AVATAR: Contribution to Human-Computer interaction processes through the adaptation of semi-personalized virtual agents

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Abstract— **In this article a process of animation of 3D models is proposed to transform them into virtual agents or avatars with the possibility of being used in Human-Computer interaction processes. The resulting virtual agents have been adapted as tools that serve as a starting point for the development of real-time interaction algorithms. The characteristics of the generated tools allows to deepen in techniques of machine learning and artificial intelligence, endowing to the virtual agents of movements with natural and real characteristics. It is possible to use them as puppets, capturing the movements of a person and transferring them to the animation; it is also possible to program specific sequences whose interaction processes are completely determined. Finally, the idea of developing algorithms involving artificial intelligence combined with human intelligence to improve interaction processes is proposed.**

Resumen— **En este artículo se propone un proceso de animación de modelos 3D para transformarlos en agentes virtuales o avatars con la posibilidad de ser utilizados en los procesos de interacción Humano-Computadora. Los avatars resultantes se han adaptado como herramientas que sirven como punto de partida para el desarrollo de algoritmos de interacción en tiempo real. Las características de las herramientas generadas permiten profundizar en técnicas de aprendizaje automático e inteligencia artificial, dotando a los agentes virtuales de movimientos con características naturales y reales. Es posible usarlos como títeres, capturar los movimientos de una persona y transferirlos a la animación; también es posible programar secuencias específicas cuyos procesos de interacción están completamente determinados. Finalmente, se propone la idea de desarrollar algoritmos que involucren la inteligencia artificial combinada con la inteligencia humana para mejorar los procesos de interacción.**

I. INTRODUCTION

Recent years, the constant technological advances have markedly changed the way we communicate and interact with the rest of the world. The ease of establishing communication networks with individuals, that are miles away, has generated the sensation of a non-personalized communication. Probably the tendency to establish social relationships in a virtual way will be accentuated even more due to the high rates of technological insertion worldwide. This proposes a challenge in the field of Human-Computer interaction, in order to achieve a more personalized presence within the metaverses in which we engage daily. In this context, the concept of avatars emerges as a digital representation of the presence of users in virtual reality spaces where they can interact with computer generated environments or with other users [1].

In the virtual world, avatars have gained a lot of space and are a widely used resource. The applications that involve avatars are varied and cover many fields. Depending on the situations and contexts the same person could use different avatars in different scenarios [2]. For this reason, the characteristics of avatars vary according to the utility for which they are required. We can mention its use in online video games [3] [4], where avatars can have human characteristics, be fantasy creatures, animals or objects. For social uses and in collaborative work environments that require remote presence [5] - [7], it is important that the avatars show anthropomorphic characteristics with attractive and more elaborate results, since it directly influences the opinion and perception of other users in the virtual environment. For educational and therapeutic purposes as virtual tutors or playmates [8] - [10], more expressiveness is required in order to demonstrate emotions using non-verbal communication; the characteristics of the avatar's face and the naturalness of his movements influence the people who observe him. Although each of the applications analyzed has specific features, there are general characteristics of avatars due to the common purpose they have: allow people to express their own things about themselves, in a virtual environment [1].

Considering the avatar as a representation of the individual who creates it, it is possible to notice features of his personality. Mainly, one can observe an idealization of one's image, the need to stand out and the orientation to follow a trend [11]. We can cover these characteristics in a single concept called personalization, although this concept is implicit in the definition of avatars, it can become a problem when our goal is to use the avatar in interaction processes in real time. Most of the tools available to create avatars are focused solely on obtaining models with detailed characteristics regarding external designs, leaving aside the intrinsic characteristics. These internal characteristics are very important when trying to convert the avatar into a Human-Computer interaction tool, through computerized animation processes.

The present work focuses on presenting a process of adapting a 3D model to be transformed into an avatar that can be programmed by artificial intelligence algorithms and thus

generate interaction in real time or to be used as a virtual puppet moved by a person through of an interface that includes artificial vision. When there are specialized tools to obtain models of ideal external characteristics [2] [6], our contribution is centered on an ordered scheme that allows turning any 3D model into a Human-Computer interface.

In section II, a brief study of works related to the subject is presented. Next, in section III, the process of adapting 3D models to become avatars for Human-Computer interaction is detailed. In section IV, some of the possible applications of the tool generated are shown, concluding in section V with the presentation of conclusions and future work that is planned to be carried out based on the results obtained at present.

II. Related Works

In this section we focus on two specific applications of the use of avatars as Human-Computer interaction agents; the first involves the use of avatars in applications of intelligent environments, and the second involves the generation of interaction and learning tools for children with autism.

