SVHSIEVS FOR NAVIGATION IN VIRTUAL URBAN ENVIRONMENT

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ABSTRACT

Many virtual reality applications, such as training, urban design or gaming are based on a rich semantic description of the environment. This paper describes a new representation of semantic virtual worlds. Our model, called SVHsIEVs[1]should provide a consistent representation of the following aspects: the simulated environment, its structure, and the knowledge items using ontology, interactions and tasks that virtual humans can perform in the environment. Our first main contribution is to show the influence of semantic virtual objects on the environment. Our second main contribution is to use these semantic informations to manage he tasks of each virtual object. We propose to define each task by a set of attributes and relationships, which determines the links between attributes in tasks, and links between other tasks. The architecture has been successfully tested in 3D dynamic environments for navigation in virtual urban environments.

KEYWORDS

Virtual environments, semantic modeling, ontology, Virtual Human

1. INTRODUCTION

Nowadays, many applications use virtual environments in different contexts such as medicine [1], virtual heritage [2], education [3], Geographical Information Systems [4], scientific research [5], and WorldWide Web [6]. Current virtual environment representations describe models of environments so that browsers can effectively visualize their geometry and can support low-level interactivity in most of cases [7][8][9]. There is a gap between the low-level representation of the universe and how we conceptualize (and therefore how we think and talk about this universe). Thus, a high-level model's representation (including semantic descriptions of objects in the environment) is desirable in order to support user interactions which are richer in a more abstract level (querying for contents) and reasoning of deployed agents on the environments they inhabit.

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[1]Semantic Virtual Humans In Virtual Environments

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We believe that the semantic information in virtual worlds should be considered as a component of the universe. Therefore, the construction of virtual environments should contain semantic annotations about the environment [7][10]. Modeling techniques are rooted in semantic information systems, namely databases, geographic information systems, etc. Data representation is a critical issue for these systems. Traditional approaches simply focus on techniques that support efficient storage and retrieval of data. Otherwise, semantic modeling makes the data meaningful, and therefore machine-readable [11]. The Semantic Web is a good example of what semantic modeling can provideby inserting machine-readable metadata, it allows the information stored in meaning web pages to be processed by algorithms and researches based on their content [6].

The role of the semantic modeling of virtual environments (VEs) is to provide an abstract, high-level and semantic description of different aspects of a VE: structure of the virtual environment, behaviors and interactions of entities, domain knowledge, etc.[8,9]. A main motivation for adding a semantic model is to ease the design of intelligent VEs. This intelligence of VEs mixed with artificial agents and users can be defined as the capacity of artificial agents to exhibit human-like behaviors and to be capable to assist users to solve a specific problem [12].

Ontologies have been used in virtual worlds as a relevant formalism to provide a conceptual representation of scene contents. The main idea has been a direct mapping between graphical contents and ontologies [8,11]. The concepts in an ontology can be the exact copy of the specific graphical resources, butthis leads to several inconveniences. First, ontologies are not able to represent entities with no graphical representation in VEs. Second, it is not possible to share common properties among a family of graphical resources. For instance, movable objects have some properties in common in comparison with unmovable objects.

In short, our model proposes that each virtual object in a particular virtual environment is geometrically considered as its minimum bounding-box, and corresponds to a particular type of object in a specific ontology. In addition, this model also establishes relationships between elements in the VE. This model (called SVHsIEVs) uses virtual humans in VE. Each virtual human uses both two techniques. The first technique: Guidelines, ensures coherence and sequence of tasks. The second technique: Querying ensures the communications between agents and ontology.

In the next section, we briefly review related works. A detail description of the proposed semantic modeling is given in section 3. Section 4 describes the definition and the role the ontology in VEs. The architecture of the proposed environment is illustrated in section 5. Section 6 concludes the paper and outlines some future works.

