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AUTHOR Jensen, Jens F.
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ABSTRACT

This paper addresses some of the central questions currently related to 3-Dimensional Inhabited Virtual Worlds (3D-IVWs), their virtual interactions, and communication, drawing from the theory and methodology of sociology, interaction analysis, interpersonal communication, semiotics, cultural studies, and media studies. First, 3D-IVWs--seen as a new and unique form of multimedia--are introduced and the social construction of the 3D-IVW technology is briefly discussed. Second, a selection of the basic concepts and identifiable entities in 3D-IVWs is defined and commented upon; these include representation, virtual worlds, objects, actors, bots or autonomous agents, avatars, and human actors. Third, some of the strange digital creatures that currently inhabit 3D-IVWs in the form of cyber-hybrids are outlined, including Alife/digital Biota, characters using genetic algorithms, game characters, mask characters, virtual humans, and avatar/agents. Fourth, modes of interactivity and virtual interactions between human actors, designers-in-avatars, user-in-avatars, bots, and objects in the new Virtual Worlds are briefly presented and typologized. Finally, the changing Internet and the virtual futures of 3D-IVWs are reflected upon. (Contains 21 references.) (MES)

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3D Inhabited Virtual Worlds
Interactivity and interaction between avatars, autonomous agents, and users

Jens F. Jensen,
InterMedia-Aalborg & Department of Communication, Aalborg University, Denmark
jensf@hum.auc.dk

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Abstract: This paper addresses some of the central questions currently related to 3-dimensional Inhabited Virtual Worlds (3D-IVWs), their virtual interactions and communication. First, 3D-IVWs – seen as a new and unique form of multimedia – are introduced and the social construction of the 3D-IVW technology is briefly discussed. Second, a selection of the basic concepts and identifiable entities in 3D-IVWs is defined and commented upon. Third, some of the strange digital creatures, which currently inhabit 3D-IVWs in the form of cyber-hybrids, are outlined. Fourth, modes of interactivity and (virtual) interactions between users, avatars, bots, etc. in the new Virtual Worlds are briefly presented and typologized. Finally, the changing Internet and the virtual futures of 3D-IVWs are reflected on.

Three-Dimensional Inhabited Virtual Worlds (3D-IVWs) are currently becoming a reality. They first appeared in computer games and stand-alone multimedia applications, but are increasingly appearing in networked-based systems, e.g. the Internet, intranets, and the World Wide Web. Considered as new media, they can be characterized by the following traits:

- 3D-IVWs are generated from software, drawn as interactive computer graphics in 3 space dimensions (plus a 4th dimension in time), i.e. they exist only in cyberspace: in the digital domain of the computers and the computer networks.
- 3D-IVWs are represented on a two dimensional screen, i.e., 3D graphics in this context are understood as a way of representing 3D data in 2D so that it can be viewed on a computer monitor or a TV screen.
- 3D-IVWs usually contain computer-generated representations of their users – *inter alia*, so that other users can see them – in the form of so-called 'avatars'. In other words, this software is inhabited – inhabited by its users, designers and developers.
- These avatars can be moved around as movable computer graphics on the 3D scene and the movement is controlled interactively by the user.
- An avatar has a viewpoint that is fixed relative to the avatar.
- Consequently, as the user moves the avatar around, its viewpoint also moves. Because the background is animated, as well as the objects in the scene, the user can see the whole scene move relative to the figure. In short, the user can interactively control the viewpoint relative to the 3D space or scene.

One might call these environments '3D Inhabited Virtual Worlds'. However, they have other names as well, such as '3D Cyberspace', 'distributed virtual reality', 'Shared Spaces' [Bradley et al. 96], '3D Internet' [Wilcox 98], '3D Web', '3D chat', 'inhabited digital spaces' [Damer 95], 'Avatar Cyberspace' [Damer et al. 98b], 'avatar virtual worlds' [Damer 98a] etc. These 3D worlds are currently enjoying rapid growth. Fully implemented, existing virtual worlds include: Active Worlds, WorldsAway, Biota's Nerve Garden, Blaxxun, Traveler, The Palace, Oz, Worlds Chat etc. – and even more 3D-IVWs are under construction at the moment. Some of these 3D-IVWs are (re)constructions of large 3 dimensional 'cities' with buildings, streets etc., others are marketplaces, stages, TV programs, space stations, still others are strange places that have no similarity, whatsoever, with anything in the non-virtual world [cf. Jensen 98, 99a]. The majority of these worlds are accessible from the WWW.

Thus, while the Internet has [cf. Jensen 96], until now, primarily been a set of sites, which could be visited, a pile of two-dimensional documents that could be surfed, it is slowly turning into a three dimensional space with a virtual volume – thereby, for the first time, giving the term 'space' in 'cyberspace' a literal meaning – i.e., an entirely digital environment that can be lived in and populated and in which the users can move around, communicate, and interact. In these Virtual Worlds, it is possible to meet and have (mediated) social interactions and communication with other users on the network in real time. Via these simulated interactions, a new type of virtual social practice and virtual social structure or culture is being created. In other words, the Internet is changing from a dead and flat library, to a social and communicative space: a web of human relationships – a community. And the users are transforming themselves as well from 'surfers' to 'settlers' [cf. Bradley et al. 96].

