Proposal to the National Science Foundation

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TITLE OF PROPOSED PROJECT
Universal Access to Intermental Knowledge Networks: Human-Computer Interface Technologies that Include People with Severe Disabilities

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A. PROJECT SUMMARY

The proposed interdisciplinary work will develop and exploit a general type of knowledge network, termed an intermental knowledge network (IKN). The fundamental idea is that, with the help of computers and networks, an IKN primarily connects minds to one another and to electronic information resources. Some of these minds belong to persons with disabilities—including severe disabilities—who deserve full access to the IKN. Society will be the richer for their participation in and contributions to the IKN. The project brings to the table two powerful interactive multimedia software systems being developed at Syracuse University. TangoInteractive is a highly versatile collaboratory system designed for use on the World Wide Web. NeatTools, a visual programming environment for rapid prototyping of human-computer-interaction and other dataflow applications, includes Internet sockets allowing interactive applications at a distance. A major goal will be to adapt both of these software systems towards universal access, so that people with disabilities (e.g. blindness, deafness, or quadriplegia) will be able to participate effectively with their peers in the emerging knowledge networks, and, with NeatTools, to build programs independently. Moreover, the new features to be added will provide new functionality to the benefit of all users. The project also incorporates significant hardware development, with emphasis on affordability. NeatTools operates in conjunction with custom sensors and interface boxes to provide access to computers and the Internet for people with severe physical disabilities. This development will continue in order to maximize access to the IKN as well as to expand individual capabilities in the classroom, home, workplace, and community. Besides continued research and development of sensor and transducer modalities, the project will develop affordable higher-level systems such as eye-tracking headsets with adaptive displays, and haptic feedback systems to be applied in those instances where the simpler approaches are insufficient to enable an individual to participate in the IKN. Correspondingly, increasingly sophisticated signal-processing algorithms will be introduced for advanced gesture and expressional recognition. The IKN will serve concurrently as a subject of study and research, and as an interactive environment of practice for this interdisciplinary collaborative project, which includes four American universities (Wisconsin, Washington, Catholic [DC], Syracuse), and two institutions in Kuwait concerned with disability issues; the Trace Center (Wisconsin) is a pioneer in universal access strategies for public access to information. The scientific framework of the project will be based on hypotheses and goals that will be tested and evaluated with the help of individuals with disabilities, who will serve as active members of the research team. A major area of focus will be science education, with emphasis on active learning and remote participation in science experiments and simulations. The objective will be not only to optimize learning and appreciation of science, but also to encourage and enable talented individuals to pursue careers in science and technology notwithstanding their disabilities. This highly interdisciplinary project will impact the following fields: science education, disabilities, distributed computing, information technologies, and human-factors engineering (expressional and perceptual interfaces, and human-computer interaction).

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C. PROJECT DESCRIPTION

Introduction

We propose to research and develop innovative, powerful human-computer interaction software and hardware systems, so as to include individuals with disabilities including severe disabilities such as quadriplegia, deafness, and blindness. The general objective will be to connect such individuals optimally and interactively to the knowledge-base of the world. Thus, they will participate actively in what we term Intermental Knowledge Networks (IKN), in which *minds* become connected to one another, as well as to information and knowledge resources. For specific content and context, emphasis will be placed on science and technology education applications, including computer-interfaced laboratory activities for high-school and college students. The project will promote active learning in a constructivist paradigm, in which students—in teams that could include disabled students—help create their own knowledge by exploration and investigation.

Our proposal is motivated by the mission statement of a key partner, the Trace Research and Development Center at the University of Wisconsin, namely “To advance the ability of people with disabilities to achieve their life objectives through the use of communication, computer and information technologies.” The Trace Center— which has pioneered in universal design for information appliance interfaces, and the accessibility of Web technologies such as HTML 4 and Java—will be responsible for the design of our IKN for universal access and lead the assessment of it in operation with our set of carefully designed deployments. They will also be a focal point of expertise on interfaces aimed at blind users. The two groups at Syracuse (NPAC and Pulsar) are responsible for the software infrastructure and some general interface hardware, aimed especially at quadriplegics. Our other partners include the biomedical engineering department at Catholic University of America and the Human Interface Technology Laboratory at the University of Washington, who will be develop critical sensors and be part of the IKN in design and deployment phases. Schools in Syracuse, Washington DC, and Kuwait will be used to deploy and assess our approach.