2. RELATED WORKS

Semantic modelling techniques are rooted in Information Systems, namely Databases, Geographical Information Systems, and World Wide Web. Data representation is a crucial issue for these systems. Traditional approaches merely focus on techniques that promote efficient storage and data retrieval. On the contrary, semantic modeling aims to make data meaningful and consequently compatible with machine-process able. The semantic web is a good example of what semantic modelling can provide. By inserting machine-readable metadata, it allows the meaningless information stored on web pages to be processed by algorithms, which perform researches based on their content.

This section describes several approaches and concrete works concerning the addition of a semantic level to a virtual world, and designing of VE along with the semantic model. The metadata are added in the model as the objects are created. This technique has been used either for content-oriented and system-oriented approaches, building the VE based on a pre-existent semantic level. The main idea of this technique is to get benefits from an existing semantic model. For instance, one can use an existing Geographical Information System to build virtual urban environments, adding semantic annotations to the pre-existent VE[10]. The semantic annotations can be multimedia resources, such as texts, images, sounds, and Web links. In this case, the added information makes sense only for the user, but isnot semantically interpreted by the system.

Cavazza & Ian [14] present technical problem in the implementation of intelligent virtual worlds, theydeal with the need to find a knowledge representation layer. They recognize that in some virtual world applications there is a need for the simultaneous access to concrete and abstract information. These intelligent virtual worlds, based on theproposed common representation layer, offer advantages regarding adaptability and reusability.

Thalmann et al [15] present an informed environment that creates a database dedicated to urban life simulation. They introduce a method for building virtual scenes with semantic information for the exploitation of such scenes. The three-dimensional scene provided by the designer is divided into two parts, one for visualization and another for database construction. The database contains geometrical and semantic information for mobile entity simulation.

Doyle [10] introduces the concept of the annotated environment, so the structured representation of their content and their objectives are available to any agent in the environment. This description of an agent architecture gives the possibility to interact with an annotated virtual environment, with a structure for representing information in these environments.

Badawi& Donikian [16] describe the STARFISH (synoptic objects for tracking actions received from interactive surfaces and humanoids) architecture that uses synoptic objects to allow real-time object manipulation by autonomous agents in a virtual environment. A set of actions is defined. Then these actions are assigned to interactive surfaces that definethe geometry of an object and that are concerned by the action. The agent then uses these interactive surfaces to get the data specific to the object when it wants to manipulate it and to adapt its behavior accordingly.

The current trend is the use of ontologies to model the semantic information of virtual environments. Vanacken et al [17] introduce the use of semantic information, represented using ontologies, in conceptual modelling of interaction invirtual environments.

This semantic information itself is created during the design of the virtual world. More concretely, semantics is incorporated in NiMMiT (Notation for MultiModal interaction Techniques) [18], a diagram based notation intended to describe multimodal interaction. Some works have proposed complete architectures that include a semantic layer, which is the interface between the agents and the world. This layer usually models the world through a semantic representation defined according to a set of ontologies. Chang et al [19] present a framework that allows separating the agent mind from the environment. An ontology-based cognitive middle layer between agent minds and the environment manages semantic concepts. Ontologies are mapped onto the environment, through which characters understand the world as instances of interconnected concepts rather than numerical values, allowing them to infer the relation between objects. This layer also represents actions through causal rules whose effect is turning the target object into an instance of another concept.

With Grimaldo et al [20], an approach that uses ontologies as a basis to animate virtual environments inhabited by intelligent virtual agents is presented. The proposed architecture is a multi-agent framework, which can be divided into several parts: ontologies that define the world knowledge base; a semantic layer which is the interface between the agent and the world; planning based agents that receive sensorial information from the semantic layer and calculate the appropriate sequence of actions in order to achieve their goals; and a 3D Engine that extracts graphical information from the object database and performs visualization.

The ontology is consideredas a means for social relations between agents within an artificial society. These relations must be used into account in order to display socially acceptable decisions [21].

This approach has been used to simulate the virtual bar of a university, where groups of waiters and customers interact with both the objects in the scene and the other virtual agents finally displaying complex social behaviors [22].

