CyberPsychology & Behavior
Volume 3, Number 3, 2000
Mary Ann Liebert, Inc.

Evolution of the Virtual Human: From Term to Potential Application in Psychiatry

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ABSTRACT

Virtual reality applications in mental health have traditionally involved the creation of virtual environments that acted as provocative agents either for the purposes of the identification of disorders or their treatment. There is infrequent mention of the utilization of "virtual humans" despite the obvious significance of humans within our lives. More broadly, the term *Virtual Human* is frequently used in a number of contexts extending from its use as a term, modifying anything that needs to be modernized, to the application of 3D animated figures that exist in virtual realities. These applications refer to quite different phenomena in very different contexts leading to a high level of ambiguity and uncertainty when referring to virtual humans. In the following, the various applications of the term *virtual human* will be reviewed and critiqued through its most frequent applications, in various fields. They will be reviewed in an ascending manner from the least human of application to the most. Finally, a definition will be offered reflecting the potential complexity of the term as it reflects the expression of our most human factors, and how these are needed in the development of a model of a virtual human in psychiatry.

INTRODUCTION

Virtual reality research within psychiatry/mental health has predominantly dealt with the creation of realistic environments that are used for the purposes of the diagnosis and treatment of specific disorders. These have included phobias, such as fear of flying, claustrophobia, acrophobia, and arachnophobia, that evoke the "sense" of fear, much as the real situation might.[1] The presence of "virtual humans" within these virtual environments has been and is for all practical purposes nonexistent. When used, they predominantly serve the role of props, rather than humans.

The purpose of this article is to define the particulars of a virtual human that would be needed in order to be of value within psychiatry. Before doing so, we will review the application of the term *virtual human* from its application as a modifier, through current application in medicine and various industries and disciplines, to finally offering a definition that provides a sense of the factors that would be necessary in order for virtual humans to have potential use in psychiatry.

LEVELS OF EVOLUTION (IS THERE A BETTER WORD?)

There appears to be ambiguity surrounding the concept of a virtual human and the use of the term. The breadth of its application makes

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it difficult when discussing the issue to be certain of what is referred to, especially when those attempting to discuss the topic are from different fields or disciplines (i.e., engineering vs. psychiatry). Six levels can be used to track the use of the term, from its most abstract through various applications in different fields. These six levels involve the use of *virtual human* as a term, to the corpus of humans, application in biomechanics, animation and avatars, and, lastly, our proposed definition.

Level 1—Term

This appears to reflect the current fad to add the word "virtual" to anything to promote its being contemporary/modern. You can find the term *virtual human*" referring to websites of state capitals (*http://vhsp.dphhs.state.mt.us/*), consulting firms dealing with virtual organizations (*http://www.ntwkfirm.com/*), job recruitment firms (*http://www.vjf.com/HRdept.hrhome.html*), and genetic libraries (*http://www.ornl.gov/TechResources/Human_Genome/genetics.html*). Even in medicine you can find publications that have succumbed to the need to modernize themselves by the use of the term as in the case of patient recruitment for research protocols.[2] Over 9,700,000 hits resulted from entering the term *virtual human* into an Alta Vista search engine. It is difficult to imagine that a majority or even a fraction would deal with virtual humans. Nevertheless, it demonstrates the popularity of the term at this time.

Assessment. These terms offer little to either the conceptual framework or our potential understanding of the concept of the virtual human. Needless to say, these types of applications will continue and possibly increase as the term and its applications increase.

Level 2—Corpus

A frequent use of the term is to computerize 3D representations of the human body or parts of the human body. There are, in fact, numerous examples of this. The National Library of Medicine (NLM) has had the "Visible Human Project" for a number of years. For those who might not be acquainted with this project, the Visible Human Project® is an outgrowth of the NLM's 1986 Long-Range Plan. It is the creation of complete, anatomically detailed, three-dimensional representations of normal male and female human bodies (*http://www.nlm.nih.gov/research/visible/visible_human.html*). Their use of the term *visible human* is appropriate. Yet, several of the projects and products that have spun off from this project refer to themselves as virtual humans. These 3D re-creations of humans use the term to refer to the either slices of humans or the representation of organ systems in part or whole.