In the first application, in intelligent environment, in [12] the implementation of an avatar is presented as an interface for the voice control of an intelligent house, where the most remarkable results are presented in the reduction of resistance to people to talk with the appliances and generally improves the interaction of users with the control system. However, the article mentions the need to improve the characteristics of the avatars in order to make them more attractive to people and equip them with artificial intelligence algorithms in such a way that they can take the initiative in the interaction. Another interesting contribution is shown in [13], where through an avatar that combines semantic analysis and artificial intelligence techniques, tourist information points are presented located in the province of Teruel in Aragón, Spain. The contribution of this work is focused on the algorithms that allow a natural interaction in real time between the users and the avatar, where the avatar answers the questions in a logical way and according to the context. In both [12] and [13], systems use avatars that interact using artificial intelligence algorithms but are not customized in any way.

With respect to the generation of interaction and learning tools for children with autism, in [8] the development of an avatar used as a tutor for children with Autism Spectrum Disorder is presented. The results of the application of this tool show a high degree of acceptance by children to interact with the avatars. However, the presented avatar shows limitations when it generates processes of fluid interaction, since its system does not include voice recognition that allows a real conversation. Another application of avatars in the treatment of autism is presented in [14], where through the use of a serious game interaction is generated with an avatar that tries to improve the communication skills of children. Although children show great acceptance towards the avatar, it is recommended to take into consideration the individuality of each child when designing. In [15] and [16] two applications are shown that, as in the previous case, allow social teaching with the aim of strengthening verbal and non-verbal communication skills through avatars. In these tools there is a more detailed development of the tool with avatars that allow interaction in real time and also have feedback systems to monitor the interaction with children. Both cases demonstrate acceptance by children and the benefit of using artificial intelligence algorithms. However, there is still the problem of customization, all solutions use a specific avatar without considering the specific requirements of each user. Finally, another interesting contribution is presented in [17], where through the use of an avatar an emotional teaching is generated, generating different facial expressions to demonstrate emotions. Considering that the people affected by the Autism Spectrum Disorder do not have a correct development of emotional identification and expression, this tool represents a great contribution.

III. Adaptation Process

In this section we present the process of adapting a 3D model to turn it into an avatar. The contribution of this process lies in being able to use a customized model and turn it into an avatar capable of being programmed with artificial intelligence algorithms or be used as a virtual puppet with the adaptation of an artificial vision system.

Fig. 1 shows the adaptation process of the 3D model until it becomes an avatar with the possibility of being programmed for independent or controlled interaction processes.

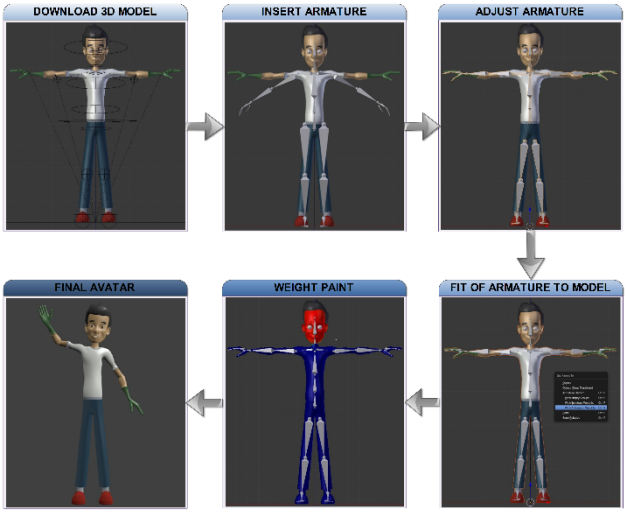

Fig. 1. Process of adapting a 3D model in an avatar. a) 3D Model, b) Insert armature, c) Adjust armature, d) Fit of armature to model, e) Weight paint, f) Final avatar

The process begins with obtaining the 3D model as seen in Fig. 1 – a. In this case it is possible to download an available model or design and implement your own model. The basic characteristics of the model that we select to work are expressiveness, having nice colors, being complete and being compatible with Blender, that means, having ".blend" extension. The reason for the compatibility is that our work was developed in this software because of the facility it presents to integrate with Python, allowing us to develop our algorithms in this programming language. In our case we have obtained a 3D model from a web repository under the Creative Commons License (CC). Next, we must place our 3D model in the center of the scene and add an armor with a series of perfectly defined bones depending on the parts of the body. This process is observed in Fig. 1–b. One of the most delayed processes is shown in Fig. 1–c, where the result of coupling the armor to the body of the 3D model is observed.

This step is vital in the process to obtain an avatar that can be animated with natural and real movements. Then, in Fig. 1 – d, we proceed to pair the armor with the 3D model. It is important that each of the bones of the armor have an identifier that will be used in the painting of the weights. By matching the armor we make sure that by moving a bone, the area of the body affected it will also move. Afterwards it is necessary to apply weights painting that consists in creating modifiers for the armor deformation, which allows us to define objects and groups of vertices causing each bone to move a certain group or area of the body of the 3D model. The painting of weights is based on a color code, where the areas of low influence between the bone and the body of the 3D model take on a blue color, while the areas of greatest influence have a red color; this is observed in Fig. 1 – e. Finally, in Fig. 1 – f, se the avatar is observed as the final result of the animation process. This avatar can be animated from a sequence of frames, Python scripts or artificial vision systems. In this way we have obtained a customized or semi-personalized avatar that can be used in the development of other applications.