Ibânêz et al [23] think that application approaches are necessary, and they are different from one another in nature. Thus, the model they proposed is situated at a lower level than approaches, which depend of applications. Their model does not intend to substitute to application dependent approaches, but to constitute a common lower level for all of them. The authors'intention was to create a useful model, that is, a model actually employed by the world creators. Thus, their principle was that it should not require a great annotation effort from the environment creators. As a result, the model consists of a reduced number of different features, and the majority of them can be automatically annotated.

Tutenel et al [24] introduced the Semantic Class Library to design semantic VEs, notably 3D games. After creating a 3D model, the designer associates the elements of the 3D model to existing classes in the library. Otherwise, the designer can create a new class with the desired properties. Beyond the 3D representations of objects within the game world, the Semantic Class Library provides additional semantics to the objects, such as physical attributes (e.g., the mass or material), functional information (e.g., how one can interact with an object).

3. VIRTUAL HUMAN

Lot of research has been done on behavioral animation of virtual agents over the last few years – see [25] for a good introduction to the field. The pioneer work of [26] showed how to design a framework to animate natural ecosystems. He simulated artificial fishes in the natural complexity of virtual underwater worlds. However, human behavior is clearly different and more complex to emulate. Possibly, the more relevant works in this field came from Thalmann's group [15]. The goal of these previous works was to design agents with a high degree of autonomy without losing control. Their agents are an extension of the BDI architecture described in [27], and they include internal states as emotions, reliability, trust and others. BDI-based agents have been also used in games such as Epic Game's Unreal [28].

Some research has been done about the questions of credibility of groups of synthetic characters, usually centered on the interactions either among a human user and a virtual character [29] or between virtual characters [30]

Creating Virtual Humans is a complex task, which involves several Computer Science domains: Geometric Modeling, Computer Graphics, Artificial Intelligence, and Multimodal Interfaces [31]. In his works, Gutierrez proposed a semantics-based approach in order toorganize the different kindsof data that constitute a Virtual Human.

The knowledge defined by the synthesis, functionalities and animation of VHs is formally specified by the way of ontology. This approach is similar to our purpose in the section 4.2.

4. ONTOLOGY IN VIRTUAL ENVIRONMENT

Virtual Humans are virtual entities with a rich set of functionalities and potential, present in a VE. One of the main instruments used to lay-down the foundations of a knowledge-based system are ontologies. Ontology defines a common vocabulary for domain-users (researchers or experts in a particular area) who need to share information in a particular domain. It includes machine-interpretable definitions of basic concepts in the domain and relations among them. The semantics-based representation can be enhanced by means of knowledge-management techniques and tools. One of the main tools used to lay-down the foundations of a knowledge-based system is therefore an ontology. A first one focuses on the adaptive multimodal interfaces system and a second one formalizes the knowledge related to the creation of virtual humans and serves as a basis for a general ontology for Virtual Environments [32]. Many consider W3C'sWeb Ontology Language (OWL) the prospective standard for creating ontologies on the Semantic Web.

OWL has three species: OWL Lite, OWL DL and OWL Full, in ascending order according to expressiveness. We can divide the use of ontologies in thedomain of Virtual Environments into three uses; the first use: Ontologies in the context of Virtual Environments [33,34], the second use : Ontology for interactive Virtual Environments[35,36], the third use: Ontology for Virtual Humans [31,37].

5. OUR FRAMEWORK (SVHSIEVS)

In the framework SVHsIEVs, we attempt to apply the influence of the integration semantic layer in virtual worlds. This semantic layer is distributed according to two levels. The first level is global, in this level we can define semantic information on a more global way. The second level concerns the virtual objects; in this level, objects need to transcend the geometry concepts and more abstract information need to be incorporated into the object's description. Many properties of real-world objects should be represented in their virtual counterparts to allow an algorithm to perform some kind of reasoning on objects (e.g., the physical attributes define whether or not the object is too heavy to carry, or the functional information is necessary to decide if an AI character can use the object to reach a goal).

In our proposal semantic information use the ontology to describe the concepts used in the domain along with their properties and relations between them, in each two levels.

