A New Realistic 3D Body Representation in Virtual Environments for the Treatment of Disturbed Body Image in Eating Disorders

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ABSTRACT

In the last few years virtual reality has become an efficient tool for the treatment of eating disorders. One of the main problems in virtual environments finding a realistic body model that can be modified according to a patient’s criterion. Several 2D morphing techniques have been used for changing the body of the subject. In this article we present a new method for accurate 3D deformation of a human body model that uses a reduced number of parameters. The original goal was to reform different parts of a 3D human body through geometry. The chosen algorithm is based on a series of boxes around the geometry parts to be changed. Any change in the position of a box vertex is converted to geometry deformation and eventually to oportune displacement of the neighbour boxes. As discontinuities have to be avoided, all boxes have a field of deformation decreasing in intensity as distance increases. To achieve a high grade of realism, a set of user photographs taken from several angles are positioned at the head of the mannequin. Depending on the position of the user, one of the photographs is selected and oriented toward the user. The method is under clinical testing in a virtual reality tool for the treatment of eating disorders. With this method, the model can express several aspects of the way the patients perceive their bodies. Initial clinical results have been very promising.

INTRODUCTION

Eating disorders (EDs) are clinical syndromes characterized by an altered eating behavior that is a consequence of dramatic efforts that patients make to control their weight and shape. However, body image disturbance is what essentially distinguishes ED from other psychological conditions that occasionally involve eating abnormalities and loss of weight.1

Body image (BI) is a term coined by Schilder2 that refers to the picture of our own body that is formed in our minds. That is, the way in which our bodies appear to ourselves. Partici-

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larly, two aspects of BI can be distinguished: accuracy of body size estimation and feelings toward the body.\textsuperscript{3} In ED, both aspects are disturbed because overestimation is frequent and body dissatisfaction is a constant.

The severity, course and relapses of ED suggest that we do not yet have effective treatments that contemplate the complexity of these disorders. Current treatments of ED have the stabilization of eating habits as a first aim in order to obtain a regulation in weight and bodily functions. The treatment of BI remains in second place, although this element is considered to be central in ED psychopathology. In fact, dissatisfaction and distortion of BI are not only a part of the diagnostic criteria in ED, but their first manifestation.

The review of the studies on treatment for BI in ED carried out by Cash and Grant\textsuperscript{4} revealed that we cannot treat ED without correcting the BI. It is necessary to treat BI disturbances specifically within the general treatment of ED. However, it seems unlikely that BI improves without a direct intervention on it.

There are few studies focused on the treatment of BI disturbances in ED, and most of them have used traditional methods such as movable calipers, silhouette tests, distorting mirrors, or videos, relaxation, imagery techniques, and cognitive discussion. There is one pioneer experience in the treatment of BI called VR: THE VIRTUAL BODY PROJECT (VEBIM) from G. Riva and colleagues.\textsuperscript{5} This program addressed the development and use of virtual environments (VEs) for the study and treatment of BI disturbances in a non-clinical population. Later, in an article published at the end of 1998, Riva’s team applied VE to one anorexic patient and, in spite of not being a controlled study, their results are very encouraging.

Given the novelty of this topic, there are still many aspects to study. For instance, controlled researches with clinical samples are needed. Besides, it should be taken into account not only the global silhouette, but also specific body areas. It is also necessary to introduce other discrepancy indexes to contemplate subjective, desired, actual, and healthy BI. The effectiveness of one specific component in the assessment and treatment of BI in ED by means of VR has been proved by our previous works.\textsuperscript{6}

The use of schematic figures of different body sizes has been the most widely used measure for the assessment of subjective components of body image disturbance.\textsuperscript{3,7}

Several implementations of the procedure have been realized in the presentation of body schemas on a computer screen and in a computer-based test that generates frontal view silhouettes and side view silhouettes of a human. The use of BI presentation on a VR system has been implemented using 2D morphing techniques.\textsuperscript{5} More recent works propose the use of VRML and Quicktime format on the Internet\textsuperscript{8} for a web-based body image assessment tool. This proposal of this web-based product does not include the ability for real-time modification of specific body areas.