It is these 3D Inhabited Virtual Worlds and their virtual interactions and communication that are the primary objects of this study.

Hypotheses and Theory

The paper is based on the following hypotheses (all in accordance with semiotic theory and media studies):

- That interactive multimedia systems and, more specifically, 3D-IVWs, like other media, develop a set of signs, codes and conventions, i.e., they develop a formal language specific to that medium just as theater has developed a dramaturgy, film a film language, television a television language, etc.
- That through theoretical work and empirical analysis it is possible to identify and describe the formal language and functionalities of 3D-IVWs.

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- And that knowledge of older media can be helpful in the process of identifying and analyzing the new language and new aesthetics of 3D-IVWs. Presenting themselves as 3D-IVWs with artifacts and actors (avatars, autonomous agents etc.) it is the assumption of the paper that this new medium can be informed by theater and film theory in particular [cf. Jensen 99b].

On the other hand, although interactive multimedia in general, and 3D-IVWs in particular, are informed by existing representational conventions from film and theater (such as the relationship between stage and actors in theater, or the function and representation of point-of-view and 3D-perspective in film), they also break with the traditional functional and aesthetic conventions of these art forms. The most obvious examples are the user's ability to control movement and point-of-view in the Virtual World, the users mutual interaction represented by avatars, or users and avatars interaction with autonomous agents. In these aspects there are clearly no immediate parallels in the worlds of film and theater or other traditional (mass) media. Consequently, we have to supplement the first three hypotheses with the following (all in accordance with sociology and interaction analysis):

- That the signs, codes and conventions of the 3D-IVWs create a framework for and influence the interactivity (user/system) and the virtual interaction (user/user, user/environment, etc.) within the 3D-IVWs.
- That through theoretical work and empirical analysis it is possible to identify and describe the interactivity and (virtual) interaction.
- And that knowledge of interaction in non-virtual settings can be helpful in analyzing interactivity and virtual interaction within 3D-IVWs.

In regard to theory and methodology, the paper draws from sociology, interaction analysis, interpersonal communication, semiotics, cultural studies, and media studies.

The Background and the Social Construction of the Technology

3D-IVWs have a complicated background and consist of the convergence of a number of very different media and areas. Sue Ki Wilcox points out no less than five fields, which are said to have inspired 3D graphics. The first fields are: computing, the Internet, science fiction and theater. Fields which are said to have contributed the following characteristics: "Computing supplies the power to make desktop virtual reality happen; the Internet provides the space and freedom in which to develop; science fiction introduces the idea of cyberspace; and theater teaches the concepts of actors and role-playing" [Wilcox 98]. A bit earlier she also involves the social aspect as an important element. "Currently, the social aspect of the World Wide Web is just beginning to emerge from the newsgroups and e-mail stage... and the more lifelike it becomes, the more people want to be involved. Avatars promise to be even more engaging..." [Wilcox 98].

Bruce Damer identifies – slightly more modestly – Virtual Worlds as the children of two humble parent technologies: 'text-based virtual community' and 'computer games' [Damer 98a, Damer et al. 98a]. The aforementioned contributed in the form of communities built up around text systems and simple text messaging such as conference systems like the WELL, MUDs, MOOs, UseNET, IRC, chat rooms in on-line services and on the WWW, as well as some early text-based virtual communities expanded with graphic interfaces, where users are represented by avatars (such as Habitat, mid1980s), which is said to have contributed the sense of community built up around common interests. Computer games primarily contributed realistic 3D graphics and effects, especially "the power of existing 3D rendering engines developed for gaming applications such as Doom and Quake" [Damer et al. 1998a], which demonstrated that 3D graphics and virtual worlds could be fast and effective using minimal computer hardware like a regular personal computer. In other contexts, Damer includes a third predecessor: "The whole infrastructure of Internet Protocol and the World Wide Web" [Damer 96].

In this context, 3D-IVWs will be considered as consisting of four basic elements or building blocks: Virtual Worlds, 3D-graphics, Artificial Life, and Virtual Communities:

- The term 'world' refers to the all-encompassing context for the totality of human activities and experiences and the term 'Virtual World' refers to "computer programs that implement digital worlds with their own 'physical' and 'biological' laws... VW is concerned with the simulation of worlds and the synthesis of digital universes" [cf. Heudin 98, cf. below].
- '3D-graphics' refers to a way of representing three-dimensional data or 3D graphical spaces in two dimensions so that it can be viewed on a screen or a computer monitor.
- 'ALife' or 'artificial life' refers to digital simulations of living systems, which incorporate metaphors from biology, i.e., biologically inspired, synthetic organisms.
- And 'Virtual Communities' refers to human social communities that form in and around digital virtual worlds, often in the form of a group of people communicating with each other through computer networks.

These four elements are brought together and integrated within 3D-IVWs, which are generally constituted around computer simulations of whole worlds or digital universes with artificial life forms and social communities. The following will expand upon this attempt to define and discuss some of the key concepts in relation to 3D-IVWs.

