INTERACTION MANAGMENT BETWEEN SOCIAL AGENTS AND HUMAN

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Abstract:

In this paper we address the problem of managing social interactions between a human user and a set of social agents in structured environments. These agents have to regulate a measurable characteristic of the user.

Our study focuses mainly therapeutic, caring for elderly people and assessment applications. The agent concept considered in this study is suitable for multi-robot systems (physical, service, mobile or not), but also to virtual agents (avatars) in a virtual reality (VR) application.

The proposed approach has been adapted for an application of social phobia treatment using virtual reality. Thus, we conducted a case study to show the effectiveness of our contribution.

Keywords: *multi-robot system, multi-agent system, social interaction, virtual reality, virtual reality exposure therapy.*

1. Introduction

Currently, research works on multi-robot systems (MRS) are one of the most important areas in robotics. This can be explained by the many benefits of cooperation of several robots especially for engineering applications. MRS allows a greater tolerance to faults; it has better efficiency and performance while having opportunities for tasks development and expansion.

According to [1] and [2], the research work on MRSs can be classified in three categories, the first one concerns reconfigurable robots systems whose idea is inspired by organization of insects and animals [3-5]. The second category concerns the trajectory planning of a group of robots such as the control of aircraft traffic [6]. The third focuses on cooperative multi-robot architectures, such as, the project ACTRESS [7] on the maintenance in known and structured environment.

Unlike conventional control systems, cooperation must be considered in the modeling, analysis and improvement of MRS. Implement this task is not easy. One of the most used tools for overcoming this difficulty is the multi-agent systems (MAS). An MRS can be considered as a robot with a distributed artificial intelligence.

On the other hand, recent years have seen a significant growth in the development of non-invasive, wearable and wireless sensors technologies [8-10]. This technique allows for physiological measures such as HR (Heart Rate), SC (Skin Conductivity) skin conductance, EMG (Electromyogram), EEG (electroencephalogram). These tools have been widely used in clinical, therapeutic and assistance applications.

The objective of this work is to propose an approach to manage social interaction between a human user and a set of agents integrated in structured environment. Their mission is mainly to regulate a measurable characteristic of the user. We cite as an example an elderly person in a structured flat. This person will be assisted by a group of robots to take his medication in case of falling of his blood glucose or to be assisted in achieving a daily task (for example preparing a meal). Agent concept considered in this paper concerns the physical robots, mobile or not, service robot, as well as avatars in a virtual environment in a virtual reality (VR) experience.

Another applications that interests us is treating cognitive disorders using VR, in fact, several research have documented the effectiveness of exposure therapy using VR and particularly with phobias [11-16]. The principle of this technique is to expose the patient to anxiety-provoking situations in a gradual, repeated and complete manner, in order to desensitize him/her [17],[18]. Our idea is to integrate virtual actors in a virtual world and to create anxiety-provoking situations as it would in real-life.

Our contribution is based on three basic concepts:

- Make the user live an experience close to the real world by participating in a story, planned and designed by an expert;
- Let the user free to decide and move in the virtual environment (VE). He/she is guided by the progress of events.
- Introduce the user's measured state in the control of actions to activate.

The system consists of the user and the world made of objects and agents. Our system must satisfy the following points

- Regulate the state of users around a level given by an expert that depends on the user and application;
- Ensure the coherence in the agents behaviors in their world and hence the cohesion of the story experienced by the user.

We propose an application of exposure therapy virtual reality guided by a measure of the patient's state.

To implement our approach, we conducted a pilot study for treating social phobia that we will detail in this paper.

2. Related works

There are many research projects to develop cooperative MRS. Research work on MRSs in different application areas continue to grow since the '80s. Planetary exploration has received notable attention from researchers.

The experimental project "Robot Work Crew" developed by NASA [19] addressed the problem of tightly coupled coordination of two robots and the cooperation and coordination problem for heterogeneous and homogeneous MRS in difficult environments. The robotic deployment of a modular solar photovoltaic tent using Campout architecture [20] was also studied.