Our first contribution is to show the influence of adding semantic information (contextual attributes and relationships between concepts) to virtual objects and with the aim to use this information to define and redefine interaction with environment.

Our second contribution concerns the use in our modelofVirtual Humans two technics: Querying and Guidelines.

Our third contribution concerns the use of this semantic information in management of tasks for each virtual object; we propose to define each task by more attributes and set of relationships, this relationships determine on one side the links between the attributes in a task and on the other side they determine the relations between tasks.

As discussed earlier in this paper, the proposed framework is based on the integration of semantics information in virtual environment, and we show this integration in different layer.

Also, for each objet in the environment composed of two aspects: geometry and semantic, the aspect semantic is based on contextual information only but using the relationship between different concepts, these concepts are present information's semantics of different objects in virtual environment.

In this paper we present a Semantic Virtual Environment approach that uses ontologies as an appropriate basis to animate virtual environments inhabited by intelligent virtual Humans. Figure 1 show the architecture of our multi-agent framework, which can be divided into several parts:

Ontologies define the world knowledge base as well as the set of all possible relations among the agents and virtual humans. We distinguish two levels of representation: the SVE Core Ontology is a unique base ontology suitable for all virtual environments which can be extended by different Domain Specific Ontologies in order to model application-specific knowledge. Then, environments can be constructed by instantiating the classes of these ontologies. For example, in section Implementation we will create pedestrians a virtual city with a large number of objects – cars, crossroads, etc.

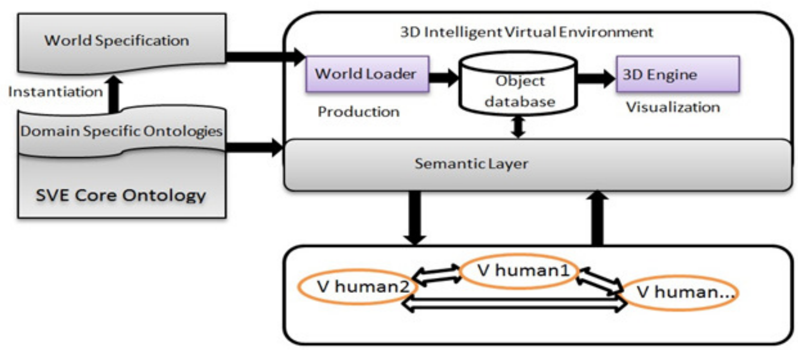

Figure 1. SVHsIEVs architecture

The Semantic Layer is the interface between the virtual human and the world. It uses the ontology so as to reduce the information flow; this layer is in charge of executing the actions requested by the agents as well as maintaining their semantic effects.

In the structure of Virtual Human we find the combination between three aspects: Virtual human intelligent (VHI), Querying and Guidelines. The VHI insures the intelligent interaction with world and the others VHI and the querying insures communication (asks and answers) with the world. The Guidelines insures the planning of different tasks.

5.1 Ontology of virtual environment

The goal of ontology design for virtual environment in this architecture is two parts. First, we would like to keep the information that exists in the virtual environment such as object geometry and transformation. Second, we use semantic information about the virtual objects can facilitate the computation of advanced reasoning procedures such as a navigation in the world.

Our ontology design of the virtual environment is shown in Figure 2. The root of the ontology is the environment node, which contains world information (environment) and all the virtual objects (object) in the environment. In order to retain the semantic information of the virtual objects, we have designed the base Info and Transform nodes; in this node we show sub-information as position and rotation. Each object also has some additional attributes such as name, weight, height and tag. All this attributes are designed for public properties for virtual objects. For example, the urban environment, one can tag certain objects as s pedestrian area and car area such that these regions can be treated appropriately by the urban environment according to their meanings in the world. Each object in environment as (building, car and Column lights…) may also have the attribute of Approximation 3D, which is a polygon that can be used to define 3D approximation of obstacles in the environment for the navigation.

