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BIOGRAPHY

Dr. Thomas P. Caudell {{**photo 1**}} is an Associate Professor of Electrical and Computer Engineering at the University of New Mexico, and a member of the newley formed University of New Mexico Interdisciplinary Computational Systems (ICS) Group. His current research is in virtual reality and artificial neural networks. He is studying the use of virtual reality technology for engineering, manufacturing, and construction applications in industry, and as an environment for conducting empirical studies on neurobiologically-based autonomous attentive perception systems and mobile robots.

Prior to moving to New Mexico he was Senior Principal Scientist and Principal Investigator of the Boeing Computer Services' Adaptive Neural Systems Research and Development project, which has developed and deployed several very large multiuser neural networks applications within the Boeing Company. He was also involved in the initial efforts to import virtual reality technology into The Boeing Company. Previously, he held the position of Senior Staff Physicist at the Hughes Research Laboratories in Malibu, where he lead their neural networks project and started their first virtual reality project. Dr. Caudell has been professionally active in the field of virtual reality and neural networks since 1986 and has over 75 publications in these areas. He received his Ph.D. in Physics from the University of Arizona in 1980.

VIRTUAL REALITY/ CYBERSPACE: CHALLENGES TO COMMUNICATION STUDIES[5]

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ABSTRACT

This paper describes the most dramatic development within the new generation of computer-based media currently emerging, that of virtual reality/cyberspace. This discussion presents a number of challenges to the field of communication studies: to deal with the technosphere; to articulate the continuous discontinuity in communication technology; to avoid the threat of the ultimate second reality, and to benefit from the opportunity of the ultimate writing/drawing space.

Virtual Reality/Cyberspace

Carl Sagan classifies tools as extragenetic (that is, outside the genetic code but inside the body) or extrasomatic (that is, outside the body). Media use tools for the storage and for the transmission of information. Those two distinctions yield a two-by-two matrix, which can serve as a useful taxonomy of media (Figure 1). In the first generation (speech), storage and transmission are both extragenetic; in the second generation (print), storage is extrasomatic; in the third generation (television), transmission is extrasomatic; and in the fourth generation (hypermedia), both storage and transmission are extrasomatic. In this emerging fourth generation, which completes the taxonomy, information is stored electronically in disc/ks (floppy disks, hard disks, videodiscs, CD-ROM discs, etc.) and transmitted through the informatics infrastructure of a network of computer nodes linked by telecommunications.

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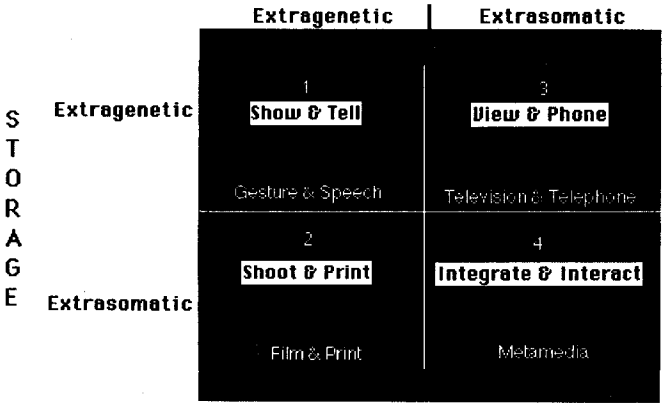

Figure 1: Four generations of media transmission.

We usually consider media as mediating between people. However, they can also be considered as mediating, within each person, between the subjective map and the objective world. The subjective map could be considered as composed of a perceptual map and a conceptual map, corresponding roughly to the thing and the word in the objective world and to text- and image-based media (Figure 2). It is a useful metaphor to consider the perceptual map as a function of the right hemisphere and the conceptual map as a function of the left hemisphere. Within this metaphor, the computer could be considered as the corpus callosum. This captures the two basic characteristics of computer-based media - integration and interactivity. The corpus callosum links the two hemispheres, as the computer integrates text and image, and it may link the cerebral cortex with the rest of the body, as the computer provides interactivity between thought and action.