The robot soccer is also a framework for developing cooperative SMR, results are of interest for other application areas. The soccer robot developed by the team FU-Fighters [21] is popular. The system is characterized by a generic and modular architecture composed of layers provided with 3 elements: sensors (Perceptual Dynamics), behavior (Activation Dynamics) and actuators (Target Dynamics).

The project Martha is one of the few cooperative MRS designed to serve human [22]. Its objectives are the control and the management of a fleet of autonomous mobile robots for trans-shipment tasks in harbors, airports and marshalling yards. Experiments were conducted with a family of 3 mobile robots called Hilare. There are also other research projects that are conducting laboratory experiments on more specific issues related to cooperative MRS, their framework is more general to target specific applications. In this paper, we conduct a study which finds application in MRS for therapeutic, evaluation and assistance purposes.

The project eCIRCUS (Education through Characters with emotional-Intelligence and Rolplaying Capabilities that Understand Social interaction) proposed a new approach in the use of ICT to support social and emotional learning within Personal and Social Education (PSE). To attain their aim, eCIRCUS studies educational role-play by the use of autonomous synthetic characters and the implication of the user through affective engagement [23].

3. General principle of our approach

1.1. Methodology

The problem considered in this paper concerns the management of social interaction between a user and a set of agents.

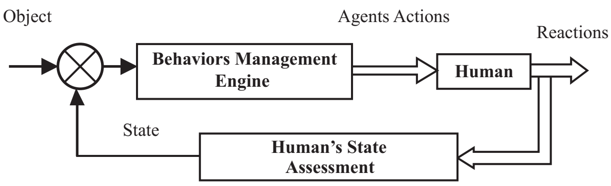

Fig. 1. Regulation loop of the human user state.

The mission of agents aims to control the state of the user around a value given by an expert; they must also ensure the coherence of their behavior.

The "state" of the user is a generic term that can represent measurable characteristics, that is dependent on the use of the system (a position in space, a physiological value, a gestural characteristic, the achievement of an action). For example, in an experience of virtual reality expo-sure therapy, the state of the user is the measured anxiety levels. From the user's point of view, the system can be seen as a control loop of his/her state as shown in Fig. 1.

The "Assessment" bloc informs the system of the user's state calculated from the recorded measurements.

The "Behaviors Management Engine" bloc is the regulating element of the system. It compares the state that is measured on the user with a reference state fixed by an expert, in order to decide on the nature and degree of actions to generate.

1.2. The Behaviors Management Engine

a) Multi-Agent System

Our solution to the problem discussed in this paper is based on the theory of MAS that [24] consists of a group of rational agents interacting with each other. Agents may share the same interest, conflicting interests or more general ones. There are several definitions of an agent and none of them is prevailing [24]. An agent can be anyone that perceives his/her environment through sensors and acts on it through effectors [24]. An ideal rational agent tries to maximize the performance level with regard to what he perceives and the knowledge at hand [24].

The applications envisaged for our approach consist of user agents and their entourage made up of cooperating objects.

b) The agents and their actions

We denote by agent's actions or behavors. An agent can have two kinds of actions: "Stimulating" actions and "Background" actions. "Stimulating" actions are those which are likely to induce a change in the user's state.

The "help" actions and the "auxiliary" actions belong to this type. The "help" actions allow the user to follow the scenario's progress. The "auxiliary" actions indicate the ones that must be activated simultaneously with another action for some coherence reasons of the scene. An "auxiliary" action has an indifferent effect on the user. The "Background" actions are activated by the agents when the user is interacting neither with the user nor with another agent.

A^s represents the set of stimuli and A^f the set of "Background" actions, where:

"Stimulating" action is mainly characterized by its effect. This effect can be "Positive", "Neutral" or "Negative" with a degree of relevance given by an expert.

c) The MAS Environment

Let's remember that the user is an element of the MAS environment. In order to be able to react correctly, agents must know, at any time, the user's state. We express the state with two variables: the magnitude and its derivative.

The user's state to be measured depends on the context of use. If the goal is to lead the user to a given point, the measure is the position relative to the target. This measure determines the progression of the person to the expected objective state.