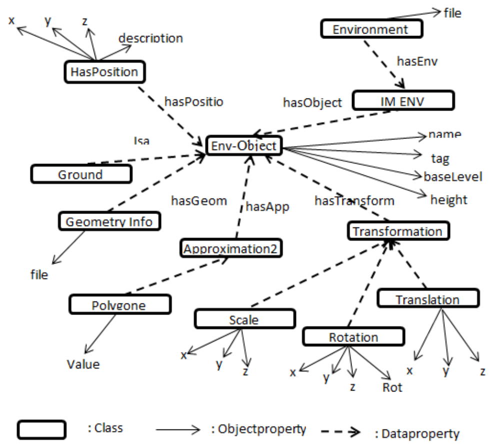

Figure 2. Ontology design for virtual environment

5.2.VHs architecture

The Virtual Human is based on three aspects; Virtual human intelligent (VHI), Querying and Guidelines. The VHI gives the intelligent interaction with world and other VHI and the querying gives asks and reception the answers with world. The Guidelines gives the pacification of different tasks.

The module gives the aspect querying, it is a communication module, and in this module we show two types of communication: the first protocol with other Virtual Human by message for example demand the service or information, the second protocol with environment by the queries. The answer of these queries is divided into two cases according to natural answer; if the answer is a static information like position or direction by example, in this case, the answer is simple processing; we take the query and search in the ontology of data information without treatment. In second case, we use different modules as reasoning module and ontology.

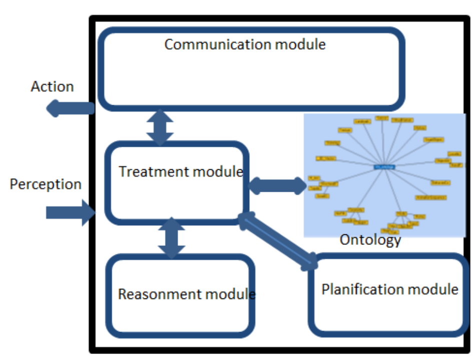

Figure 3. A Virtual Human architecture

We show the aspect of guidelines in planning module, this module is ensuring the planning of different tasks; in this part we using ontology for giving all information's of each task, because each information, it is influence in the order between tasks. For example we have four tasks T1, T2, T3 T4, with the following planning.

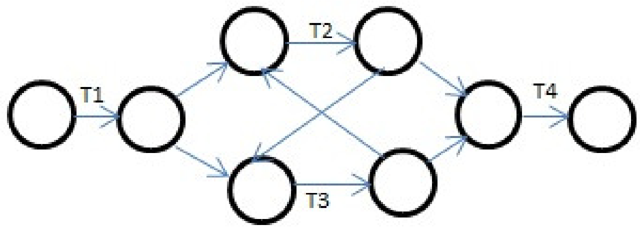

Figure 4. The sequence of tasks

We note that T2 and T3 are independent; in this case the order is not important. By adding more information as the nature task such as the time attribute for example, this task is joined with time or not; T2 is the task “buy in the store” and T3 is the task “buy in internet”; therefore, we run T2 before T3 because T2 depends on the opening of the store.

The reasoning module it is means of present the intelligent, this module likes with all reasoning tasks for each virtual human; we show the experience or information’s of finding the path between two points in the network of points after the Transformation the points network for VE into form « case base ».(as shown in Figure 5)