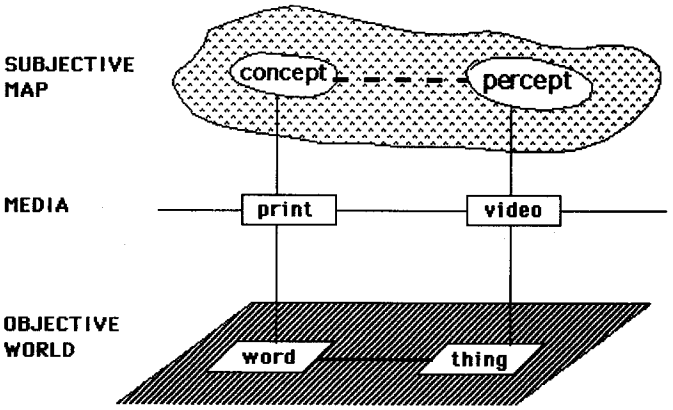

Figure 2: Media 'media'ting between subjective map and objective world.

Now that we have the technology to simulate the entire nervous system, we can seriously consider mapping our subjective maps isomorphically on to the objective world. Hypermedia can serve two basic functions in such a mapping - as a window on the objective world, and as a mirror of the subjective map. The two terms - virtual reality and cyberspace - are used almost synonymously. The same people who had attended the First Conference on Cyberspace in Austin, Texas in May 1990 [2] turned up, with similar papers, at the Virtual Reality conference in San Francisco, California in January 1991 [3]. However, it would be useful to differentiate between the window function (virtual reality) and the mirror function (cyberspace). This distinction has a number of important implications. For example, whereas the window function emphasizes veridicality (an accurate perceptual map), the mirror function emphasizes rationality (an accurate conceptual map). The cartoon-like images currently available are a liability in virtual reality - virtual reality is 1% reality and 99% virtual - but may be an asset in cyberspace since a cartoon can emphasize the important aspects of a complex situation and thus help deal with the management of complexity.

Whereas traditional media invite you into an alternative reality, hypermedia invites you into a virtual reality. This is the most dramatic development within hypermedia because it holds out the promise of finally providing an artificial medium which is a medium in the sense that water is a medium for fish and air is a medium for homo sapiens. Traditional media may engross you, but hypermedia engorges you. Virtual reality is such a good simulation of natural reality that you can behave and experience within this artificial environment much as you would behave and experience in the natural environment which it represents.

Perhaps the best way to understand virtual reality is to consider it in terms of the widening of the bandwidth of the interface between the computer and the user. The WIMP interface (Windows-Icons-Mice-Pulldown menus) of the Apple Macintosh was heralded because it facilitated the interactivity between the computer and the user. It was like improving your axe by buying a new handle rather than a new head. However, it is a very mixed metaphor - are we in a house (window), a drafting office (icon), a pet shop (mouse), or a restaurant (pulldown menu)? It turns out that we are on a desktop, with a trash can sitting on it! Whereas the WIMP interface is a good first step towards the intimate coupling of the person with the machine, it is not a true graphic interface. Imagine, however, that the computer screen opened to an image of an office. If you want to use your computer for word-processing, click on the typewriter sitting on the desk; if you want to use it as a data base management system, click on the appropriate drawer in the filing cabinet; if you want to use it as a front end to control a videodisc-player or a CD-ROM player, click on the icon representing the device on the top of your cabinet; and, if you want to throw something away, there is a waste-paper basket under the desk where it belongs. Imagine further that, with steadily improving graphic and sound capabilities, you have a high-resolution colour image of an office rather than a simple black-and-white line drawing, and that this image was expanded to fill an entire wall and then wrapped around to fill a whole room. Suppose that you could interact with this room, not by pointing to icons and pulling down menus with a mouse, but simply by pointing to representations of the various objects in your office and

voicing your command. You are now in virtual reality. Alternatively, imagine that the office image was shrunk rather than expanded, and that two slightly different versions of the office image were presented in a set of goggles to your two eyes to produce a stereoscopic effect. Suppose even further that the mouse was replaced by a dataglove so that, rather than merely pointing to objects in the office, you could manipulate those objects. Welcome again to virtual reality.