The magnitude of the measurement is determined by three intervals: Low, Normal or High. For derivative, we decided to divide it into three intervals: "Falling" (negative), "Stable"(nul) and "Rising"(positive).

In Fig. 2, the cells of the table correspond to the user's states; the arrows represent the possible transitions between states.

The set of user's states is denoted by *S*:

The objective is to bring the user's state back to (Nul-Stable) denoted: $s^* = (N, S)$.

The transition model of an environment expresses the way it changes state when a given action is activated. The user's transition model is stochastic. Activating a stimulus action does not necessarily mean that the user passes into another state.

Let s the user's state at instant t and s' the state in which he passes after activating action a with: $s, s' \in S$ and $a \in A^s$. The transition model is a probability distribution $(s', | s, a)$ on all possible states s'.

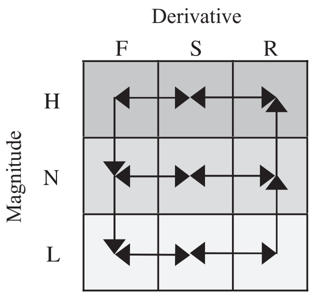

Fig. 2. User's states.

		Derivative	
Magnitude	F	S	R
H	3	2	1
N	4	5	4
L	1	2	3

Fig. 3. State Utility.

d) User's state controlling

In stochastic environments, finding the series of actions that enable you to reach the objective is not a simple research on a graph, because transitions between the different states are non-deterministic and agents must take into consideration the probabilistic aspect of transitions in their decisions. The expected utility concept is one of those used to introduce the transition uncertainty between states in the agents' decision [24].

A state's utility s, denoted $U(s)$, is a real number that expresses its importance in the achievement of a given objective.

$$U(s): S \rightarrow \mathbb{R}$$

The objective of an agent is the environment' stat $s^* = (N, S)$, a state with the highest utility and desired by his environment. Fig. 3 shows the utility of the user's different states. We also note that in our case, a state's utility does not change from one agent to another, because they cooperate and share the same objective. For an agent to be rational in state s, he must choose an optimal action a^* that maximizes the expected utility given by:

$$\sum_{s' \in S} p(s', | s, a) U(s')$$

with

$$a^* = \arg\max_{a \in A^s} \sum_{s' \in S} p(s' | s, a) U(s')$$

Each agent calculates his own optimal action a^* that maximizes the sum over all the products of the probability to pass into each possible state s' by its utility $U(s')$.

The utility of state are given by the importance of the state to achieve the objective of agents.

We are interested in the calculation of the probability distribution. Suppose that the user is in state s. We can say that the user "Reacts" to action a if:

a - is "Positive" then the user passes into a higher state than s (according to the order given in the definition of the set S.),

a - is "Negative" then the user passes into a lower state than s,

a - is "Neutral", then the user does not change state.

$\bar{s}$ is the state in which the user goes if he "Reacts" to action a. We suppose that the user either passes into state $\bar{s}$ or does not change state. From this last characteristic, we can write that:

$$a^* = \arg\max_{a \in A^s} (p(\bar{s} | s, a) U(\bar{s}) + (1 - p(\bar{s} | s, a) U(s))$$

The probability $p(\bar{s} | s, a)$ does not depend only on s, $\bar{s}$ and the nature of a, but on certain other parameters as well, that are related to the effect of a on the user and to his activation conditions. For this reason, $p(\bar{s} | s, a)$ depends on two different elements:

- The probability for the user to pass from state s to state $\bar{s}$ if a is activated in conditions where the user sees or hears a with certainty;
- The activation conditions of in the actual context of application.

e) Conflicts management

In case of collaborative agents, coordination allows to ensure that no agent perturbs the others when he chooses an action, and his actions are useful to the collective objective of the group. Assignment of roles to agents is a very much used tool as a coordination technique. A role can be seen as a masking operator on all of an agent's actions in some specific situations. We decided to let only one agent interact with the user, by introducing the principal agent's role. The latter will be assigned to the most certain agent capable of making the user pass into a useful state.