Virtual Worlds – basic concepts

Representation. The concept of representation refers to all aspects of the appearance of virtual worlds including the appearance of avatars, bots, objects and other elements of the virtual world. Representation is related to the concept of sign. A sign is "something which stands for something else to somebody" [cf. Peirce 31-58]. In other words, a sign is a manifest, perceivable entity (whether it is a thing, an element of behavior, a form of appearance, etc.) which is received by the sense organs of an interpretative, mental apparatus and is interpreted as referring to something else (an item, phenomenon, feeling, event in the real or virtual world, etc.). The interpretative, mental apparatus establishes a relationship or a 'link' between the entity, which represents and

that, which is represented. The actual sign is then finally constituted as a relationship between these three entities: the representation, the entity that is represented, and the mental apparatus that interprets the first by linking it to the second [cf. Jensen 93]. In this way, signs can be seen as quite a distinctive class of phenomena, since they have meanings: they stand for or refer to other objects or events. The concepts of sign and representation naturally play a key role in this context of what are, in a certain sense, purely symbolic worlds; worlds which are exclusively constituted by representations, by signs. There are several types of representations or identifiable entities in 3D-IVWs, which will be considered and commented upon in the following.

Virtual World. The concept 'Virtual World' covers the total virtual environment, i.e., the whole 3-dimensional scene or 3D-space with its set of various objects and with all its special characteristics. The terms 'Virtual World', 'scene' and 'space' are here more or less synonymous. This 'virtual 3D space' has a number of general characteristics:

- It is coordinate-based, i.e., every position in the space can be identified by a set of 3 coordinates.
- It is geometrically finite, i.e., it makes up a 'bounded', 'delimited' world.
- It is continuously navigable, i.e., the user can move seamlessly through the world without transition of any kind. The space itself, however, can be made up of several linked files, as long as they appear to the user to be seamless.
- It is defined by a set of 'physical', 'biological', 'social', etc. rules. These rules have an affinity to physics-based laws like laws of nature, i.e. they define how one may move, interact, communicate, etc. in the space, except that in this case it is the designer, the creator of the world, who has established the rules.
- Each world represents a specific vision of what a virtual world can be and which experiences it can offer its inhabitants and users. Virtual worlds thus have their own ontology since all conceivable forms of existence seem to be possible within them, or more precisely: the nature of being is here only limited by the current technology and imagination.

In these virtual worlds or 3D-spaces there may be various types of interiors or elements, which can roughly be divided into objects and actors, differentiated by whether or not their primary function is to carry out an action.

Objects. An object can be defined as a limited, relatively autonomous part of the world. Examples of objects are trees, billboards, windows, doors, posters, etc. including props, i.e., the accessories or attributes of an avatar such as: a hat, a bike, a cane, etc. Objects typically consist of two basic components: 1) a model that determines what the object looks like, its size, etc. and 2) some characteristics that determine where it is placed, which actions it can carry out, etc. Objects can also be assigned actions, therefore, drawing a precise border between objects and actors, especially 'bots' (cf. below) can, in some cases, be difficult.

Actors. 3D-IVWs are not, however, solely composed of a space and objects; this space is also inhabited. Actors are entities that inhabit the virtual worlds and whose primary function is to carry out actions. They have two main forms, which will be described – for the moment– as relatively sharply differentiable polar opposites. This is done based on questions such as: who is controlling the actors? 'who is doing the driving'? On the one hand there are actors that react independently of the user, but which are controlled by software or AI, the so-called 'autonomous agents' or 'bots' (short for robots). On the other hand, there are agents, which directly represent and are controlled by users, the so-called 'avatars'.

Bots or autonomous agents. A bot or an autonomous agent is a bit of software, which is not directly or interactively controlled by a human user, but runs on its own, controlled either by a program or by some form of built in intelligence. In real life (RL), robots are often physically manifested as machines. On the Internet or the Web bots are often invisible or are only represented in a visible mode in the interface during input or output situations. The special thing about bots in 3D-IVWs is that they (most often) are represented as visible, that is, they have a sensory representation in the virtual world. In many cases, bots are similar to other users (i.e. avatars) and appear as a kind of automated or virtual avatar. Similarly, they may have some degree of built in AI, independence, self-motivation, personality, etc. Often bots are given specific assignments. In 3D-IVWs, they are usually used to inhabit sparsely populated spaces and thereby to provide the user or the avatar with company (automated conversational agents), to show the way or to guide tours, to answer questions, to entertain by asking riddles or offer clues to puzzles, to provide information on present users, the present scene, etc.

Avatars. At the pole directly opposite the bot or the autonomous agent is the avatar. Even though avatar technology is relatively new, the term 'avatar' is paradoxically quite old. It comes from Sanskrit and means something like 'the embodiment of a spirit in the flesh'. In its modern, digital, virtual incarnation an 'avatar' is defined in many different ways. Wilcox defines an avatar as "an electronic representation of a person in cyberspace", "[a] virtual expression of yourself, wearing your wardrobe of virtual clothes" or "an electronic version of the human form designed to let you enter cyberspace" [Wilcox 98]. And Damer defines it as "a digital body you can see", "a virtual personality in a 3-dimensional world" [Damer 98a] or "animated 3D models of users" [Damer et al. 98b]. An avatar is, in other words, a representation of the human actor or user in the virtual universe which can be manipulated and controlled by the user in real time, even if the representation is, at the same time, bound by the limitation and laws of the virtual world in question. In this particular sense, avatars are – as Wilcox also formulates it – "extensions of ourselves". So if Marshall McLuhan's old catch-phrase "media and technology are extensions of ourselves" has ever been relevant it must be now, in relation to 3D-IVWs, where the slogan has been given a most concrete incarnation in avatar technology.