The 3D corpus or "part object" representation model appears to be the model most widely used in medicine and surgery today when researchers refer to virtual humans. In these applications, organs are recreated and interaction is offered as an educational alternative, as in the case of a surgical or examination procedure that would be difficult to emulate in a real patient, such as gynecological, urological, or prostate exams.[3–5] These are often made more realistic by the use and augmentation of haptic feedback, allowing the sense of touch to be further made real.[6]

Assessment. These applications represent the lowest form of human representation (i.e., the body). Actually, in most cases it truly represents digital anatomy, sometimes gross anatomy, others microanatomy, others organ system anatomy.[7] Yet, it is not a virtual human.

Level 3—Biomechanics

"Biomechanics uses laws of physics and engineering concepts to describe motion undergone by the various body segments and the forces acting on these body parts during normal daily activities."[8] The field of biomechanics concerns a broad range of questions that pertain to the corpus of man/woman as it exists in real space and time. These questions concern the anthropometry of the body, measurements of physical properties of body segments, that are needed in the development and testing of the biomechanical questions: strength assessment, the characterization of the ability to lift and move real objects in a real world; and, Ergonomics, the assessment of the biomechanical applications in different settings. Increas-

ingly, virtual humans or digital human simulations are being used in the areas of automotive and other related areas of design. The growing use of these technologies reflects economic and scientific considerations. These applications often save considerable funds by narrowing the errors that would be incurred if digital models were not used.

Assessment. These applications represent a significant step in the evolution of the digital human. Not only is there motion, but also quantitative means to both characterize and represent motion. Is this closer to being a virtual human? At a base level, yes. The body now moves, and there are suggestions that such motion and an understanding of that motion is immensely important, especially in our understanding of several psychiatric disorders.[9] Yet, it still does not have the most minimal features required to call it a virtual human.

Level 4—Animation

In the case of animated figures, we begin to see the principle elements of the virtual human. There is movement of the body and face that has the potential to convey human emotion as well as motion. In fact, recent digital graphic animations have grown extremely lifelike in their ability to portray complex affects and emotions. Dramatic examples have been shown recently in a number of popular and successful films. In large part this is due to advances in motion capture and the ability to represent complex and lifelike, animated figures. (see *http://www.vicon.com/animation/default.htm* and http://www.pixar.com/aboutpixar/corporate.html)

Assessment. Animated figures have the potential to represent a broad and inclusive range of factors that will be associated with virtual humans. Advances in the technical display of digital data make this crucial in the ultimate creation of a virtual human.

Level 5—Simulated humans

Human simulation modeling has been underway among engineers for a number of years. These endeavors have primarily focused on attempts to create autonomous humans that act and behave like humans. These have been and are significant contributions to the ultimate creation of the virtual human. Badler presents a list of major features that are necessary for simulated humans.[10] A partial review of these are: must have a structure like the human skeletal structure in order that movement will be based on biomechanical considerations; should move and respond like a human; should be sized to human proportions, and preferably based on anthropomorphic population data; should have a human-like appearance; and it must be able to exist, work, act and react within a 3D virtual environment. From these considerations, Badler and his group developed a simulated human they named Jack. Although meeting some of the features described, Jack still falls short of other significant features that are required for a virtual human.

The laboratories of Nadia and Daniel Thalmann have made significant contributions, as well, in the area of simulated humans. Among their many contributions have been their concentration on creating realistic 3D human shapes, facial deformations, muscle-based motion, and a high degree of concern about realism of the human body.[11–15] In fact, they have one of the few articles that deals with the potential applications of virtual humans in psychiatry.[16] Here they state that "Virtual humans. . . . have behavior, perception, memory and some reasoning." They are also quite aware of the innate difficulties attempting to produce behaviors. Theirs may be the most sophisticated perspective of simulated humans.

Assessment. Simulated humans bring together the best of the two previous areas, animated figures that are constrained by physical laws as defined by biomechanics that ultimately will move as humans and potentially act like humans. This is truly exciting. Yet, this still falls short of being a virtual human.

Level 6—Virtual human

The model of a virtual human that would be useful in psychiatry demands greater details in a number of areas not dealt with yet. Much as those interested in simulating humans have

made significant strides in a number of areas that deal with the depiction of the human and its animation, a number of relevant areas have not been included that ultimately define humanness, at least from the perspective of a psychiatrist who is interested in alterations that often occur in these areas and are classified as abnormal.

Before listing these areas it is important to establish the framework of these dimensions. To facilitate the presentation, two modes on expression are used (i.e., display and interaction). It is important to do so. The former being an extension of the levels covered, the latter being a potential goal, but a goal that is far beyond our capability within the near future.

