Virtual Agent Behavior Modeling in Case of a Risky Situation in a Virtual Electrical Substation

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Keywords: Virtual Reality Technology, Electrical Substation Modeling, Agent Modeling, Intelligent Virtual Agents, Risky Situation, Goal Change, Priority Change, Social Power.

Abstract: In this paper, the behavior of a realistically represented intelligent virtual agent (IVA) that accompanies students during their visit to a virtual electrical substation is modeled. The choice of technologies for modeling the agent and the task environment is considered. The properties of the task environment are discussed. The agent's behavior when a risky situation occurs is investigated. For this purpose, an IVA behavior model, based on psychological theories of motivation, emotions, and power is proposed. A change in the IVA priorities and, as a consequence, a change in its goal is modeled. Results of a survey, studying the trust, which the IVA receives from the students, are presented. To have a more realistic IVA, the model includes knowledge of the environment, the shortest evacuation route learning, visitor training locations, priorities, emotions, social power strategy, set goals, abilities to learn, abilities to change priorities and goals when a risk occurs, and a role of a specialist – electrician.

1 INTRODUCTION

Prediction and prevention of risky situations, disasters, and accidents unite the efforts of researchers and experts. When they do occur, they require an immediate response, a change in priorities for all affected, a search for an exit, evacuation, and damage limitation.

The behavior of intelligent agents, designed to communicate with users in critical situations includes some requirements for their modeling so that the users could trust them. These are, for example: having knowledge of the environment; having up-to-date information about the course of events; being able to show empathy, being able to change priorities, having a strategy for demonstrating power, having social communication skills, and being realistic.

A great advantage is the possibility to model the risky situation in a way that allows presenting the risk most realistically and, at the same time, organizing all corresponding actions in a safe way for the users. Virtual Reality technology (Favian, 2019, Gartner, 2018, Resnick, 2022) enables appropriate means for achieving extremely realistic and at the same time completely safe experiences of the modeled events by the customers. Therefore, this technology was chosen for conducting experiments within the presented study.

Electrical energy is generated and used in real time. A large part of the facilities in an electric grid such as substations, overhead power lines, renewable energy sources, and conductors, are located outdoors. They are dependent on the meteorological conditions; the change in the amount of consumed power; the health of the facilities and many others. Power generators and consumers may be located at great distances. Power consumption is constantly growing and becoming a key factor in industrial development and social life. The electrical substation in particular is an example of a risky working environment (B2B, EPRI, OSHA, saVRee), which justifies its choice as an object for conducting the experiments.

In this paper, the behavior of a realistic intelligent virtual agent (IVA) that accompanies students during their visit to a virtual electrical substation is modeled. The properties of the task environment are discussed. The agent's behavior when a risky situation occurs is investigated. For this purpose, an IVA behavior

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model, based on psychological theories of personality motivation, emotions, and power, is proposed. A change in the IVA priorities and, as a consequence, a change in its goal is modeled.

The remainder of this paper is organized as follows: Section 2 justifies the choice of the technology Virtual Reality to recreate a risky situation and IVA behavior in the course of its development. Existing models in the field of electric power engineering, using Virtual Reality technology are also discussed.

Section 3 presents modeling the IVA behavior in a risky situation when a change of goals and priorities is needed. The IVA must have a Self-Transcendence Need and knowledge of the hierarchy of all needs according to subsection 3.1. The need for an Expert Social Power Strategy Model using is explained in subsection 3.2. Modeling the Agent Type, the Performance Measure, the Task Environment, the Actuators, and the Sensors is shown in subsection 3.3.

Section 4 considers modeling the appearance of the IVA, its role, and the scene. Using Unity Game Engine reasons are explained in subsection 4.1; Modeling the appearance of the IVA and ins role are discussed in subsection 4.2; Modeling the scene in 4.3 respectively.

Experimental settings and experimental results are presented in Section 5 as follows: in 5.1. and 5.2. The experimental setting of the first and second experiments are explained; in subsection 5.3. A Survey of the students' opinions after the conducted experiments is presented.

The conclusion, contributions, and future work are discussed in Section 6.