For example, in the case of a virtual reality exposure therapy, if two virtual agents decide to speak simultaneously to the patient, it may interfere with each other.

The stimulus expected utility suits perfectly this end.

Let r_i the capacity of agent i to be the principal agent. r_i is the highest expected utility calculated over all possible actions of agent i. The "Main Agent" role will be assigned according to the following algorithm:

For each Agent i in parallel

1. Calculate r_i of agent | *QUOTE* ⑦⑦*i*⑦.
2. Transfer r_i to the other agents.
3. Wait till you receive the others' potentials.
4. Attribute the "Main Agent" role to that agent who maximizes r.

End For.

f) The story manager

Remember that the MAS must regulate the user's state and generate coherent stories. Our approach consists in proposing a set of tools that allow people not familiar with cinematography to transform a story into feasible scenarios whose principal element is the user. The actors are represented by agents.

g) The scenario

The story manager helps the agents to determine all the possible actions with respect to the situation they are in. An agent's situation is defined by his geographical location and the scenario progress. While evolving in the world, the user generates events that depend on his geographical location. These events will help, on one side the story manager and on the side agents, in order to react to the user's actions.

For example, go to a specific location to take drugs. The accomplishment of tasks by the user is indicated by events. Let the set of events. Each task the user is asked to fulfill corresponds to a node in the scenario. A scenario is made of an ordered sequence of nodes from the beginning to the end of a session. The couple (a,e), where: $e \in E$ and

$$a \in \bigcup_{j:0 \ n-1} A_j^s$$

represents action a that asks the user to accomplish a task and event e indicates that the task has been accomplished by the user, with n the number of agents and A_j^s the set of stimuli of agent j. A node does not correspond to one couple (a,e) only but to many. In fact, a task can be asked from the user either in different ways by the same agent, which corresponds to different actions, or by other agents. Similarly, a task can be accomplished by the user in different manners, which corresponds to different events. Therefore, node i is associated to a set $C_i = \{c_i', c_i'', c_i''', ...\}$ of couples $c_i = (a,e)_i$ and so allowing the transition from node i to $i+1$.

Couple c_i represents a condition of passage from node i of the scenario to node $i+1$. Action a asks the user to accomplish a task, event e indicates its accomplishment. So, a scenario with m nodes can be defined by the ordered series $Sc : C_0, C_1, C_2 \dots C_m$.

h) Reaction to events

The events triggered by the user enable agents to react to his actions. A given event is associated, by an agent, to one or several actions which are going to be activated.

Let $M_e : E \times \bigcup_{j:0 \ n-1} A_j^s \times N \rightarrow B$ the matrix that gives the event-action links, with n the number of agents and N the interval of nodes. As an example, indicates that the accomplishment of event e at the third node of the scenario will be followed by the activation of a.

i) Links between actions

In some situations, when an action is selected by an agent, it must be followed by another action, either from the same agent or another one. The answer to this question consists in using priority rules represented by a graph of links between actions. This is valid only in the case of a reduced number of actions, as it is in our study.

$$M_p : \bigcup_{j:0 \ n-1} A_j^s \times \bigcup_{j:0 \ n-1} A_j^s \times N \rightarrow B$$

is the matrix that gives the action-action links, with n is the number of agents and N the interval of nodes. For instance $M_p(a', a'', 2) = 1$ indicates that at the second node of the scenario, the execution of action a' will be followed by the execution of action a''.

Synthesis on the mechanism of action selection:

This mechanism is given by the following algorithm where the main steps are summarized:

- Determine the user's state.
- If a node is validated then go to the next one.
- Find the set of possible actions coming from events at the actual node of the scenario.
- Find the set of possible actions coming from priorities between actions at the actual node of the scenario.
- Find all possible actions A^p.
- Calculate the expected utility of stimuli that belong to A^p and find the optimal action a^*.
- Assign the role of "Main Agent".
- If an agent is the "Main Agent", then activate stimulus a^* otherwise choose randomly and activate a "Background" action.