Those two scenarios describe the two basic strategies for creating virtual realities. The first strategy is best illustrated by Myron Krueger, widely recognized as the father of artificial reality, who creates responsive rooms which interact with people in them. The second strategy is illustrated by most of the other people who have followed him into the field. Like the Zen monk, who decided that the world could be covered in leather by making a pair of leather sandals, they dress people in goggles and gloves which create the illusion of being in a virtual reality they can explore and manipulate. This distinction is analogous to that between the original Ganzfeld and the pocket Ganzfeld. The original, designed by German psychologists to create an environment in which all receptors of the eye were equally stimulated, was a hemisphere, six feet in diameter, with the subject sitting in the centre; the pocket version, designed with typical Yankee ingenuity by American psychologists, was created by cutting a ping-pong ball in half and taping one half over each eye.

Communication Studies as a Central Discipline

Virtual reality/cyberspace introduces new issues into the discipline of communication studies, which make the old issues, published only a decade ago, look quite quaint [6]. The Ferment in the Field was a Tempest in a Teapot. The central issue could be whimsically reduced to the question of whether communication studies should be a branch of political science (critical studies) or of business administration (administrative studies). The threat of dissolving into another discipline, which has always haunted the field, is now replaced by the opportunity to be the central discipline in the academy. The shift in emphasis from media to hypermedia is part of a system of correlated shifts - from a modern, industrial society, based on energy, to a post-modern, post-industrial society, based on information; from physics, a study of energy systems, to biology, a study of information systems, as the basic discipline; from a behavioristic concept of the person to a humanistic concept of the person, and so on. This paradigmatic shift also shifts communication studies from a peripheral to a central role in the university.

Each of us is given, as a conception day present, in the zygote formed when the sperm of our father penetrates the ovum of our mother, the vast body of information which our species has accumulated over billions of years of survival on our planet. Each of us adds ontogenetic information to this phylogenetic information during our individual lifetimes. This information is added by means of the extragenetic and extrasomatic tools for the storage and transmission of information, described above as four generations of media. Education could be considered as this process of supplementing phylogenetic information, acquired during the evolution from animal to human, with ontogenetic information, acquired during the evolution from child to adult. Communication studies could be considered as the study of those generations of media and, hence, as the central discipline within the academy.

Although virtual reality/cyberspace is the natural domain of communication studies, we have been slow to move into it. Communication studies formally entering the field only last year with the publication of a special issue, *Virtual Reality: A Communication Perspective,* in the official journal of the International Communication Association [7]. The vacuum is being filled by scholars from other disciplines - from architecture, from engineering, from journalism, from literary studies, from philosophy, from political science, and so on. The variety of disciplines represented is an indicator of how widespread the reverberations and repercussions of this development are. However, there is a danger that, in becoming everything, it becomes nothing. The ubiquitous is paradoxically elusive. The fish will be last to discover water.

The remainder of this paper is an attempt to centre virtual reality/cyberspace firmly within the discipline of communication studies. It presents four concepts, with their correlated concerns, as challenges to communication studies.

Technosphere

The person could be considered as the triple overlap of three spheres - ecosphere, sociosphere, and technosphere (Figure 3). It is important that the environment be differentiated into the natural world (ecosphere), social world (sociosphere), and artificial world (technosphere), because, whereas the person is part of all three, the relationship between the person and each of the spheres is different. The person is the most complex system in the ecosphere, an element of the sociosphere, and the source of the technosphere. The study of the person in each of those spheres is therefore different. Person-in-ecosphere is the domain of the natural sciences, person-in-sociosphere is the domain of the social sciences, and person-in-technosphere is the domain of what Herbert Simon has called the sciences of the artificial and Carl Popper has called world three.

If communication studies is to stake its claim to virtual reality/cyberspace as a domain of expertise, then we must consider certain theoretical issues within the person-in-technosphere which have not been part of the discourse within the field. For example, we must recognize participant effects. In the social sciences we recognize observer effects. Since the person is an element of the sociosphere, his/her observing of it affects the observation. It is not so well recognized that, in the sciences of the artificial, there is an equivalent participant effect. Since the person is the source of the technosphere, his/her participation in it affects the participation. The debate within communication studies between those who view technology as liberating and those who view it as oppressive is like that between the blind men generalizing about the

elephant from the tusk and the trunk, They both have part of the truth. Insofar as one uses the technology, it becomes an extension and thus potentially liberating; insofar as one does not use it and others do, it becomes part of the environment and thus potentially oppressive. To phrase it more crudely, in cyberpunk terms: If you are not part of the steamroller, then you become part of the road.