2 VIRTUAL REALITY TECHNOLOGY AND PROJECTS IN THE FIELD OF ENERGETICS, USING IT

The new technologies of Virtual reality (VR), Augmented reality (AR) and Mixed Reality (MR) reveal new possibilities for realistic and more impactful modeling of processes, phenomena, behavior, objects, environment, IVAs, NPC-non-player characters and the interrelations between them (Flavian, 2019). Evidence of the great interest in these technologies and the applications, using them, are the numerous developed applications in various fields; the ranking of these technologies in the top 10 strategic technologies for 2018 (Gartner, 2018); the outline of trends, stimulating the development of metaverse technologies today and over the next three to five years (Gartner, 2018, Resnick, 2022).

With VR technology, users have the opportunity to interact only with virtual objects in a virtual environment. Being completely safe, they can experience in a truly realistic way the course of life-threatening situations, such as storms, fires, and accidents. They can manipulate the objects with no consequences for them in case of making a mistake. By using VR, the user achieves the psychological feeling of being present at the location of the simulation. It is also called immersion or embodiment.

The provision of innovative training approaches through interactive 3D lessons in virtual reality is of interest to several modern technological companies from the electric power system (B2B, 2022, EPRI, 2022, OSHA, 2022, saVRee, 2022). The lessons cover training in maintaining workplace safety by complying with Occupational Safety and Health Administration - OSHA standards (OSHA, 2022), transformer oil sampling, familiarization with high voltage electrical substation equipment such as power transformers, oil circuit breakers, re-closers, switchgear, etc., viewing 3D models of the constituent components of the equipment, the power line operators' training system, etc. (Vanfretti, 2020, Perez-Ramirez, 2019, Sier 2022). Other examples of Immersive virtual training for substation electricians are (Silva, 2021, Memik, 2021, Tanaka, 2017, Hernandez, 2016).

According to the Electric Power Research Institute – EPRI (EPRI, 2022), AI technologies should be actively used in the electric power industry (Vanfretti, 2020, Hernandez, 2016, Silva, 2021).

Usually, electrical substation training projects, based on Virtual Reality technology, lack an intelligent agent model, which actively communicates with the learners and assists them by guiding them.

The development of a virtual consultant-electrician can help achieve automatic diagnosis and monitoring of the equipment in the electrical substation and ensure the safety of the workers. Our motivation for modeling an IVA - consultant to students-visitors to a virtual electrical substation was to study its behavior, on the one hand, and to see how it is perceived by the students.

3 MODELING THE IVA BEHAVIOR IN A RISKY SITUATION WHEN A CHANGE OF GOALS AND PRIORITIES IS NEEDED

There are a lot of examples in the literature of solving conflict situations, evoking mixed emotions (Lee, et.al, 2006, Campos, et.al, 2012, Campos 2012, Basheer, et.al, 2013). It is relevant to consider a complex system that solves problems in a dynamic environment, in real-time, as a rational agent that has Beliefs, Desires, and Intentions (BDI) (Rao and Georgeff, 1995). Rao and Georgeff propose a BDI agent-based air-traffic management system. Desires are seen as motivational states of the system. The occurrence of events may require a change in the goal chosen to be achieved by the system or the intention (Kinny and Georgeff, 1991). A system with evaluator CBR (Case-Based Reasoning) and advisor BDI agents is used for a web-based risk management system for small and medium businesses (De Paz, et.al, 2011). BDI agents are used for social simulations (Adam and Gaudou, 2016, Puica M. A, Florea A. M., 2013).

In works (Moffaert, 2016, Natarajan, et.al. 2005) an IVA is trained to achieve goals, which, to varying degrees, satisfy the controversial requirements of the users. Pareto front goals are those, which propose different ways of balancing conflicting demands. The users have to choose one that balances their requirements in the best way. (Moffaert, 2016, Natarajan, et.al. 2005).

Other authors focus on the way of achieving a given goal (Budakova, et. al. 2020, 2020a). They introduce a hierarchy of requirements concerning the way of achieving a goal. When it is not possible to achieve a goal by complying with all the requirements, compromises are suggested. For this purpose, the characteristics-requirements are classified as acceptable and unacceptable for the users.