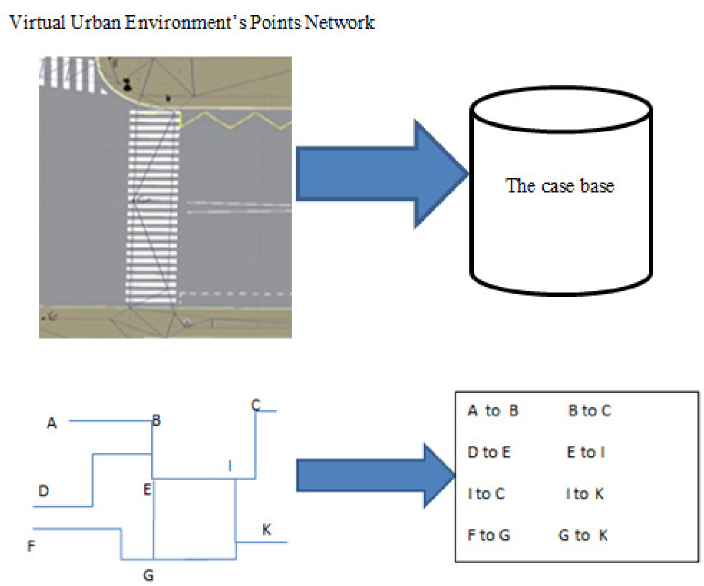

Figure 5. Transformation the points network for VE into form « case base »

The path between two points is the sequence of sub-paths, result of the induction algorithm on the case base.

In other case; if VH cannot get the solutions, because these information do not exist in his ontology, it sends the query to environment or other VH to get this information. This asks is assumed by the querying module. According to the following figure:

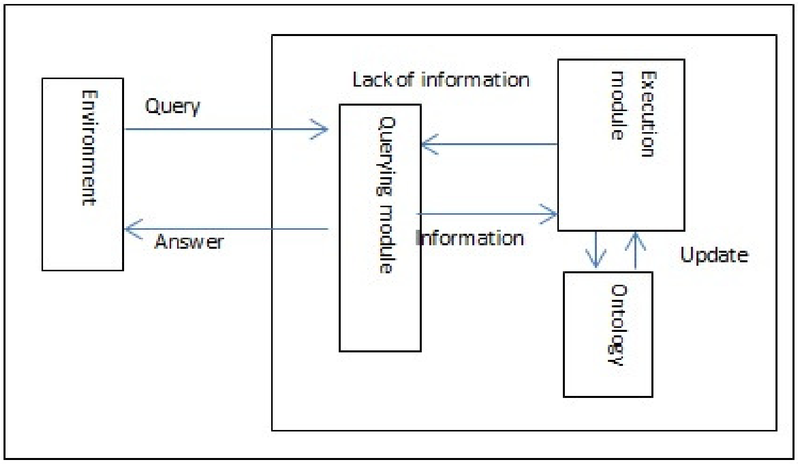

Figure 6. The internal handling of requests to VHs

5.3. Ontology design for Virtual Human

In our architecture, a VH has ontology, in this ontology we describe the basic ontology classes and attributes (as shown in Figure 7) that we have designed for the applications of the VH navigations. Although a VH is also an object in a virtual environment, they have more active and complicated roles to play. For example, a user in Anthropometry Description set attributes as Height, Wight, Age, Gender, Speed and Acuity. A VH may contain some basic attributes such as name, Transform, and status. We also take the Tired and stress for present the influence of these properties in speed and acuity of VH.

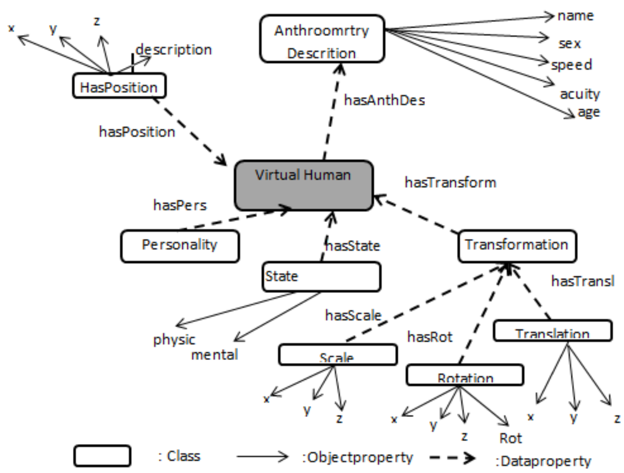

Figure 7. Ontology design for VH

5.4 Implementation and results

We have implemented our model in Unity3D; developed in C#. We built our ontologies using the Protégé and Jena for update. Access to the ontology is obtained by sending SPARQL queries. In this section, we will give two examples of using semantic information in the virtual world to enhance the functions and behaviors of the VH.