The avatar serves several functions. It is necessary in order for the user to be visible to others and thereby to have a 'presence' in and interact with others in the virtual world. It is necessary for the user to have a position in the form of a set of 3 coordinates and thereby a viewpoint and a sense of 'presence' in the 3-dimensional world. And it is generally necessary in order for the user to enter, move around in and experience the virtual space as well as to become a member of the virtual community. In 3D-IVWs then, avatars are used (virtually) to meet new people, have new experiences, visit new places, learn, play, etc.

An avatar has two important aspects: appearance and functionality. One important thing about an avatar is naturally its appearance, what it looks like, because it is synonymous with the way the user presents himself in cyberspace. Another important thing is functionality, since an avatar can have many different functions. It can be equipped with animation, behavior patterns (where 'behavior' here refers to a sequence of animations), it can show emotion via facial expression, carry objects, belongings

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or props or be able to prove identity in connection with financial transactions and, if desired, also give gifts and have pets. As far as special behavior patterns go, the components of animations and behavior – like avatars themselves – are often selected from galleries and then personalized. Specific animations and behaviors can then be released or triggered by different factors such as: user behavior (a click of the mouse and the like), a time factor, collision detection, proximity to other objects or avatars, the appearance of an object, a touch sensor, etc. Although by definition avatars are under the control of the user, the degree of control can vary in practice quite a bit. In certain cases the user can completely control all of the avatar's movements and communicative actions down to the smallest detail. In other cases, the user can only determine actions, behavior patterns, gestures, moods, manipulation of objects, etc. on a more general level. This behavior is then carried out by a pre-programmed automatic system. In yet other cases, parts of the avatar's behavior can be controlled by the user, while other parts are controlled by a system or a more or less intelligent program.

Within the avatar category there are both *user-in-avatar*, which is a representation of the human user in the 3D Virtual World and *designer-in-avatar*, which is a representation of the designer, developer or creator of the 3D world (sometimes called 'God'). 3D Virtual Worlds are then the only type of software, where one can actually meet and speak with the author of the application – within the application itself.

Human Actor. Finally, there is the human actor or user of the 3D system or world, who actually controls the avatar and/or the viewpoint of the world.

Cyber-Hybrids

Although there is then, in principle, a differentiation, in terms of definition, between bots and avatars, both concepts cover a relatively wide spectrum of very different types of phenomena with differing degrees of control. There also seems to be a tendency toward the appearance of more and more hybrids – we could call them 'cyber-hybrids' – combining avatars and bots. Furthermore, these hybrid forms are in many ways the most interesting and most promising in the virtual worlds at the moment. Rather than considering avatars and bots as polar opposites, it may therefore be more productive to consider them as the outer points along a continuum, between which can be found all sorts of combinations or hybrids. The following will briefly outline a typology of these strange new hybrid creatures, which currently populate this continuum in the virtual worlds [cf. Wilcox 98].

Alife/Digital Biota. Along the continuum between autonomous agents and avatars, Alife (Artificial Life) or digital biota is closely related to the former. Alife and digital biota are artificial or 'alien' life forms, i.e., biologically inspired, synthetic organisms in the form of quasi-autonomous software. Thus, Alife is the virtual world's counterpart to the real world's plants and primitive animal life forms. Jean-Claude Heudin describes the vision of ALife in Virtual Worlds in the following way: "Imagine a virtual world with digital creatures that looks like real life, sounds like real life, and even feel like real life ... This virtual world could be familiar, reproducing some parts of our reality, or unfamiliar, with strange 'physical' laws and artificial life forms" [Heudin 98]. Alife as a general area of research deals with artificial living systems and the general principles of the living state. *Alife online* describes the field and its background context in the following way: "Artificial Life – literally 'life made by Man rather than by Nature'. Artificial Life ('AL' or 'Alife') is the name given to a new discipline that studies 'natural' life by attempting to recreate biological phenomena from scratch within computers and other 'artificial media'... By extending the horizons of empirical research in biology beyond the territory currently circumscribed by life-as-we-know-it, the study of Artificial Life gives us access to the domain of life-as-it-could-be... " [Alife online 98]. With regard to the definition of 'digital biota' and their boundary surfaces to creatures such as bots, agents, AI, etc., Biota.org writes: "Digital Biota are a class of self-replicating autonomous software objects which includes computer viruses, artificial life programs, some cellular automata and some genetic algorithms. Once released they live or die by their own decisions as they interact with their environment. They are usually capable of reproduction – if they also have the ability to mutate and be affected by the force of natural selection to some degree then they can evolve. Biota shade out into the region of semi-autonomous objects which includes artificial intelligence, software agents and bots. These generally have only limited control of their own functionality, operate according to outside goals, and do not reproduce... The increase in avatar inhabited virtual environments on the Internet is one potential breeding ground for such digital biota" [Wilcox 99]. As can be seen here, there is not only a continuum between agents and avatars, the continuum stretches across the whole field of actors and objects: from avatars, to biota and Alife, to agents, AI, bots and (semiautonomous) objects.