The IVA is trained to make only acceptable compromises to manage the way to achieve the goal and not to make unnecessary compromises. An algorithm of learning by reinforcement learning is used, in which a matrix of the characteristics is introduced, as well as weights, denoting their degree of importance.

The IVA in the considered scenario is modeled to be a bearer of self-transcendence values, i.e., to have a self-transcendence need. According to (Maslow, 1954, Liu, 2022), it means concern for the well-being of others, empathy (Paiva, et. al. 2017), socially engaging emotions (Liu, 2022, Paiva, 2017), and prosocial behavior (Liu, 2022, Paiva, 2017, Gratch, 2004). To realize this need, two goals are set in front of the IVA. The first one is to accompany the visitors to pre-set locations in the electrical substation. The second goal is to ensure the safety of the visitors.

According to the scenario, at a randomly chosen moment after the tour starts and before it ends, an explosion occurs, requiring the evacuation of the visitors. This means that the IVA has started actions to achieve the first goal – visiting a sequence of designated training locations. Before achieving it, however, it has to stop the actions for achieving it and undertake actions to achieve the second goal – evacuation to save the students from the explosion.

Consequently, not the manner of achieving one goal is managed here, but the pursuit of one goal must be stopped and actions for the achievement of another goal must be initiated. If we can talk about compromises, the compromise here is to leave the first goal unachieved to achieve the second one. For the specific scenario, the compromise is that the planned places for training remain unvisited to guarantee the students' safety.

3.1 Self-Transcendence Need and Resulted Behavior Modeling

To realize a change of goals, the IVA must have a Self-Transcendence Need and knowledge of the hierarchy of all needs. In his theory of personality motivation, Maslow defined a pyramid that illustrates the hierarchy of needs (Maslow, 1954). For the purposes of the experiments in this paper, only the possibilities for the IVA to take care of user safety and knowledge transfer are modeled.

According to Maslow's theory (Maslow, 1954), the place of each need in the hierarchy can change depending on the degree of their satisfaction. When, for example, there is an explosion, great uncertainty arises and this need is given the highest priority. The most important thing is to protect the visitors' life and health. And when there is no danger, the transfer of knowledge is valued as the most important again. According to the theory of Ortony, Clore, and Collins (OCC model) (Ortony, et. al. 1988), the occurring events receive a cognitive appraisal, giving rise to emotions. The emotions are "valenced reactions". Following this cognitive approach, which explains the emergence of emotions, it is assumed that the explosion receives a negative appraisal and the state of safety - a positive one.

A module of the environment called "critic" defines the priorities of the needs, the cognitive appraisal to be given to the events, which occur in the task environment, and the emotions, caused by these appraisals (Russel and Norvig, 2009). The IVA's priorities and emotions are associated with taking specific actions. The rules defined in the "Critic" module cannot be changed by the IVA. These rules tell the agent what is right and what is wrong. The rules, determining the agent's priorities, emotions, and actions, which correspond to them, can be briefly described by the pseudo-code, given here:

Function Environment State (*percept*) **returns** an action

if environment _state = = *exploded* **then**

  priority ← Update Highest priority (***safety achieving***)

  evaluation ← Assigning evaluation (***negative***)

  emotion ← Assigning evaluation (***fear***)

  return action *evacuation*;

else if environment _state = = *safety* **then**

  priority ← Update Highest priority (***teaching***)

  evaluation ← Assigning evaluation (***positive***)

  emotion ← Assigning evaluation (***pride***)

  return action *next learning place*;

According to this pseudo-code, if there is an explosion, ensuring safety becomes the highest priority for the agent. The explosion receives a negative cognitive appraisal and as a result, the emotions of fear and empathy arise, and immediate action is taken to evacuate the visitors out of the electrical substation. If there is no explosion and the situation is safe, the most important priority for the IVA is to be useful to users. Safety receives a positive cognitive appraisal.

This appraisal gives rise to the emotions of joy, and the opportunity to share knowledge evokes pride.

3.2 Expert Social Power Strategy Modeling

The simulated agent is in the role of an electrician who accompanies the students on their visit to the virtual electrical substation. It is necessary for the students to follow the agent's instructions especially when a critical situation arises. A number of studies (French and Raven, 1959, Pereira, et.al. 2016, Hashemian, et.al. 2018) prove that social power and the use of a social power strategy have an impact on social interaction.