In our recent works about the use of VR in eating disorders\textsuperscript{6} we have implemented a human body deformation algorithm that permits real 3D deformation of specific body areas. This approach presented several limitations such as discontinuities in body areas and discrete modification of the deformation parameters.

In this work we present a new method for accurate 3D deformation of a human body model using a reduced number of parameters. The chosen algorithm is based on a series of boxes around the parts to be deformed. Any change on the position of a box vertex is converted to geometry deformation and eventually to oportune displacement of the neighbour boxes. As discontinuities have to be avoided, all boxes have a field of deformation that decreases in intensity as distance increases. To achieve a high grade of realism, a set of user photographs taken from several angles are positioned at the head of the mannequin. Depending on the position of the user, one of the photographs is selected and oriented toward the user.

**BRIEF SOFTWARE DESCRIPTION**

The aim of the software introduced in this article is to provide a platform for the visualization of 3D VEs and to simplify and accelerate their development. At the present time we are using this software for modeling VEs re-
lated to phobia treatment (e.g., anorexia, claustrophobia).

The special case of VEs related to anorexia treatment has led us to the development of a real-time 3D geometry deformation algorithm that allows the user to deform different human parts. As with every 3D software, a fast computer is necessary to run the environment. The minimum requirements to run this software are a Pentium II, a 3D graphics accelerator, and a mouse. In addition, the program is able to work with any kind of VR helmet (monoscopic and stereoscopic) and any kind of tracker (Polhemus, Intertrax, etc.). Visual C++ 6.0 (Microsoft) was used to develop the software. We used World Toolkit 8.0 (Sense8) as 3D graphics library.

VIRTUAL REALITY ENVIRONMENTS

There are many graphic formats and software packages that are designed to generate 3D objects and even complete VR environments. However, more than just geometry is needed to model a VR environment. A series of properties (such as sounds to be played, objects to move, and interfaces to manipulate) are also necessary. For this purpose there is a very extended language that is capable of modeling all these additional properties: VRML (Virtual Reality Modeling Language). This legatee is compatible with every Internet browser.

The reason for the development of our own software is the need to incorporate some characteristics to our VR environments that VRML 2.0 does not support:

- To deform 3D geometries in real time within the VR environments.
- To use a data base that allows the used to personalize some of the VE parameters.
- To type text or numbers inside the VE using VR keyboards.
- To save data obtained while the user navigates the VE.
- To use trackers to move objects or even the point of view.
- To allow stereographic visualization.

BASIC VR ENVIRONMENT OPERATION

Apart from the user movement itself, the kind of action that can happen inside a VE are:

- An object moves following a fixed trajectory.
- An object suffers a deformation following a defined pattern.
- A sound starts to play and increases or decreases its intensity.
- A light is turned on and increases or decreases its intensity.

A timer controls each one of these functions. Timers contain values ranging from 0% to 100%, and they are like the wires moving all the things happening inside the VE. A TIMER can be fired using different commands (play, stop, swing, go(10), jump(10), goto(50), etc.). These commands are triggered by an event.

Events are activated by actions of the user or by timers reaching some predefined level. An event can be activated, for example, because the user has stepped on an object or has made a click on it. Although there are plenty of functions to make almost anything happen inside the VE, all of them work under the same predetermined philosophy.

DEFORMATION ALGORITHM, PROBLEMS SOLVED, AND USED MECHANISMS

Although the reason for the development of this algorithm has been the human-like geometry deformation, it has been designed to deform any kind of geometry; therefore, specific language to define the geometry behavior under deformations has been created.

Bearing in mind that the deformations are not going to be made by a technician but by a common user, the interface needs to be fast and easy to use. This interface consists of several sliders, each of them modifying a deformation parameter (arm thickness, legs length, breast volume, etc.).

The definition of these sliders and the deformation parameter that they control are part of the same file that defines the VE; that is, the
user interface is not constrained by the application but can be modeled at will for each different VE.