The best know examples of Alife and digital Biota are probably: Tom Ray's Tierra, a digital ecosystem that produces synthetic organisms based on a computer metaphor for organic life; Karl Sim's 3D virtual creatures; and Biota's Nerve Garden, a biologically-inspired multi-user collaborative 3D virtual garden hosted on the Internet – i.e., a public terrarium in cyberspace – where visitors can plant a seed and watch it grow.

Characters using genetic algorithms. A bit closer to humans on the continuum between the artificial and the human are characters, which use genetic algorithms. In other words, these characters have a built-in ability to learn from the interactions they participate in, to learn from experience, and thus continuously change their characteristics and functionality. They often have a relatively independent existence in the given virtual world where they can live out their own life. Among the best known examples are perhaps CyberLife's popular game *Creatures*, where the user is supposed to raise the creatures from the egg stage, and the Japanese Tomogatchi.

Game Characters. In the middle of the continuum, but perhaps closest to the autonomous agents, are Game Characters. They are, as the name indicates, often related to games and can be regular autonomous agents with an independent existence and functionality in the universe of the game. At any given time, however, a user can take over control of a game character – for example

as a tool for getting into a game, in order to learn the rules of a game or under particularly exciting and critical passages in the action – in which case the Game Character's status is temporarily transformed into an avatar.

Mask Characters. Closer to avatars are Mask Characters. Mask Characters are avatars which – aside from the usual physical form and functionality of an avatar – also have a character that can control, guide or inspire the user, who is using it. F. ex., the character can tell the user, which high-level directions make sense in a given situation, and then given the user's choice, improvise a course of behavior [cf. Hayes-Roth et al. 97]. In other words, it is a 'smart' avatar with an independent mental life, a consciousness or a will. As such, Mask Characters are used in ecommerce, learning, and entertainment as well as to teach users to play certain roles in the virtual environment. Examples are Hayes-Roth's and Extempo's 'Imp Characters' which are guided by their roles, their personalities, their moods, as well as real-time directions form the user or other software.

Virtual Humans. Virtual Humans are 'naturalistic' copies or stand-ins for humans, where the main principle is to create the most convincing, realistic or perfect simulation of the human form and function (while normal avatars and agents may look like just about anything). Emphasis can be placed either on form (appearance) or functionality or both at once. Virtual humans are used primarily in simulations and in the testing of products and environments, but also in games and movies. Along the continuum between autonomous agents and avatars they, in reality, cover the whole stretch. In the bot-incarnation they may appear as pure dummies which make up simple pre-programmed, animated figures in a 3D model or they may be autonomous agents, which are controlled to some degree by artificial intelligence. In the avatar-incarnation they may be directly and interactively controlled by a human actor, e.g. in the form of 'ergonomic avatars' in connection with virtual trials of products, processes or environments by way of simulations in cases where Real Life trials may be inexpedient. The same virtual human can in fact change between being a bot and an avatar. The most prominent examples in this category are perhaps the computer-generated – but very realistic – Japanese pop star and personality Kyoko Date, made up of 40,000 polygons, and the work done on realistic avatars and virtual humans at MIRALab, Geneva.

Avatar/Agent. Furthermore, there are more and more examples of actors in virtual worlds being able to instantly switch, so to speak, from the avatar-mode to the bot-mode. One example is 3D Planets 3D-assistant, a 3D representation that can both function as an agent controlled by a program and be used as an avatar, depending on the situation encountered and the programs being run. The assistant functions in principle as an interface between the program that is actually running and the user, sometimes controlled by the program and sometimes controlled by the user. In this way, the 3D-assistant perhaps gives us a taste of what a so-called 'assistant interface' might look like in the future. Or one might imagine a user who participates in a communicative community represented by an avatar, but whose avatar lives on – even *after* the user has left the world and the computer – switched to some kind of 'automatic pilot', continuing to interact and communicate with other agents and avatars (perhaps also running in an automatic mode). In this mode the automatic avatar might either follow pre-determined parameters or pre-programmed behaviors, follow some form of artificial intelligence, or even simulate or mimic what it has learned from the particular user.

Interactivity, Interaction & Virtual Interaction

An area of particular interest in connection with 3D-IVWs obviously involves the new possibilities for interaction and interactivity that arise, partly seen in relation to RL-interaction, and partly in relation to interaction and interactivity [cf. Jensen 97] in more conventional media and computer applications.

Interaction. In sociology the word 'interaction' refers to the actions of two or more individuals which can be observed to be mutually interdependent, i.e., interaction can be said to occur when each of at least two participants is aware of the presence of the another and each has reason to believe the other is similarly aware, in this way establishing a state of reciprocal awareness. In other words, interaction is the relationship between two or more individuals who, in a given situation, mutually adapt their behavior and actions to each other. Important aspects here are that limited, clear-cut social systems and specific situations are involved, where the partners in the interaction are located in the same time and space – i.e., are in close physical proximity – and 'symbolic interaction' is also involved, that is, a mutual exchange and negotiation regarding meaning takes place between partners who find themselves in the same social context. A phenomenon which communication and media studies would call communication, or more precisely – since the partners in the interaction are situated in the same context – face-to-face communication or interpersonal communication.