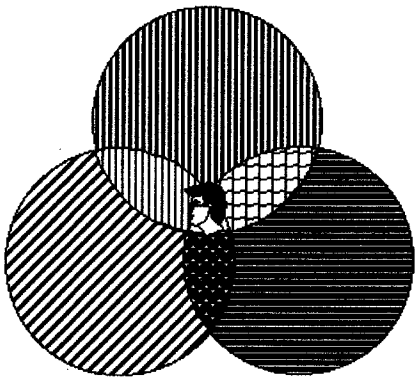

Figure 3: Person as triple overlap of echosphere, sociosphere and technosphere.

Continuous Discontinuity

The paradigmatic shift from a modern, industrial society, based on energy, to a post-modern, post-industrial society, based on information, has taken place. Despite the King Canutes trying to stop the third wave, Marie Antoinettes saying 'what revolution?', ostriches in a very vulnerable position, it is clear that the revolution is over. However, one needs only read the popular press to realize that most people are acting and speaking as if nothing has changed. We are merely going through another recession. Opinions differ only with respect to how long it will last before things get back to normal. We have gone through a revolution, and things will never be normal again. If we sleep through the current turbulent transition, undisturbed by the confusing co-mingling of the death rattles of the industrial society and the birth cries of the post-industrial society, we will wake up, unprepared, in an entirely different world.

Whereas we are familiar with the technophobes, among us and within each of us, who argue that nothing has changed, we are less familiar with the technophiles, among and within us, who argue that everything has changed. Many who gravitate to virtual reality/cyberspace tend to view themselves as entering a brave new world in which nothing is familiar. There is a tendency for people involved in virtual reality/cyberspace to overemphasis the subjective map in over-reaction to the traditional over-emphasis on the objective world. Each subjective reality is equally reliable and valid. There are no absolute standards of ethics, logic, or aesthetics. What is good, what is true, and what is beautiful are relative to each person. It is understandable that standards defined largely by dead white Anglo-Saxon males be challenged by live people of different colors, different ethnic backgrounds, and different sexes. However, there are a lot of babies in that bathwater! It may, indeed, be necessary to throw it all out and then start rescuing the babies which are worth rescuing. However, if we throw out rationality itself - that is, the faith that there is an objective world, and that it is possible for us to create a progressively more and more accurate and more and more complete subjective map of it - then there is no basis for deciding what to keep and what to throw away. Recognition of participant and observer effects, in the technosphere and sociosphere respectively, as discussed above, by extending the definition of rationality, may salvage some of those babies.

Virtual reality/cyberspace is the arena in which the extremists - technophobes and technophiles - will wage their information war. Communication studies can provide a balanced middle ground between those two extremes. Charles Darwin demonstrated that phylogenetic development was a process of continuous discontinuity, and Jean Piaget demonstrated that ontogenetic development was a process of continuous discontinuity. In both cases, there is a continuity with respect to function (adaptation to the environment) and a discontinuity with respect to structure (of different organisms in the case of phylogeny and different cognitive structures in the case of ontogeny). Media development is also continuous with respect to function and discontinuous with respect to structure. That is, the function of communication is common to all four generations, but the structure of technologies, as a means to this end, changes from generation to generation. Computers do not replace television sets any more than television sets replaced books and books replaced speech. However, as each new technology is assimilated, the structure of communication is transformed to accommodate it. Just as the first transition from speech to speech-print and the second transition to speech-print-television were documented by communication studies, so also will this third transition to speech-print-television-hypermedia. Eric McLuhan, in revising his father's Understanding Media, takes a bold step towards laws of media which help provide a language for talking about the structural shift in communication as we move into each new generation [8].

Media Blur

Rationality can be superficially considered in terms of a full and accurate subjective map of the objective world. Bad communication reduces the completeness and accuracy. However, communication which is too good can paradoxically also reduce rationality. William Kuhns [8] argues that the failure to distinguish what is real and what is mediated - media blur - is widespread in our media-saturated world. Virtual reality/cyberspace will dramatically increase the blurring of media and reality.