We distinguish that the navigation of a VH in virtual urban environment is based on more tasks, among these tasks are collision detection; avoidance of collisions and search of goals. In the two first tasks, we use the two attributes speed and acuity, dynamically changing, because they are in relation with other attributes (tired, stress, age, etc.).

In figures 8, we show the influence of age on speed and acuity. We distinguish three phases: the first phase increases the speed and acuity when the age increases. The second phase is almost stability of speed and acuity between 20 and 40 years. The last phase, after 40, decreases the two parameters.

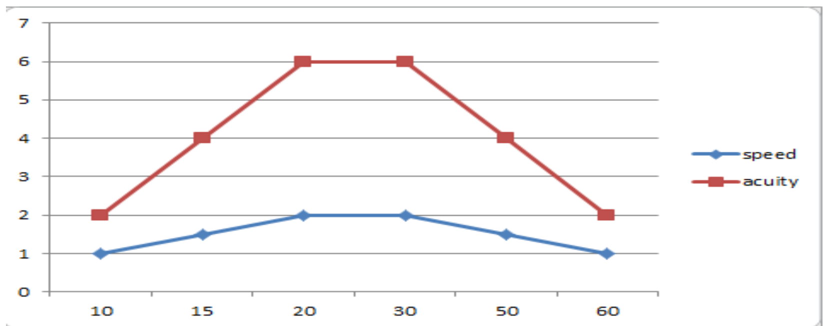

Figure 8. The influence of age factor on speed and acuity

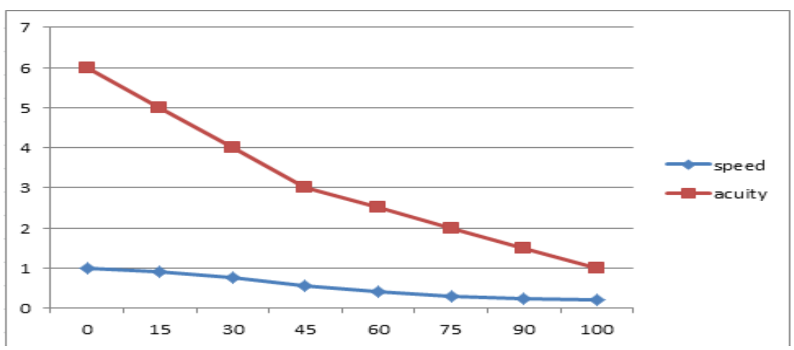

Figure 9. The influence of tiredness factor on speed and acuity

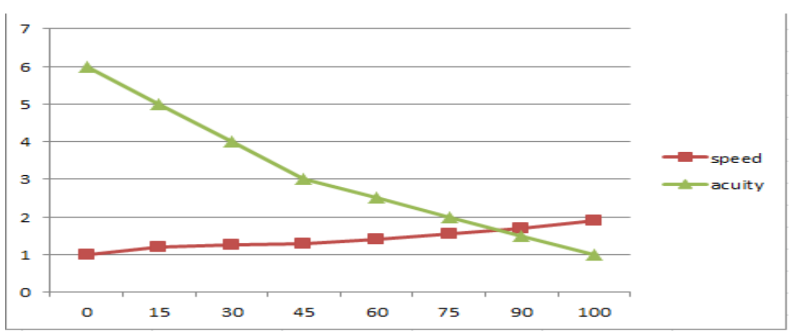

Figure 10. The influence of stress factor on speed and acuity

In figure 9, we add another factor, the tiredness to test the influence of this tiredness attribute on VH's speed and acuity. We show the inverse relationship between tiredness and speed; the speed and acuity decreases with increase of tiredness.

In figure 10, we add another factor, the stress to test the influence of this stress attribute on VH's speed and acuity. We show the inverse relationship between tiredness and acuity; the acuity decreases with the increase of stress, and the speed increases with the increase of stress.