Virtual interaction. In relation to this general definition, *virtual interaction* takes on a number of special traits. Once again interaction is connected to a concrete situation and a limited and clear-cut (though here virtual) social system and once again we can speak of symbolic interaction between the participating partners. However, the special thing about interaction in virtual worlds is that the interacting partners are situated in the same time (in terms of real time systems), but not within the same space. On the contrary, the interacting partners – understood as the human actors – are physically distributed without any immediate physical proximity, i.e., the interaction itself is mediated and only the interactors representations share this physical proximity. The concept of 'virtual interaction' refers, in this context, to the relationship between virtual representatives of human actors situated in the same time and virtual space – i.e., in a form of virtual proximity – within a limited (virtual) social system; virtual representatives who mutually adapt their behavior and actions to each other and which mutually exchange and negotiate meaning and create a 'symbolic interaction'. Consequently, there is no face-to-face communication. On the contrary, there is a new form of face-to-interface or interface-to-interface communication. Only the avatars practice (virtual) face-to-face communication. One of the unique traits of virtual worlds as a medium is then, that they allow for the possibility of practicing face-to-face communication with all that that implies with regard to facial expression, gestures, body language, etc. – in a mediated and virtual form. Thus, in Inhabited Virtual Worlds, interpersonal communication and the knowledge that this discipline represents becomes, for the first time, relevant to the computer world. Moreover, since there is a sliding scale from representations of human users – ava-

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tars – to bots, animated objects, etc., the concept of virtual interaction also covers the mutual relationship between avatars, bots, objects and other elements within the virtual world.

There are several different types of virtual interactions and simulated communication of interest in 3D-IVWs. If, to begin with, for the sake of clarity, we disregard the entire population of cyber-hybrids and only examine avatars and autonomous agents as relatively pure forms, these virtual interactions can be represented by the following matrix [cf. Fig. 1] where the redundant combinations have been eliminated.

	Actor (human)	Designer-in-Avatar	User-in-Avatar	Bot	Object	Virtual World
Actor (human)	Ac / Ac					
Designer-in-Avatar	D-in-A / Ac	D-in-A/D-in-A				
User-in-Avatar	U-in-A / Ac	U-in-A/D-in-A	U-in-A/U-in-A			
Bot	Bot / Ac	Bot / D-in-A	Bot / U-in-A	Bot / Bot		
Object	Ob / Ac	Ob / D-in-A	Ob / U-in-A	Ob / Bot	Ob / Ob	
Virtual World	VW / Ac	VW / D-in-A	VW / U-in-A	VW / Bot	VW / Ob	VW / VW

Figure 1: Matrix of types of interactions in 3D-IVWs

Due to limited space, only some of these types of virtual interactions will be described and discussed below.

Human Actor/Avatar. Interaction between a human actor and an avatar consists of the user controlling the avatar and communicating and interacting through the avatar. This depends, among other things, on how the avatar is controlled: via keyboard, mouse, joystick or some form of motion capture. Thus, this area corresponds to a certain degree, to the traditional area of Human Computer Interaction, or what is called interactivity [cf. Jensen 97] in conventional computer systems. The interaction is, however, mutual since the user must also adapt to the avatar's specific movements (e.g. its degrees of freedom) and abilities, its repertoire of expressions, as well as its built-in limitations. It is, for example, quite important whether the given avatar can express itself in written language, only in spoken language, or only through body language and facial expressions. The relationship between human actors and avatars also touches on the pivotal question of identity. A question, which in virtual worlds, more than being a philosophical or existential issue is primarily a question of relationships between an avatar and a person in RL. The question of identity concerns e.g. whether a person in RL can have several alternative virtual identities, the question of techniques for validating identity, visual appearance as a key to identity, etc. Identity in virtual worlds, then, concerns how it can be verified, stored, communicated, transmitted, etc.

Human actor/Object. Controlling an avatar is one thing, manipulating an object in a virtual world is quite another. How does one f. ex. throw a ball or catch something? This form of interaction deals with how one interacts with a virtual object-world via the computer's traditional input-output devices, but it also deals with how users implement objects in real time.

User-in-Avatar/User-in-avatar. Mutual interaction between avatars is perhaps the most interesting part of interaction forms in Virtual Worlds. It deals with how avatars communicate or exchange information between each other – through written text, voice, gestures, facial expressions, etc. – and how they exchange objects including HTML documents, business cards, props or other 3D objects. However, it also deals with how changes in the position of the avatars, movements and communication are tracked and how these changes are communicated to the rest of the surrounding world. Likewise, it deals with how avatars document their identity in relation to one another, f. ex. in connection with financial transactions.