4. Application in virtual reality exposure therapy

To implement our approach we have developed an application in the context of cognitive and behavioral therapies. During the last two decades, many research works tried to experiment and evaluate the usage of VR to treat cognitive and behavioral disorders, and particularly phobias. The idea consists of making the patient evolve in a virtual environment (VE) where the she/he gradually faces situations that are feared in real life in order to desensitize him/her [25], [26]

We are interested in social phobia which is a pathology whose fearful conditions can be easily created by an inductor based on VR using everyday life scenes and at the same time to have some measurable emotional reactions from the patients

The virtual actors are represented by the agents of MAS, the patient will be considered the user.

Video recording of real actors embody the actions of different agents, these videos are inlaid in the virtual environment by chromakey technique. An evaluation of the effect of these actions has been established by a psychologist.

The virtual environment is a bank. We chose a bank for many reasons. It offers the possibility to diversify the anxiety provoking situations, such as talking to strangers, carrying out tasks while others are looking at you. The patient will also be motivated by the final objective that is withdrawing money. The agents present in the VE are: The secretary "Madeline", at the reception desk (on the right in Fig. 4), a customer in the hall "Simon" (on the left), a counter clerk "Guy" (in the middle).

The VE is projected on a wide screen. The patient is wearing a surfing tool that allows him move around into the bank. At the beginning of a session, the patient is at the bank entrance and the therapist explains to him the objective without giving him any details. The patient enters the bank and an electronic display says “Please go to the reception desk”. At the reception desk, the secretary asks him what she can do for him. He answers, and then she phones the counter clerk to have his opinion about the operation. Next, she tells the patient to go to desk number 2 to withdraw money. Finally, the counter clerk gives him his banknotes. This scenario corresponds to the main framework of the story, but even if the patient does not follow this scenario voluntarily or involuntarily, the agents help to go back to it.

Fig. 4. The virtual environment and virtual agents.

Fig. 5. Examples of stimuli.

Fig. 6. Examples of three basic actions..

The patient's state can be “reassured”, “Anxious” or “Very Anxious” associated respectively to “Low”, “Normal” and “High”. Similarly, a stimulus may be “reassuring”, “anxiety provoking” or “neutral” associated respectively with “Positive”, “Negative” and “Neutral”. In Fig. 5, three stimuli are shown. These are, respectively from left to right: “Reassuring”, “Anxiety Provoking” and “Neutral”. In Fig. 6, three “Background” actions are illustrated.

The principle of exposure therapy is to put the patient in front of anxiety provoking stimuli. Therefore, we can consider that our goal is to bring the patient back to the “Anxious”-“Stable” state.

We are interested in calculating $p(\bar{s}|s, a)$: the probability that the patient passes from state s to $\bar{s}$. We said earlier that $p(\bar{s}|s, a)$ depends on the contextual conditions of activation of a. These conditions are summarized with two parameters: the distance between the patient and the source of the action and the vision direction of the patient with respect to the source of action.

Let:

- the probability that the patient “Reacts” to stimulus a : the patient reacts to the action a if he passes to the state compatible with the nature of the action.
- the probability that the patient hears or sees stimulus a;
- the probability that the patient passes from state s to $\bar{s}$, knowing that he has seen stimulus a;
- the probability that the patient has seen or heard action a, knowing that he passed from s to $\bar{s}$.

According to Bayes' theorem [24], we have:

$$P(S) = (P(S \cap R))/(P(R \dashv | S)) =$$
$$= (P(S \dashv | R)P(R))/(P(R \dashv | S))$$

Remember that we considered action a as is the only stimulation source of the patient in the VE (it comes from the role assignment to $\bar{\ }$a single agent). Therefore, if he changes state from s to s, then it is done because of action a. For this reason, we can conclude that $P(R|S) = 1$.
we have:

$$p(s\rceil s, a) = P(S) = P(S \dashv | R)P(R)$$

$P(S \dashv^{-}| R)$ is the probability that the patient passes from s à s knowing that he has seen or heard action a. We consider that $P(S \dashv | R)$ depends on the effect of action a, according to the following relations:

$$P(S \dashv | R) = \{■(3/2(\varepsilon(a) - 1/3\}$$

if a is "Anxiety Provoking". $@1-3|\varepsilon(a)|$
if a is "Neutral". $@-3/2(\varepsilon(a)+1/3)$
if a is "Reassuring". $)\dashv$