It is expected that if the IVA uses a social power strategy it will have a greater impact on the students and they will follow it to a greater extent. According to the Theory of Social Power proposed by French and Raven, there are five approaches to realizing social power: Reward Social Power; Coercive Social Power; Expert Social Power; Legitimate Social Power; Referent Social Power. It is also important what type of Power Resources the agent has at its disposal. The modeled IVA is in the role of an electrician, which is one of its Power Resources. It also uses Expert Social Power because it has knowledge of the task environment, training locations, and evacuation routes.

As a social power strategy, the agent uses phrases like: "Let's go. I will take you out by the shortest and safest route. I know the electrical substation very well."; "You will enjoy the following video tutorial. You must see it. It's just for you".

It is assumed that this role, the knowledge, and the used social power strategy will help the IVA to gain the trust of the visitors. The obtained results are discussed in section 5.

3.3 Modeling the Agent Type, the Performance Measure, the Task Environment, the Actuators and the Sensors

According to (Russel and Norvig, 2009), intelligent agent modeling and modeling the task environment are directly related to each other. Therefore, they are considered in this section.

The world of the virtual agent - an electrician is simplified at the maximum. Like a simple reflexive agent, it chooses its actions based on the current perception and does not store a history of perceptions.

As a result of the environment monitoring, the IVA can dynamically change its goal. This enables the agent with the ability to cope with the uncertainty and stochasticity of the task environment.

The agent undertakes a visit to the locations, designated for conducting the training process. The agent has autonomy when learning to find the shortest safe evacuation route or the shortest route to a given goal to conduct a video tutorial with the visitors. A Q-learning reinforcement algorithm is applied (Sutton and Barto, 1998).

In summary, it can be said that the modeled agent is a learning agent, which is utility-based, has goals, and responds to the immediately observable characteristics of the task environment.

The task environment is known to the virtual agent – the electrician. It can lead the students –

visitors of the virtual electrical substation to all intended goals; in case of an explosion, it chooses the shortest safe route of evacuation.

For the purposes of this experiment, the task environment is assumed to be fully observable.

The working environment is considered episodic. For each episode, the agent perceives the state of the environment and takes an action.

The other modeled moving-on-the-scene virtual electricians in this experiment are only considered as objects. They neither cooperate nor compete with each other. They do not take part in the experiment and do not affect the behavior of the intelligent virtual agent – an electrician under consideration. It means that the modeled environment is a single-agent one.

For the conducted experiments, a dynamic, uncertain, and stochastic environment was modeled. This is achieved by limiting the abilities of the IVA. For example, the future state of the environment does not depend on the actions of the virtual agent – an electrician. The IVA is not capable of predicting or taking actions to prevent a critical situation. The environment is dynamic, as it can change while the agent shows the objects in the electrical substation to the students. For example, a storm may start, and an accident or an explosion requiring evacuation may occur. Consequently, the environment is also uncertain.

Table 1: The model of the working environment.

Working environment	
Model of the electrical substation	Including generators, transformers, circuit breakers, gauges, etc.
Other characters	Other characters, move on the scene.
Users	Students, visiting the electrical substation.
Models	Model of a storm; Model of an explosion; Model of accidents such as short circuit occurrence, electrical sparks, arcing etc.
Input module	Camera, microphone, keyboard, and motion controllers;
Output module	Visualization of the scene, of the IVA, of the occurring events.
Module "Critic"	Rules, define when and which priority is most important; which event receives what rating; what emotion it evokes; what action to take.

Table 2: The model of a Utility-Based Intelligent Virtual Agent.