User-in-Avatar/World. Interaction between a user-in-avatar and world primarily concerns the physical, biological and social 'rules' that are established for the world in question and the possibilities and limitations they set for the ways in which the avatar can navigate, maneuver through space, communicate, interact, etc. within that world. It also, however, concerns the 'rights', i.e., the range of permitted actions, that the avatar have within that world: the right to chat on certain channels, the right to enter but not to change the world, the right to make changes in the world and to what extent. For example: is the avatar allowed to move objects? leave graffiti tags on the walls? carry out vandalism? and will these changes endure when the avatar leaves the world? But avatar vs. world interaction also concerns which types of avatars the given world permits. Is it possible, f. ex., for the user to bring along his own tailor-made avatar designed independently and therefore new to the world? how complex is this avatar allowed to be in terms of polygons, considering the amount of calculation time that is needed for its representation? alternatively, are only avatars designed especially for the world in question permitted or is there a specific avatar file format? It also concerns how avatars arrive in the world (is there a pre-determined arrival spot?) and which objects can be brought into the world (does the world accept avatar props such as hats, bikes, dogs, etc. or is it necessary to leave them outside the world?). This type of interaction is not just about what avatars can do in relation to the world, but also about what the surroundings can do in relation to the avatar, e.g. what does the world look like from the avatar's position? does the world address – e.g. speak directly to – the user-in-avatar (or human actor)?

User-in-avatar/Bot. Interaction between user-in-avatar and bots concerns what bots are programmed to do and whether there are characteristics of avatar behavior that trigger agent actions and vice versa: collision detection, proximity, visibility, touch, etc. It also concerns whether agents are equipped with some form of artificial intelligence, originality, or self-motivation. Bots are often used in 3D-IVWs to carry out standard functions such as greeting avatars to the new world, giving guided tours or simulating interaction and communication with real avatars when no others are present.

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User-in-avatar/Object. Similarly, interaction between user-in-avatar and objects typically consists of avatars being affected by the object (f.ex. stopped by it) or in some way being able to handle it (pick it up, carry it, move it). Or conversely, that an object reacts to the proximity of an avatar (becomes visible, rotates, blinks, makes a sound, etc.). Also in this case various types of triggers for action such as collision detection, closeness, visibility, touch etc. play an important role.

Virtual World/Bot. The relationship between Virtual Worlds and bots concerns things like which bots the given world allows, and which rights they are given from the world creator. This type of interaction may deal with protecting the world from being changed or destroyed by invading bots. Examples: can a virtual dog dig a hole in a lawn? can virtual weeds in the form of biota spread throughout a garden? can virtual termites chew holes in the furniture?

Virtual World/Object. The relationship between Virtual World and objects deals with which types of objects the virtual world accepts and which actions can be connected to those objects. It also concerns whether or not objects are persistent. This last instance can allow a user to place an object in a virtual world, to give a virtual gift, etc., which remains in the world even after the user/avatar has left it.

Virtual World/Virtual World. Finally, interaction or relationships between Virtual Worlds concerns whether or not it is possible to jump from one virtual world to another, as well as *how* these jumps can be carried out. In other words, it concerns the technical specifications for the various network-connected worlds. From the most general perspective it therefore also deals with whether development is moving toward universal cyberspace, where virtual worlds are compatible and interconnected, or whether there will be a multitude of incompatible, isolated islands of virtual worlds. The World-to-World relationship can also concern more specific problems regarding world's relationships to each other. What happens f.ex. if an object is thrown over the border of a world? Could it turn up in a nearby world, which may run on another server? Could it cause damage in the new world when it lands? And could it be retrieved from that world beyond?

The Virtual Futures of 3D-IVWs

3D-IVWs are not just being met with pure positivity and great expectations. There are also researchers who criticize the whole idea of 3D interfaces. "2D is better than 3D" was, for example the headline on Jakob Nielsen's Alertbox about a year ago "...because people are not frogs", he explained [Nielsen 98]. And he continued: "If we *had* been frogs with eyes sitting on the sides of the head, the story might have been different, but humans have their *eyes smack in the front of their face*, looking straight out". In arguing that 2D is more natural and intuitive than 3D, Nielsen digs up one of the world's oldest arguments – the evolutionary or perceptual aspect: "Evolution optimized *homo sapiens* for wandering the savannah – moving around a plane – and not swinging through the trees ... 2D navigation (on the ground) vs. 3D navigation (in the air)". A strange argument in itself, especially when Nielsen continues: "I do maintain that we are more capable of moving around a flat surface and that we spend most of our time doing just that". Strange, because moving around the surface of the earth is not moving in 2D since we do not find ourselves *in* the plane or surface of the earth, but *on* it. Contrary to Nielsen, it could be claimed that the fact that our eyes are placed in the front of our heads and that we are equipped with stereoscopic vision means that we have the ability to estimate distance and to see in depth, i.e. to see in 3 dimensions. Even 2-dimensional realities such as paintings, photography, film, etc. have developed a whole series of techniques to construct or fake a 3D effect [cf. Jensen 99], and correspondingly human perception has a built-in ability, as well as a tendency, to read 3-dimensionality into such 2D-representations. 3 dimensionality, depth, and perspective are as such extremely important for everyday perception and ordinary orientation. And, at this point, there is no reason to believe that the computer as a medium will not take advantage of this perceptional bias as well.

On the other hand, there is a long *de facto* list of important critical notes about the use of 3D on computers, some of which Nielsen correctly points out. Notes, which all primarily refer to today's state-of-the-art computer technology: devices such as the screen and the mouse, and current interaction techniques such as scroll, drag, drop etc., are all intended and designed for 2D interaction, not interaction in 3D. Navigation in a 3D space is often so confusing and difficult that users get lost. The 3D aspect means, among other things, that the user must also think about the 'behind' factor, i.e. what is behind him, are distant objects hidden by closer objects, smaller objects hidden by larger ones etc.? Besides, since the user must exert extra energy and attention in order to control and navigate the 3D view there is often a tendency to produce 'navigational overhead'. Poor screen resolution makes distant objects unrecognizable and text placed in the background illegible, and so on.