Eric Voegelin [10] distinguishes between the first reality, which we experience, and the second reality, which we imagine. Our increasing capacity to create veridical second realities, using virtual reality/cyberspace, has a number of threats as well as opportunities. It can be used to help more fully understand the first reality, but it can also be used to

eclipse the first reality. Why would a political philosopher be interested in such a distinction? Voegelin argues that people often encourage the eclipse of first reality by second reality as a power ploy. First reality is controlled by nature, whereas second reality is controlled by people. The people who control this second reality have a vested interest in replacing first reality with their second reality. Unintentional blurring of first and second reality can also be threatening. In our understandable enthusiasm for virtual reality/cyberspace, we should not get carried away into arrogantly assuming that the world we imagine can substitute for the world we experience. Creating a replica of an American Indian village in a museum is a wonderful way to invite patrons to "visit" who would not otherwise be able to. This concept of the museum as a virtual reality has been unfairly derided as Levi-Strauss-meets-Mickey-Mouse . However, the replica threatens to eclipse the original if unthinking people consider this visit to the synthetic village as a substitute for a visit to the real village - or even as superior, since it is hyper real.

In our post-modern era we should keep our eyes on the obituary column. Art, history, nature, and philosophy have all recently been declared dead. Reports of their death are grossly exaggerated. Invariably we find that what is dead is a second reality which has come to be substituted for a first reality. In the domain of virtual reality/ cyberspace, now that we have a medium which is totally extrasomatic, there is a threat that the body will be declared dead. Michael Heim, Sandy Stone and David Tomas all document this tendency in *Cyberspace: First Steps* [1]. A recent issue of the Whole Earth Review asked Is the body obsolete? About half of the respondents said 'yes'. Enthusiastic advocates of hypermedia exult about escaping the constraints of space and time. However, cybernauts, lost in cyberspace without their bodies, do not escape biological time. It continues to measure out their three score and ten, whether they are chatting over the backyard fence or zapping around the universe by satellite at the speed of light. This euphoria of technophilia is simply the latest in that brilliant array of techniques, documented by Ernest Becker, for denying death.

Writing Space

Jay Bolter [3] describes the various generations of media in terms of writing spaces. The original writing space, corresponding to my first generation, is memory. This was subsequently augmented by the writing space of print (my second generation). The third generation is largely ignored. However, I would suggest that a drawing space be added to accommodate it, and to avoid the continuing privileging of the dominant left hemisphere. Bolter argues that the computer (my fourth generation) retrieves pictorial writing space, which was peripheralised by print. Within his terms, virtual reality/cyberspace is the ultimate writing space. It enables media to map isomorphically on to the objective world (window function of virtual reality) and to map isomorphically on to the subjective map (mirror function of cyberspace).

Now that we finally have a media which represents the whole nervous system, a positive prosthetic which fits, a three-dimensional tool which mediates between our three-dimensional brain and our three-dimensional world, we have to reconsider our current dependence on one- and two-dimensional tools, and our continuing use of the computer as a box to bury old one- and two-dimensional media. We typically use the computer as a typewriter to do one-dimensional word-processing. It is necessary to proceed to two-dimensional idea-processing, in which the computer is used to generate the hierarchical structure of thought underlying the sequential presentation of language, and to three-dimensional hypermedia, in which it is used to nest more nodes within any node and to link any two nodes within the hierarchy (Figure 4). This three-dimensional structure is isomorphic with the cognitive structure of the subjective map, viewed as concepts with relationships between them, and with the informatics infrastructure of the objective world, viewed as computers interlinked with telecommunications (Figure 5).

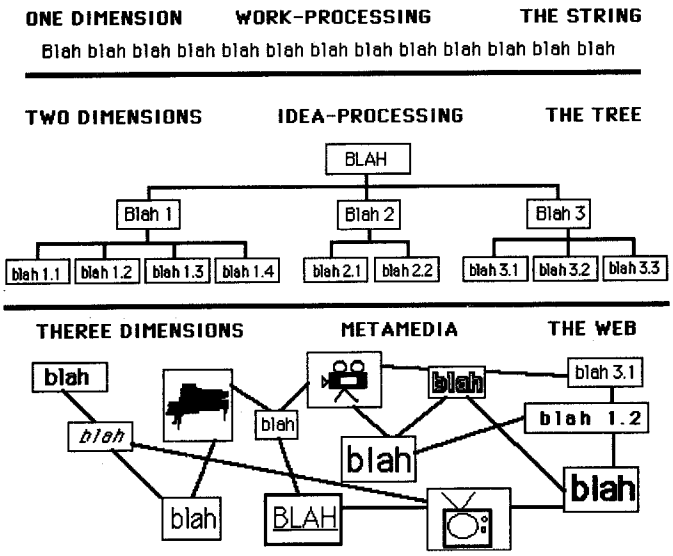

Figure 4: Three dimensions of computing.