Display. The features listed by Badler are a good foundation from which to start.[10] Taking these features as our starting point, we will expand them to reflect added detail necessary to further humanize them for the psychiatric virtual human.

- A virtual human must have a structure like the human skeletal structure, in order that movement will be based on biomechanical considerations. No addition needed. This is fundamental.
- A virtual human should move and respond like a human. Move and respond like a human? What does that mean? For our purposes, this would include two major venues of movement, the face and the body. This would reflect not just rudimentary movement and response as might be seen when humans stand and sit, but the complex of emotional, mood, and affective features that convey meaning.

  Most attention in regard to this issue has focused on the face as the primary communication organ of human emotional expression, as it should. Accordingly, several systems have been developed to define and capture the complexity of facial emotional expression most notably that beginning with Ekman.[16,17] Most reports concern themselves with the physical considerations of emulating facial expressions. Few, if any, deal with the types of alterations that are seen in various psychopathological conditions such as depression or schizophrenia. Although depression is a mood disorder and schizophrenia is a thought disorder, both have distinct facial expression complexes associated with them. Blunting in affect in the former and a flattening in the later. To fully realize the face as an expressive screen, the physical capability for display will be necessary. The creation of a system for its documentation will have to follow.

  This is true of the body as well. The body is a highly communicative instrument, just as is the face. Although the detail necessary to simulate emotions of the face requires a high degree of study of surface textures and the underlying structure to move the skin, the expression of emotions by the body requires subtlety in rhythm and coordination of different segments. One component, psychomotor functioning, has been developed to some degree and has been shown to correlate to treatment outcome and response to various therapeutic interventions.[9]

  We question the ability to create a working taxonomy of human emotions based on any theoretical model. Whereas models may capture the physical factors that require consideration (although that is apparently quite difficult), models that may recreate the expression of emotions seem unlikely at this time. What is first needed are standards for capturing, cataloging, and communicating about these affective states that include representatives of different patient populations.
- A virtual human should be sized to human proportions and preferably based on anthropomorphic population data. It is important that the population data include that of patients as well; those with eating disorders (anorexic and obese), depression, dwarfism, gigantism, and other representative populations. Also, data that represents all age groups should be included from the toddler, to the child, to the adolescent, to the adult, to the elderly,

to the extreme elderly. To do otherwise risks the misrepresentation of each of these groups.

- A virtual human should have a human-like appearance; and it must be able to exist, work, act, and react within a 3D virtual environment. This is deceptively simple to state and forms the core of psychiatric human factors. Most often these characteristics refer to the physical parameters of motion of virtual humans within virtual environments. Increasingly, this is referring to social interactions and occasionally complex psychosocial events among virtual humans or, as they are referred to, "avatars," that are occupying virtual environments. As noted, the creation of virtual humans that will allow emotional attachment to occur is the highest level of human relatedness.[18]

Interaction. Certainly, it would be wonderful to imagine that a virtual human not only existed, but it actually interacted with you. There are those that indicate that such a thing can occur now, as suggested in the previous section. This is a critical issue. What is interaction? A lack of inappropriate interaction? Not occupying the same space at the same time? A more sophisticated graphic user interface (GUI)? What is required is the ability for a program to capture and assess a viewer and their emotional status, then translate this, taking into consideration cultural, educational, psychosocial, cognitive, emotional, and developmental aspects, and give an appropriate response that would potentially include speech, facial, and body emotional expression. Not merely words! Too often the model that is presented portrays a cognitive-based response that requires a great deal of work on the part of the viewer, more so than is realistic, especially among patients with ongoing psychiatric conditions. And, most difficult is that this has to occur within a time frame that has no delay from the instant of expression of the viewer to the instant of the response. The speed and subtlety of human communication is phenomenal.

SUMMARY

The changes in the last 20 years in computer science, engineering, animation, and psychiatry have allowed tremendous advances toward the evolution of a virtual human that would be of value. As this review demonstrates, to date, the term *virtual human* has meant many things to many specialists depending on their area of specialty. In fact, as needed for application in psychiatry, there has been little to no work done in this area and the definition remains open. As both our critique and recommendations suggest, it is imperative that factors critical in the characterization of psychopathology be included in order that the resulting virtual human have potential applicability for the identification and representation of psychiatric illnesses. The ascent of the virtual human must not exclude these illnesses and misrepresent the true complexity of humankind.

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