In figure 11, we show a character called Zinab, she is a woman of 30 years old, 50% of stress and 50% of tiredness. With initial value of speed of 1 and acuity of 6, we show the stability of speed and the decrease of acuity (6 to 5.12), this decrease in acuity is the result of the influence of the stress factor. And the almost stability of speed; it is influenced due the two factors tiredness and stress.

Figure 11. The influence of tired and stress factor on speed and acuity

Each VH used the same steps to search the path but with their knowledge, these are found in ontology. In this task, there are three phases, the first phase is called localization; the input parameters of the phase is the position of the VH and the position of their goal. From this information and the positions of the points of the landmarks in the environment, the VH determines their position and the position of their goal by to graduations of environments. These graduations are saved in his ontology and all related information with other graduations such as graduations are neighbors, the distance between neighboring and between sub-paths graduations that you save a form as Figure 5.

The second step, which answers the question what kind of path I follow; (the usual path, the shortest path, the path is more popular, or compact), this choice is linked with several parameters such as physic state of VH, his personality, the overall goal is touristy, go to work or return to home). For example, we consider two VH, with identical physical state, identical positions and identical goal. In the first VH, the character is a tourist, in the second, the character goes to meet a friend. This last difference gives two different paths. The tourist chooses the most popular and security trajectory, unlike the second takes a more compact path

.

All factors are the result of influence several parameters. For example, the stress factor is the result of several elements, among these elements is the nature of the goal (important, necessary, compulsory ...). And all information related with objective, this relationship is direct or indirect; in the following example; we demonstrate the effects of new information arrives on stress factor. In our example two VH1 and VH2, VH2 event received at time = 3, giving an event of the influence of the stress factor, decreases the effect of the constraint value. This increase is the result of the relationship between the event and the goal of VH1. This relationship is defined in the ontology. The reverse with VH1 at time = 4 received another event that increases the value of the stress.

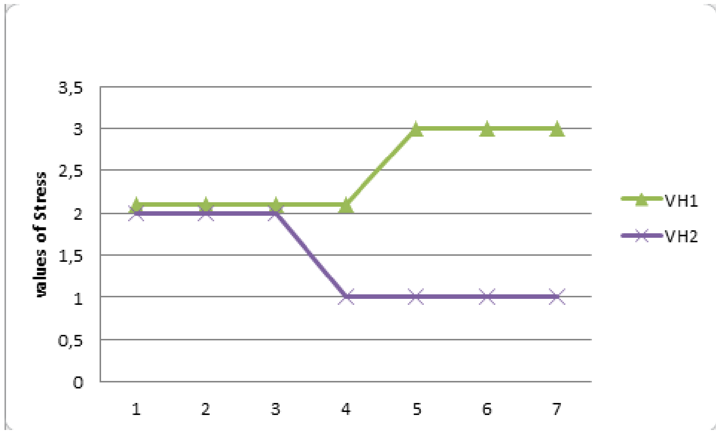

Figure 12. Evolution stress factor with time

6. CONCLUSION AND FUTURE WORKS

Using semantic information's is a key function for enabling richer contents and behaviors in the future development of virtual environment. The SVHsIEVshave presented a semantic-based framework for the virtual environment with Virtual Humans (VHs), our first parts integrated the VH in virtual environment with more semantic information, these information are helping of developing area of research that integrates computer graphics and artificial intelligence solutions. Our second parts to show the influence of adding semantic information (contextual attribute and relationships between their concepts) to virtual Human and using this influence for define and redefine his interaction with environment.

Throughout the paper, we showed the importance of semantics when modelling dynamic virtual environments. Furthermore, the VH extracted from the ontology allows the VHs to reuse their information in different contexts. We will add different animation components owned by different VHs to interact with each other, will integrate more semantic information for tasks and using these information in planning phase, will implementSVHsIEVswith other environment as theatre for example and using motions information's as mean of communication between VHs.

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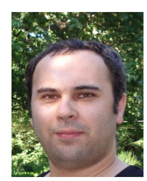

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