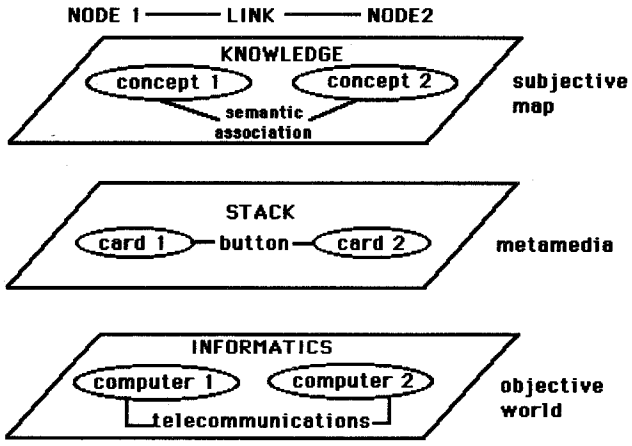

Figure 5: Isomorphism of metamedia with both subjective map and objective world.

Information overload is often considered as the basic problem of the post-industrial society. In the industrial society we had too little energy; in the post-industrial society we have too much information. However, this is like surveying a huge smörgäsbord and crying overload because we can not eat it all. In our outside-in education, in which being educated is viewed as stuffing oneself full of facts, we are overwhelmed by the fact that we could not even assimilate the contents of our local library in our lifetime. The inside-out teacher, who views education as growing from the inside out, welcomes our enriched environment. One of the few conclusions we psychologists have reached is that so-called "stupid" people grow up in impoverished environments and so-called smart people grow up in enriched environments. Beneath the pseudo-problem of information overload, however, there lurks a real problem of management of complexity. Our enriched objective world enables us to build a subtle, sophisticated subjective map of it. The ultimate writing/drawing space of virtual reality/cyberspace, in which we write/draw on the whole environment, will be a valuable tool in dealing with such complexity.

The academy has tended to confine itself largely to the first and second generations of talk-and-chalk. Communication studies could invite our colleagues into the third and fourth generations. If a picture is worth a thousand words, then a one-hour video, at 30 frames per second, is worth 1,000 times 30 times 60 times 60 - that is, 108,000,000 words. Chunking 1,000 words into an image and 108,000,000 words into a video is a powerful strategy for managing complexity. The complexity of a text-based explanation can often be greatly simplified by transforming it into an image-based explanation.

Understanding is further enhanced when hypermedia presents the image as virtual reality, and allows the user to interact with it so that he/she can learn by doing. For some time we have trained pilots by simulating a cockpit. It was suggested above how we could simulate an office. We will see more and more simulations of classrooms, operating rooms, and so on, which will use virtual reality as a window on the objective world to help us be more at home in it. Cyberspace, the ultimate writing/drawing space viewed as a mirror, can be used to create a conceptual self-portrait, a sort of expert system of oneself. The siliclone - that is, a silicon clone of oneself - is a primitive prototype (Figure 6). It can be represented as a HyperCard-based filing cabinet of one's favorite quotes, anecdotes, images, sources, and so on. Person-machine synergy can be explored as the appropriate division of labor between your natural intelligence and the artificial intelligence in this satellite brain. One vision of this division is that your siliclone focuses on storing content, setting you free to focus on putting content into context, and thus moving up a data-information-knowledge-understanding-wisdom hierarchy. This is how value will be added to raw data to generate wealth in our information society.

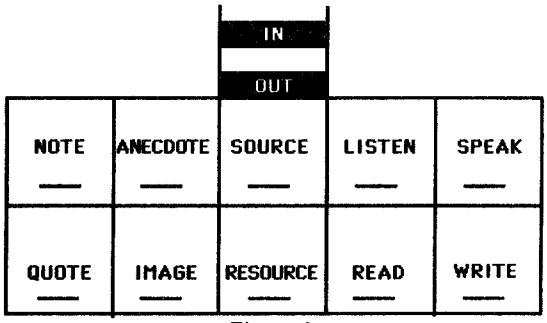

Figure 6.