$P(R)$ is the probability that the patient sees or hears action a. A model of this type is not available in literature. We defined a simplified model based on the following rules:

- The patient hears or sees with certainty the actions that are in his axis of vision and at a distance less than $4m$;
- Actions with a 30° displacement with respect to the vision axis and a distance less than have a probability 0.7;
- Actions with a 90° displacement with respect to the vision axis and a distance less than have a probability 0.3;
- The probability of actions displaced by more than 90° and at distance less than is 0.1;
- Beyond $2m$, the probability $P(R)$ is inversely proportional to the distance between the action and the patient.

5. Evaluation

In order to examine the story manager and the agent's behavior, we carried out a pilot assessment on non-phobic patients. It is difficult to show the effectiveness of our approach with a small example of three agents, like the one above, but therapists who tested the developed tool attest to its usefulness, particularly for the management of virtual agents. In a first version of the system, no measure of state anxiety is removed, the system feedback is provided by the therapist as a Wizard of Oz; he estimates the patient's state and transmits it to the system through the keyboard. The sessions were recorded in order to return and consider the moments of interaction that interest us. Now, we give some examples:

5.1. Situation n°1: Outside of the bank. Fig. 7

The situation starts outside the bank, at the entrance. All agents activate some “Background” actions. The door is half-opaque and the patient can see what is going on inside.

5.2. Situation n°2: The patient enters the bank Fig. 8

Now the patient enters the bank. While going through the main door, the electronic screen displays “Please go to the reception desk” with a simultaneous beep to attract the patient's attention, who could either go straight to the reception desk or to counter 2, or just walk in the hall.

Fig. 7. The entrance of the bank.

Fig. 8. The patient enters the bank.

5.3. Situation n°3: The patient walks in to the bank.

In this situation, the patient hesitates before going to the reception desk and continues his walk in the hall. Depending on his anxiety state, the customer in the hall might look at him to stimulate him (Fig. 9) in case he is “Reassured”, or omit him if he is already anxious (Fig. 10).

Fig. 9. The customer in the hall stimulates the patient.

Fig. 10. The customer in the hall looks the other way.

5.4. Situation n° 4: Instead of going to the reception desk, the patient goes to Counter 2

In this situation, the patient is wrong and instead of going to the reception, he goes to Counter 2. In this case, the cashier activates a “help” action and tells the patient to go to the reception. The way the patient is sent back to the reception could be “Reassuring” (Fig. 11), “Anxiety Provoking” (Fig. 12) or “Neutral”.

Fig. 11. “Reassuring” “help” action.

Fig. 12. “Anxiety Provoking” “help” action.

5.5. Situation n°5: The patient is in front of the secretary

The patient is at the reception. First, the secretary greets him and then gives him enough time to ask his question. Three possible ways of reception are shown in Fig. 13. The other agents continue to activate “Background” actions.

Fig. 13. Three ways of reception: “Anxiety provoking”, “Neutral” and “Reassuring”.

5.6. Situation n°6: A phone conversation between the secretary and the Counter clerk

The patient asks the secretary if it is possible to withdraw money. She telephones the Counter clerk to ask him if this is possible. She activates an action that stimulates the patient and the counter clerk activates an "auxiliary" action that is required for a coherent scene (Fig. 14).

Fig. 14. The secretary phones the Counter clerk.

5.7. Situation n° 7: The patient is in front of the secretary but looks at the customer

In this situation, the secretary tells the patient to go to counter n°2 (Fig. 15). The patient, who is looking in the customer's direction but not at her, hears what she says (Fig. 16). Though the customer can stimulate him, he does not do it in order not to disturb the dialog between the secretary and the patient. Here, the secretary is the "Main agent".

Fig. 15. The secretary talks to the patient.

Fig. 16. What the patient really sees.