Utility-Based Intelligent Virtual Agent	
Motivation (priorities)	Need to provide safety and to pass on knowledge;
Emotions and empathy	Joy and anxiety
Social skills	Gait, facial expressions, gestures, TTS, Speech Recognition; Social power strategy.
Goals	Two goals correspond to the agent's needs, which can also be in conflict.
Resolving a conflict situation	Resolving a conflict situation by changing the priorities and thence by changing the goal.
Behavior	Patrolling behavior; behavior aimed at finding out the shortest route to the training and evacuation locations
Ability to learn	The Reinforcement Learning Algorithm uses a reward model; environment model; dangerous places avoidance model.
3D model of an IVA,	Including movements, mimics, and gestures animation, TTS, and speech recognition.
Knowledge	Knowledge of the environment; the occurred accidents; of the evacuation route; the places where a video tutorial can be seen; the characteristics of the objects in the electrical substation and knowledge of the signs of danger of an accident. Knowledge of the needs (priorities), the emotions they give rise to, and the corresponding actions.

The model of the working environment and the model of an IVA, are given in Table 1 and Table 2 respectively. The IVA and the working environment interact continuously.

4 MODELING THE APPEARANCE OF THE IVA, ITS ROLE, AND THE SCENE.

4.1 Unity Game Engine Using

Unity 3D real-time development platform is used for modeling and control of 3D interactive applications for VR, MR, and AR (Unity Documentation, 2022). The applications, developed with the help of the Unity 3D Game Engine, allow for conducting experiments in the field of artificial intelligence, robotics, machine learning, and artificial intelligence for games (Craighead, et.al, 2008, Craighead, et.al, 2008a, Buyuksaliha, et.al, 2017, Wang, et.al, 2020, Wang, et.al, 2019, Weitnauer, 2008).

The applied programs, developed with the help of Unity consist of scenes, game objects, and scripts, written in the programming languages Python or C# using the programming environment Visual Studio. NET. The developers can add resources from the Unity Asset Store with the help of the Package Manager. A valuable option is to use sensors in the developed applications.

The great capabilities of the Unity Game Engine, its popularity, and the recognition that it is the fast way to implement a virtual reality application were the reasons why it was chosen for the implementation of the experimental setup in this study.

4.2 Modeling the Appearance of the IVA and Its Role

The IVA is modeled at full height. The 3D character Pete from the site (Mixamo) was chosen because he is dressed in work clothes and is suitable for the role of an electrician to accompany the students, visiting the virtual electrical substation (Figure 1). Again from (Mixamo) several animations of walking, running, waving, pointing, and searching were chosen to make the agent even more plausible. The package for Unity SALSA LipSync (Crazy Minnow Studio) is used to ensure synchronization of the agent's lip movement with the pronounced speech and the direction of the gaze toward the speaker. The agent can pronounce any written text with the help of the package for Unity RT-Voice (Crosstales), which uses TTS voices, integrated into the application under development.

An alternative suitable package for 3D modeling of the IVA appearance is UMA2 - universal multipurpose agents (UMA Steering Group), which provides opportunities to construct a unique avatar by changing the appearance of the agent - height, weight, placement of eyes, cheekbones, lips, as well as clothing and hairstyle.

4.3 Modeling the Scene

To model the scene, first of all, the standard Unity Environment package is used, which allows placing terrain, mountains, grass, and trees, to model a windy area. Then the sky is placed using the Classic Skybox package (Mgsvevo, 2015). The Storm Effects package (WeBee3D, 2012) is used to model a storm

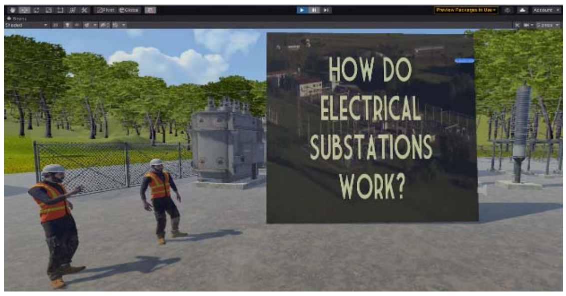

Figure 1: A model of a virtual electrical substation with a visualized intelligent agent – an electrician.

with thunder, lightning, and the appropriate sounds. The Package Pixel Art Particle System Pack (Gonzalez, 2018) makes it possible to add electric sparks, an electric arc, explosions, fire, smoke, and other sound and visual effects to the project. The substation model is based on the one, proposed in the asset store package "Electrical substation – Power Grid" (Kobra Game Studios, 2018). All object models in this package such as generators, transformers, circuit breakers, cables, etc. are authentic and fully correspond to the real ones.