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BIOGRAPHY

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CURRENT ACTIVITIES IN VR STANDARDS AT IEEE

Standards Editor: Mary Lou Padgett

The Institute of Electrical and Electronic Engineers (IEEE) plays a major role in the formation and publication of standards, cooperating fully with various national and international standards organizations such as ANSI (American National Standards Institute) and ISO (International Standards Organization) in the process.

There is probably nothing more important to the successful development and marketing of commercial products in virtual reality than the establishment of standards that can be followed by hardware and software developers. Only when various components from different producers can be integrated together into full operational systems will there be a robust market.

Working in the area of standards involves a lot of trying to predict and direct the future. The actual formation of the standards often proceeds at a glacial pace in order to fully involve all interested parties and deal with all the issues. This does not mean that benefit is not derived before the actual publication of the standard. The process itself may be just as important as the final result. In the process, future issues are discussed and publicized, and all interested parties can see and have a role in the general direction that developments are heading.

The IEEE procedures for VR standards development are briefly as follows. First, there may or may not be the formulation of a *Study Group*, which needs no formal recognition or approval, and which may exist for literally years before the process becomes more formalized. Typically a study group will have 25-100 active participants, though it may be many times that.

The process becomes formalized with the formation of a *Working Group*. To form such a group, a "PAR" (project authorization request) is filed with the Standards Board of the IEEE. Each working group will have a chair, a vice chair, and a recorder. The IEEE has found that a membership of 50 to 100 members is a reasonable compromise between the broad representation that is needed and proper coordination of the individual inputs. Typically the only requirement for being a member of a working group is the willingness to actively participate, but the group must include technical expertise in all pertinent areas.

The working group proposes the literal wording of the proposed standards. It carries no authority to make the standards, however. To do that, another group, the *Balloting Group*, is formed. At this stage everything becomes very formal and legalistic, for the Standards Board must guarantee that the Balloting Group collectively has the expertise and the objectivity to pass on the proposed standards.

After the Balloting Group and Standards Board have approved a particular standard, the IEEE can publish the standard. The IEEE supports the standards activities through the sale of official publications containing those standards, and those publications are copyrighted. Thus in the formulation of the standards, starting from the working group, the IEEE maintains strict rules to ensure the legality of its copyrights. Among other things, this means that proposed standards are not "published" (in the legal sense of the word) during the process, and the copyrights of other sources are honored.

The IEEE standards activities in VR are coordinated by Richard Blade (University of Colorado - Colorado Springs), though Mary Lou Padgett (Auburn University) currently coordinates a study group (soon to become a working group) on Computational Intelligence, that includes VR as well as neural networks, fuzzy logic, and evolutionary computing. The only official working group so far in VR is one focusing on producing an official glossary, defining various technical terms. Richard Blade recently became chair of that group, while Carol Manetta (Ford Motor Company) serves as vice chair, with Margaret Loper (Institute of Simulation and Training) as recorder and Mary Lou Padgett as liaison to the IEEE Standards Board. The Working Group can call upon the VR Technical Resource Group and the VR Standards Resource Group to provide expertise in specific areas of VR and related standards as needed. Coordination with all related standards and interested groups is a major goal.

Additional working groups are anticipated in the areas of specifications for head mounted displays, specifications for position trackers, and interaction with graphical databases. All these areas have been specifically requested, mostly by persons working in the industry needing the standards. In addition, there have been numerous requests that VR standards ensure access by disabled persons.

The NNC standards activities in VR began about 18 months ago. Since that time most of the effort has gone into recruiting members for study and working groups. Currently the IEEE headquarters is setting up a list server and an ftp site to support the activities. The list server permits a member of a study, working, or balloting group to send an email message to the entire group through a single address, thereby enabling members to have private discussions. The ftp site contains a public directory, which contains reports and information for anyone wanting to see the progress of the committee, and a private directory, which contains material only for viewing by the group members. (Once again, the reason behind the private directory is not secrecy, but copyright protection.)

Persons interested in becoming involved in VR standards activities should contact Richard Blade at r.blade@ieee.org or Mary Lou Padgett at m.padgett@ieee.org.