5.8. Situation n° 8: The patient takes the money

The patient is at counter 2. The counter clerk gives him the money. Here too, the clerk can activate a "Neutral", "Reassuring" or "anxiety provoking" action, depending on the patient's state. Fig. 17 shows the "anxiety provoking" action.

Fig. 17. The counter clerk gives the money to the patient.

6. Real case study

To implement our approach, we conducted a case study of a social phobic patient (male, 24 years). Several subjective scales and objective measure were taken to assess the effectiveness of our clinical method, including: the Liebowitz Social Anxiety Scale (LSAS), the Short Beck Depression Inventory (BDI-13) The iGroup Presence Questionnaire (IPQ), the Subjective Unit of Discomfort Scale (SUDS 0-100) and heart rate (HR).

We scheduled the clinical protocol in two phases. The first phase includes one 45-minute session in which the patient discovers the therapeutic program and become familiar with the experimental device. The patient also completed self-administered questionnaires given above. The second phase is organized into eight weekly sessions of 30 to 45 minutes each. The patient experiences in each session the virtual environment of the bank projected on a screen. The patient completes auto-questionnaires previously given before the start of the fifth meeting and at the end of the eighth.

The results showed that the solution formed by the automatic control system and the proposed therapeutic protocol can be applied successfully in therapy for social phobia. According to the results of measurement of presence in the environment of the bank (by IPQ), the patient had a large involvement in the virtual environment. The psychotherapist has confirmed both, the fluidity of our therapeutic approach and the easiness of managing this study; he gave more time to the patient and the therapy.

7. Conclusion

We have presented our approach to managing social interactions between a human and a set of social agents in environments. The proposed approach is based on cooperative MAS in which agents share the same objective and coordinate their actions to achieve it. We used coordination techniques between agents in a MAS to express the coherence between the activeted actions.

The effectiveness of the proposed approach has been proven by adapting our approach to treat social phobia by VR. The results of social phobic patient case study testify to the usefulness of the developed application.

The therapist has confirmed both, the fluidity of the considered therapeutic approach and the easiness to manage therapy sessions. We are currently studying the development of an application with real robots in order to aid elderly people to plan and organize daily tasks.