Figure 2: A scene in the electrical substation during a critical situation caused by a heavy storm.

A scene in the electrical substation during a critical situation caused by a heavy storm is given in Figure 2.

5 EXPERIMENTAL SETTINGS AND EXPERIMENTAL RESULTS

5.1 Experimental Setting of the First Experiment

One of the goals of the simulation is for the students to experience as realistically as possible an extreme situation caused by a heavy storm on the territory of the virtual electrical substation. A disaster where the rain is torrential, the thunder is frequent and the lightning is so close, is dangerous to see live. The goal is for the students to be virtually present in a risky environment, which they cannot visit live due to danger to life. Accidents are modeled, such as the occurrence of short circuits, electric sparks, arcing, dangerous amplification of the sound emitted during the operation of the devices, cracking of the ceramic insulation, windings of sand and deposits on the housings of the devices, leakage of protective oil from the circuit breakers, overheating of the transformers necessitating turning off.

In the first experiment, a virtual agent in the role of an accompanying electrician, advises the students to get into a safe, fully protected flying capsule to explore the electrical substation in this risky situation, passing as close as possible to each object. In this realistically modeled risky environment, they can choose to take the tour or not. What is studied is: the preference of the students whether to tour the electrical substation accompanied by an IVA or independently; whether the experience is realistic and whether it is useful for them to see this risky situation up close while being completely safe.

5.2 Experimental Setting of the Second Experiment

In the second experiment, the tour around the electrical substation begins under normal conditions. The virtual agent offers to guide the students to specially placed screens where they will be able to view video lessons. The agent explains that they will see three video tutorials on screens, located in different places on the grounds of the electrical substation. The topics of the video lessons are, for example, related to the principles of operation of the electrical substation; the most frequent accidents; the components of the transformer, generator, and circuit breakers; the need for the tanks to be filled with non-conductive oil, the fans, the ceramic insulation, the gauges to be monitored; what accidents can be caused by the storm and outdoor operation of the devices; what is necessary to be observed by the electricians during a tour and inspection of the facilities.

At a random moment after the tour around the electrical substation begins and before the end of the third video tutorial, an explosion occurs and the agent initiates evacuation. The students can independently explore the substation and watch the video tutorials. They can follow the IVA and its advice and recommendations or ignore it. What is investigated is whether the students prefer to communicate with the IVA.

5.3 Survey of the Students' Opinions after the Conducted Experiments

Twenty first-year students at our university participated in the experiment. After completing both of the experiments, the students must answer yes, no, or neutral to the following survey questions: Regarding the simulated environment: Was the experience truly realistic for you? Was the experience extreme? Regarding the video lessons: Was the video lesson more impactful because of the realistic setting? Is it a good idea to study in a realistically modeled environment? Did you remember and understand more and better the presented learning material as a result of the realistically modeled setting? Do you feel better prepared to go to a real electrical substation after the virtual reality experience? Would you like to walk around the model electrical substation and watch video tutorials for each device standing right in front of it? Regarding the behavior of the intelligent agent: Was the virtual agent realistic? Do you prefer to follow an IVA when visiting the virtual electrical substation? Do you prefer to explore the electrical substation on your own? Did the IVA have sufficient knowledge and social skills? In addition, students were asked to rate on a ten-point scale the realism and usefulness of the applied models and the confidence in the modeled IVA.

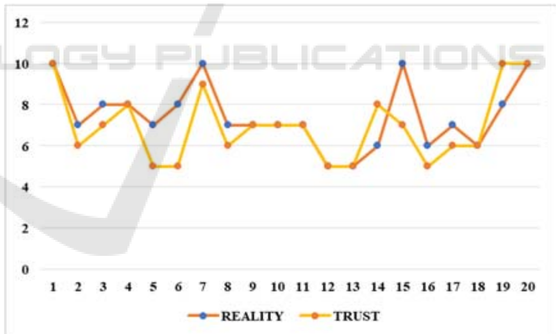

Figure 3: Results of a student rating on a ten-point scale of the realism of the applied models and confidence in the modeled IVA.