IV. Tool Applications

This section shows two applications that have been working within the AVATAR Project [10], to generate tools to improve the interaction processes in children with Autism Spectrum Disorder.

A. Avatar as a Virtual Puppet

The use of the avatar as a virtual puppet was born with the aim of providing therapists working with children with autism, a tool that allows them to interact with their patients, but using a more attractive and accepted means by children.

The tool is composed of a system of artificial vision with neural networks that identify 24 strategic points in the face of the person and moves them to the face of the avatar in such a way that all the movements can be imitated in real time. In this way any facial gesture that the user makes will be automatically replicated by the avatar.

Fig. 2 shows the results of using the avatar as a virtual puppet. The points have been identified from a webcam and moved to the avatar to animate it in real time.

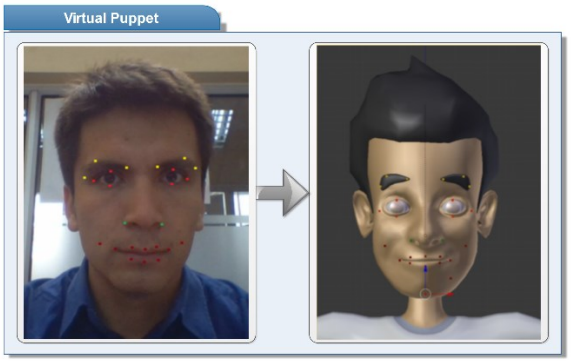

Fig. 2. Avatar as a Virtual Puppet

The advantage of this tool for interaction with children with autism is that the avatar is only used as a facade or a mask. Who is really generating the interaction process is the therapist and this is beneficial since he is the expert on the subject and who knows the child with his strengths and weaknesses. The therapist knows for sure what processes should be followed and what words are the most appropriate, for this reason we have cataloged this tool as a technological support in the teaching of social skills in children with autism.

B. Avatar animation

The avatar resulting from the adaptation process was developed in Blender and this allows it to be animated from Blender itself with previously recorded sequences or from lines of code from Python.

Fig. 3 shows two examples of ways to animate the avatar. In the first case we use Scripts developed in Python to move each bone the avatar to a specific location according to the need. To have variables to refer to, modifiers have been placed in strategic places that allow us to move the whole model. In the second case, using an artificial vision system, specific points have been identified that are related to the modifiers placed in the avatar, in such a way that the model imitates all the movements made by the user, like a virtual puppet, but with the difference that these movements are recorded in frames that will later be used for an offline animation.

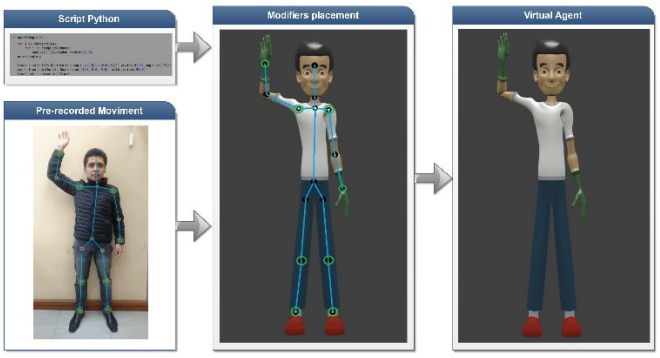

Fig. 3. Avatar animation

The integration with Python allows to extend the development of avatars by providing them with artificial intelligence, seeking interaction processes that do not require an operator to control movements in real time. The advantage of this tool is the possibility of expanding it to any application that requires the use of a Human-Computer interaction interface.

V. Conclusion and Future Works

The proposed process allows adapting any 3D model as long as it has anthropomorphic characteristics. In case of animals or objects, the same process can be followed but they could only be animated from lines of code since their use as virtual puppets would be complicated.

The steps specified in the process can be interpreted generally regardless of the software used for the adaptation. However, it is essential that the entire process be completed to develop avatars that later serve to perform animations in Human-Computer interaction processes.

The systems proposed in the applications of the tool should be considered basic ideas to test the results. Depending on the needs, artificial vision systems and artificial intelligence algorithms can be greatly improved.

The use of avatars as means of Human-Computer interaction is a subject that requires further investigation and

there are still many contributions that can be made in this regard, especially in the use of this tool as a support to improve social and communication skills in children with autism. They also allow improving the experience in virtual media of people who begin to insert themselves in this metaverse, such as children and seniors.

From the tool obtained, it is intended to develop interaction processes for therapies of children with autism with semi-personalized avatar that combine artificial intelligence algorithms with human intelligence. Similarly, from the artificial vision system, the goal is to recognize facial expressions that allow us to identify emotions, this with the aim of having a feedback on the impact generated in avatar in children and also as an emotional coach.

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