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References

[1] L.E. Parker *et al.*, "Current state of the art in distributed autonomous mobile robotics". *Distributed Autonomous Robotic Systems*, vol. 4, 2000, p. 312.
[2] T. Arai, E. Pagello, L.E. Parker, "Editorial: Advances in multi-robot systems". *IEEE Transactions on Robotics and Automation*, vol. 18, 2002, pp. 655-661.
[3] E. Bonabeau et G. Théraulaz, "L'intelligence en essaim". *Pour la Science*, vol. 282, 2000, p. 66-73.
[4] G. Beni, S. Hackwood, "Stationary waves in cyclic swarms". In: *Proc. of the 1992 IEEE International Symposium on Intelligent Control*, 1992, pp. 234-242.
[5] T. Fukuda, S. Nakagawa, "Dynamically reconfigurable robotic system". In: *Proceedings IEEE International Conference on Robotics and Automation*, 1988, pp. 1581-1586.
[6] S. Premvuti, S. Yuta, "Consideration on the cooperation of multiple autonomous mobile robots". *IEEE International Workshop on Intelligent Robots and Systems, Towards a New Frontier of Applications*, Ibaraki, Japan, pp. 59-63.
[7] H. Asama, A. Matsumoto, Y. Ishida, "Design of an autonomous and distributed robot system: ACTRESS". *IEEE/RSJ IROS*, 1989, pp. 283290.
[8] A. Teller, "A platform for wearable physiological computing". *Interacting with Computers*, vol. 16, Oct. 2004, pp. 917-937.
[9] J. Anttonen, V. Surakka, "*Emotions and heart rate while sitting on a chair*". Portland, Oregon, USA: ACM, 2005, pp. 491-499.
[10] F.H. Wilhelm, M.C. Pfaltz, P. Grossman, "Continuous electronic data capture of physiology, behavior and experience in real life: towards ecological momentary assessment of emotion". *Interact. Comput.*, vol. 18, 2006, pp. 171-186.
[11] E. Klinger, I. Chemin, P. Légeron, S. Roy, F. Lauer, P. Nugues, "Designing Virtual Worlds to treat Social Phobia". *Cybertherapy 2003* (Wiederhold BK, Riva G, Wiederhold MD, eds.), San Diego, CA: Interactive Media Institute: 2003, pp. 113-121.
[12] M.M. North, S.M. North, J.R. Coble, "Virtual Reality Therapy: An effective Treatment for the Fear of Public Speaking". *International Journal of Virtual Reality*, vol. 3, 1998, pp. 1-7.
[13] H. Grillon, F. Riquier, B. Herbelin, D. Thalmann, "Virtual Reality as Therapeutic Tool in the Confines of Social Anxiety Disorder Treatment". *International Journal in Disability and Human Development*, vol. 5, 2006, pp. 243-250.
[14] C. Botella, H. Villa, A. García Palacios, S. Quero, R.M. Baños, M. Alcaniz, "The use of VR in the treatment of panic disorders and agoraphobia". *Studies in Health Technology and Informatics*, vol. 99, 2004, pp. 73-90.
[15] C. Botella, C. Perpiñá, R.M. Baños, A. García-Palacios, "Virtual reality: a new clinical setting lab". *Studies in Health Technology and Informatics*, vol. 58, 1998, pp. 73-81.
[16] P. Anderson, B.O. Rothbaum, L.F. Hodges, "Virtual reality exposure in the treatment of social anxiety". *Cognitive and Behavioral Practice*, vol. 10, Summer. 2003, pp. 240-247.
[17] E. Klinger, S. Bouchard, P. Légeron, S. Roy, F. Lauer, I. Chemin, P. Nugues, "Virtual reality therapy versus cognitive behavior therapy for social phobia: a preliminary controlled study". *Cyberpsychology & Behavior: The Impact of the Internet, Multimedia and Virtual Reality on Behavior and Society*, vol. 8, 2005, pp. 76-88.
[18] A. Moussaoui, A. Pruski, B. Cherki, "Emotion regulation for social phobia treatment using virtual reality", *HuMaN07*, Timimoun: 2007.
[19] A. Trebi-Ollennu, H.D. Nayar, H. Aghazarian, A. Ganino, P. Pirjanian, B. Kennedy, T. Huntsberger, P. Schenker, "Mars rover pair cooperatively transporting a long payload". In: *Proc. IEEE International Conference on Robotics and Automation*, 2002, pp. 3136-3141.
[20] T. Huntsberger, P. Pirjanian, A. Trebi-Ollennu, H.D. Nayar, H. Aghazarian, A.J. Ganino, M. Garrett, S.S. Joshi, P.S. Schenker, "CAMPOUT: A control architecture for tightly coupled coordination of multirobot systems for planetary surface exploration". *IEEE Transactions on Systems, Man, and Cybernetics, Part A: Systems and Humans*, vol. 33, 2003, pp. 550-559.
[21] D. Polani, RoboCup 2003, Springer, 2003.
[22] R. Alami, S. Fleury, M. Herrb, F. Ingrand, F. Robert, "Multi-robot cooperation in the MARTHA project". *IEEE Robotics & Automation Magazine*, vol. 5, 1998, pp. 36-47.
[23] L.C.O.C. Weiss, E. André, "ECIRCUS: Building Voices for Autonomous Speaking Agents". *6th Speech Synthesis Workshop*, Bonn, Germany: 2007.
[24] S.J. Russell, P. Norvig, *Artificial Intelligence: A Modern Approach (2nd edition).* Prentice Hall, 2003.
[25] E. Klinger, P. Légeron, S. Roy, I. Chemin, F. Lauer, P. Nugues, "Virtual reality exposure in the treatment of social phobia". *Studies in Health Technology and Informatics*, vol. 99, 2004, pp. 91-119.
[26] A. Moussaoui, A. Pruski, B. Cherki, "*Social interaction control in the framework of virtual reality therapy*", France, 2009.