The result of the research showed that the students had a real, unique, and extremely exciting experience. They appreciate the fact that they could not be present in the electrical substation in a risky situation of a heavy storm and electrical accidents. 80% of the students expressed a preference to be accompanied by an IVA during their visit to the virtual substation. They shared that they enjoyed the flight capsule tour and wanted to get as close as possible to any device or sign of an accident. The students find it useful to study in a realistic setting. They expressed a preference for the first experiment, in which they were present in the electrical substation during an extreme situation created by a storm, something they could not experience in the real world.

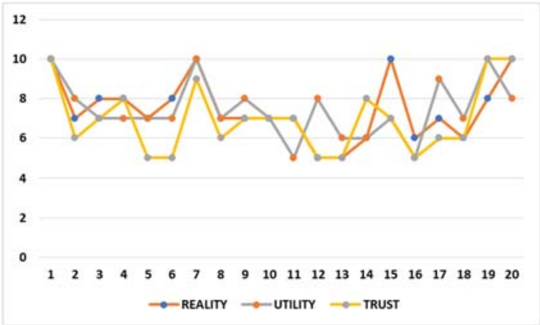

Figure 4: Results of a student rating on a ten-point scale of the realism and usefulness of the applied models and confidence in the modeled IVA.

After examining the survey data, it was found that the realism ratings of the models corresponded very closely with the IVA confidence rating (Figure 3). They also correspond to utility ratings although to a less extent. This is shown in Figure 4. It seems that it can be concluded that there is a relationship between the degree of realism of the representation of the models and the assessment of their usefulness, as well as confidence in them. But this claim requires a larger study to be confirmed.

6 CONCLUSION AND CONTRIBUTIONS

A model of a virtual electrical substation and a model of a realistic IVA - an electrician have been proposed in this paper. The modeled agent is a utility-based learning agent, having goals, and responding to immediately observable characteristics of the task environment. The justification of the IVA behavior through the theories of Maslow, (Maslow, 1954) Ortony, Clore, Collins, (Ortony, et.al., 1988) French, and Raven (French and Raven, 1959) is considered a contribution.

Two scenarios of a risky situation development, caused by a storm and an explosion, have been proposed. The behavior of an IVA in these situations has been investigated. The emergence of risk causes a change in the priorities and, as a consequence, a change in the goal of the IVA. The IVA behavior model is based on Maslow's theory of personality motivation. A contribution is that in the process of implementation of the present model, the agent terminates the execution of an initially chosen goal before achieving it and undertakes the execution of another goal in response to the change of priorities and the risk that has arisen. The IVA modeling also uses the theory of Ortony, Clore, and Collis, according to which an event receives a cognitive appraisal, giving rise to emotions. Based on this theory, the emotions and the motivation of the IVA are modeled. The IVA uses a social power strategy in accordance with the French and Raven's theories.

To gain the users' trust, the IVAs are required to: possess knowledge, and good social skills, use social resources and a social power strategy, express emotions, use appropriate gestures, gait, gaze direction, recognize and deliver a speech, make decisions in a critical situation, have goals and priorities. All these functionalities help to achieve a high degree of realism of the virtual agent.

The experiments, carried out with the students in their work with the developed scenarios of a risky situation occurring during their visit to a virtual electrical substation are discussed. The results show that the behavior of the IVA is perceived as correct and realistic. 80% of the students who participated in the experiment preferred an IVA to accompany them on their visit to the electrical substation. They consider that the use of Virtual Reality technology is suitable for modeling risky situations to be observed in a safe environment.

The study could be continued in the future in the following direction: after the risk has passed the agent could go on with achieving the unachieved original goal.

Modeling other types of risky situations and/or opportunities to prevent and predict them is also of interest. The IVA will get greater autonomy and a better performance measure. The students will get more opportunities to interact with the environment and take action to prevent accidents in the electrical substation. Greater functionality of the IVAs is also envisaged, such as explaining the actions to be taken or explaining the status of objects from the electrical substation; learning to manage the way to achieve their goals so as to increase their performance measure.

It will be interesting to model a multi-agent environment in future experiments, where the agents located in different places on the scene of the electrical substation will exchange information about the state of the objects in order to cooperate.

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