DEFORMATION MECHANISM

The deformation algorithm starts from a 3D object where the different parts to be deformed will be defined. Therefore, it is necessary to use a 3D file format capable of enumerating the different geometry parts. Almost all file formats can do it (.3DS, .RIB, .OBJ, etc.).

A box is placed around each one of these parts that will control the deformation. Modifying the position of the box vertices will modify the geometry in the same way that a piece of gelatin would affect a body inside it (Fig. 1).

This mechanism would be enough if there were only a box to deform all the geometry at once. When several boxes are used to deform different parts of the geometry, the deformation of one of these boxes may imply the displacement of others. For example, when the forearm grows, the hand box and the hand itself must be displaced to leave room for the forearm.

Another aspect to take into account is the discontinuities that can appear between two geometry parts deformed in a different way. To avoid this effect, the deformation intensity of a box decreases to zero with distance. A box deformation range can be extended beyond the box limits so that any vertex can be affected by deformations corresponding to several different boxes at the same time.

Model deformation description file

This file describes one-by-one all the boxes related to the deformation and specifies the following data for each box:

FIG. 1. The control box used for body deformation.

FIG. 2. Deformed body images showing the problem in solving for discontinuities between different parts of the body.
Integration of the deformation algorithm in the VE

The deformation algorithm allows the user to modify any vertex of a box and get the corresponding deformation. Although this method is very powerful, it must be simplified to allow its use by common users inside the VE.

The way to simplify it consists of the creation of a series of different deformation parameters that apply to the eight vertices of a box at once. These parameters allow one to stretch boxes, to make them grow, or even to twist them. Inside the VR environment, a set of sliders is displayed corresponding to these parameters so that the user can specify the strength of the deformation that displaces each of them (Fig. 2).

Relationship between deformation parameters and real size of the result

Deformation parameters only define the deformation intensities but not the measures of the deformed geometry. As we need to work with the real sizes of the deformed geometry,

- Initial box position.
- Different geometry parts affected.
- Field deformation radius and fade parameter.
it is necessary to have an estimation of deformed geometry sizes starting from the deformation parameters. Given the complexity of the deformation model, to obtain a mathematics formula relating deformation parameters and obtained measures is not easy.

The only way to face the problem is to make a conversion table relating applied deformation parameters and obtained measures. Once this table has been obtained, it can be integrated inside the VE so that the conversion can be applied and displayed or saved to the database file.

**INTEGRATION OF THE USER’S FACE WITH THE HUMAN BODY GEOMETRY**

In order to increase the user’s identification with the human body geometry a method has been developed to apply the user’s face to the human body like a geometry head.

This method exchanges the virtual head with a picture of the user’s face that has been mapped onto the plane. This plane will be rotate to keep it oriented toward the user at all times. In order to get the face pointing to the same place while the user moves around, several pictures taken from different angles will be displayed as the plane rotates toward the user. In this way, it is possible to see the human body geometry from one side. To obtain the user pictures from different angles we have two stages: Taking Pictures and ManagingPictures.

**Taking pictures**

In this phase we will obtain the pictures using a conventional camera, digital camera, or video camera. We have used a digital camera to make management of the next phase in the computer easier. In order to obtain the pictures from any angle, the camera will be fixed and the user will turn gradually around a fixed axis (Fig. 3). The more pictures we have, the better the transition between them will be. To increase the number of pictures, it will be necessary to decrease the turn angle between two different user pictures.

**Managing pictures**

The only interesting part of these pictures is the face. In order to remove the clutter, a uniform background must be used. In addition, the user should wear clothes similar in color to the background. In this way it will be easier to select, clip, and separate the user’s face from the rest of the picture. This phase can be carried out with any image editor (Fig. 4). These new pictures will be mapped to the plane and will replace the human body geometry.

**CONCLUSIONS**

We have presented an effective algorithm for accurate 3D selective deformation of the human body in VEs. The algorithm permits deformation of specific areas with a user-friendly, slider-based interface. The method is under clinical testing in a VR tool for the treatment of eating disorders. With this method, the model can express several aspects of the way the patients perceive their bodies. Initial clinical results have been very promising.

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**REFERENCES**


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