the influence of the primary emotions such as happiness and sadness is also cleared out for building and investigating the secondary emotions such as relief, confidence, prestige, uncertainty, confirmed fear, disappointment. The peculiarities of the program system, as well as of the IVA's PRE-ThINK architecture together with the conducted experiments are described and explained.

New principles and behavioral rules can be formed based on the accumulation of observations and their generalization. This is realized by means of the subprograms of the architecture component named Investigations.

Creation of a more complex situation is envisaged, in which the IVA's goals will be related to different needs to a different extent. The decision making will be more complicated and more realistic then.

Tracking the way the IVA gains experience in communication with the users of the site will be a subject of another investigation together with the way she learns to be polite and businesslike regardless of her problems, successes and failures.

It is assumed that, together with the further development of the system, it could be possible to realize a backward investigation, i.e., to predetermine the decisions, taken in a problematic situation in order to build a model of the investigated person.

The investigation of a collaborative or competitive behavior in a multi-agent system for similar scenarios would be also of great interest.

Another direction for further development is to investigate how the various ways of communication with users would influence the ranking of the IVA. Is it better for her to be more businesslike if the user is interested in what is going on when he has understood from the IVA's multimodal behavior that something is going wrong or that she is extremely happy?

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