Some of these problems will, in time, be solved, some of them will not. So, many of the critical notes will still be pertinent within the foreseeable future. Consequently, there is no reason to believe, as it has been prophesied, that the 3D interface built around the metaphor of a space will, during the next few years thoroughly replace the current 2D interface based on the classic windows and icons desktop metaphors. 3D Virtual Worlds will most likely establish themselves as a medium or a type of interface among other media and interfaces. Certain applications and domains will be suitable for 3D and implemented as 3D Worlds, other applications and domains will not be suitable for 3D and thus be implemented, f. ex., as some sort of 2D media.

In many ways, Virtual Worlds are still a medium in search of an application. However, in the foreseeable future, the most important and dominant applications of 3D-Virtual Worlds will probably be a new galaxy of entertainment spaces offering action, (multi-player) games, adventures and exotic experiences; inhabited TV where viewers transmute into users and participants – in quiz shows, games and issue forums; virtual spaces for communication and interaction from family rooms to international political discussions; collaborative, community building environments; collaborative workspaces (GroupWare); shopping and transaction spaces; virtual class-rooms where students can learn together and from each other (at a distance); virtual meetings and events (virtual conferences, cyber-tradeshows, virtual exhibitions etc.); visualization spaces for physical objects that need to be understood in their solid forms (architectural sketches, design, molecular form etc.) and the like. And, just as likely, cyber-hybrids, combining avatars and agents will be used as: advanced visible message machines always available for access in a vir-

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tual world; stand-in communicators, taking some of the information load off the user; multidimensional tools to collect data, negotiate, and act as guides in virtual environments, etc.

Conclusion

The most interesting aspects of any given new medium are always its unique characteristics, the characteristics that differentiate it from all the other known media. To summarize, the unique and essential qualities of 3D-IVWs in relation to existing media are primarily.

- The medium makes it possible to move your personal representation interactively and thereby to (interactively) control your represented viewpoint in the 3D Virtual World.
- The medium makes it possible to interact and communicate with other users via representation and hereby also to interact and communicate visually and bodily with sign systems such as (virtual) body language, non-verbal signs, facial expressions, etc. For the first time in the history of the computer, the whole range of interpersonal communication, face-to-face communication, non-verbal communication, etc. is therefore relevant and of interest to computer science.
- The media both makes it possible to communicate in a (very flexible) context and to personalize communication and interaction.
- And the encounter with the computer is transformed from an experience of a two-dimensional interface, which can be clicked on, to the experience of a space in which the user feels a presence and a community with other people; and correspondingly, that the encounter with the Internet tends to change from an experience of a web of linked 2D-documents, to an experience of a galaxy of interconnected 3-dimensional Virtual Worlds. A true cyber-space where – as Pavel Curtis once put it – "people are the killer app".

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tars – to bots, animated objects, etc., the concept of virtual interaction also covers the mutual relationship between avatars, bots, objects and other elements within the virtual world.

There are several different types of virtual interactions and simulated communication of interest in 3D-IVWs. If, to begin with, for the sake of clarity, we disregard the entire population of cyber-hybrids and only examine avatars and autonomous agents as relatively pure forms, these virtual interactions can be represented by the following matrix [cf. Fig. 1] where the redundant combinations have been eliminated.

	Actor (human)	Designer-in-Avatar	User-in-Avatar	Bot	Object	Virtual World
Actor (human)	Ac / Ac					
Designer-in-Avatar	D-in-A / Ac	D-in-A/D-in-A				
User-in-Avatar	U-in-A / Ac	U-in-A/D-in-A	U-in-A/U-in-A			
Bot	Bot / Ac	Bot / D-in-A	Bot / U-in-A	Bot / Bot		
Object	Ob / Ac	Ob / D-in-A	Ob / U-in-A	Ob / Bot	Ob / Ob	
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Figure 1: Matrix of types of interactions in 3D-IVWs

Due to limited space, only some of these types of virtual interactions will be described and discussed below.

Human Actor/Avatar. Interaction between a human actor and an avatar consists of the user controlling the avatar and communicating and interacting through the avatar. This depends, among other things, on how the avatar is controlled: via keyboard, mouse, joystick or some form of motion capture. Thus, this area corresponds to a certain degree, to the traditional area of Human Computer Interaction, or what is called interactivity [cf. Jensen 97] in conventional computer systems. The interaction is, however, mutual since the user must also adapt to the avatar's specific movements (e.g. its degrees of freedom) and abilities, its repertoire of expressions, as well as its built-in limitations. It is, for example, quite important whether the given avatar can express itself in written language, only in spoken language, or only through body language and facial expressions. The relationship between human actors and avatars also touches on the pivotal question of identity. A question, which in virtual worlds, more than being a philosophical or existential issue is primarily a question of relationships between an avatar and a person in RL. The question of identity concerns e.g. whether a person in RL can have several alternative virtual identities, the question of techniques for validating identity, visual appearance as a key to identity, etc. Identity in virtual worlds, then, concerns how it can be verified, stored, communicated, transmitted, etc.

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