Emerging Web and commodity distributed-object technologies will enrich all our lives and in particular give new opportunities for universal access to the rich set of information sources on both the Internet and intranets. Our interdisciplinary team will set up the IKN first to understand the general issues, and then to design and develop new techniques that will allow the severely disabled to access a complete educational experience at both college and precollege levels.The distributed-object approach to education allows us potentially to deliver excellent curricula at any time and any place. Our team includes, among others, the Northeast Parallel Architectures Center (NPAC at Syracuse University), which has pioneered TangoInteractive and NeatTools thus creating an infrastructure for user-constructed distributed applications, and the Trace Center which has pioneered in universal design for information-appliance interfaces, and the accessibility of Web technologies such as HTML 4 and Java.

The Web provides a universal interface to which one can couple novel low-cost human-computer linkage devices which enable one to offer custom communication capabilities that are effective for even the most severely disabled. In this proposal, we focus on the latter aspect—human-computer interfaces to Web-based education—but leverage other work by our team on enabling distance education to deliver systems that transcend the communication barriers of distance and human disabilities. Our approaches are designed quite generally, but we focus at the initial stage of our project on selected individuals at several performance sites.

The project methodology will include a growing repertoire of low-cost sensors and transducers, computer-interface boxes, and advanced visual-programming software (NeatTools) all of which we have been developing at Syracuse. NeatTools, with which one drags and drops modules to assemble dataflow networks, already includes Internet-socket modules appropriate for distributed-intelligence applications. Significant success has already been achieved locally on pilot projects with a brain-stem-quadriplegic high-school honors student, and a cerebral-palsy spastic-quadriplegic 7-year-old child. The work (see www.pulsar.org) is performed in close partnership with the Northeast Parallel Architectures Center (NPAC) at Syracuse University (www.npac.syr.edu).

To enable such individuals to lead enriching and productive lives, the project will emphasize communication and control for active learning and exploration. Accordingly, we will leverage the Web and HPCC technologies developed at NPAC, notably the Java-based TangoInteractive collaborative software, which has been designed and demonstrated successfully for distance learning and for computer-supported collaborative work. NPAC's hardware and software infrastructure will be used for our research on networking disabled individuals and also for effective coordination of the project itself, involving the participating institutions. Among the systems to be developed and tested in suitable experiments with disabled individuals in educational and home settings are: a) customizable hardware and software modules that can be appropriately configured and networked to meet the special needs of the individual, and b) specific high level systems such as eye trackers and haptic feedback systems. The proposed work on IKNs and the requisite assistive technologies will contribute to the important goal of universal access to knowledge in this information and communication age.

Objectives

The research will focus on inclusive enabling technologies at various levels of software and hardware. The entire project itself will become an IKN both for practical communication and coordination of methods, results, and plans among our investigators and participants at the various performance sites. The heart of this operational IKN will be the TangoInteractive collaboratory software, which has been designed and optimized for knowledge networking in general. With the proposed incorporation of assistive and enabling functionality at the core of Tango—and its use in conjunction with a similarly expanded NeatTools and associated hardware devices—the IKN will include those with disabilities, representing a significant subset of the world's population, who have a great deal to gain and also to contribute. Accordingly, these are our objectives and goals:

- Extend the current beta versions of TangoInteractive and NeatTools so that they are accessible to an increasingly wide range of users with varying physical abilities, who will then have IKN access. Significantly, our intent is not just to allow people with disabilities to use applications already prepared and configured for them, however useful that might be. Rather, the plan is to enable such users to compose their own applications and adaptations. This creative aspect—for which such users should be particularly self-motivated—will find expression particularly with NeatTools, which is designed for rapid prototyping in a visual-programming environment (note that users who are blind will be well accommodated in the planned extension of NeatTools; see below). The extensions, which will be incorporated as standard inclusions into the release versions of both software packages, will generally benefit all users whether or not they have any disabilities. The two ways in which this functionality will be incorporated respectively into NeatTools core program and Tango's "control application" and selectable filters are described below.

- Develop and continually refine and extend, a computerized *expressional/perceptual interface system* to accommodate a broad range of users with physically disabilities. The modular, low-cost hardware in this system will include a) mounting apparatus, b) sensors and transducers, and c) microcontroller-based computer-interface. Representative components in each category exist in various forms, so we can already assemble working systems. The heart of the system is the NeatTools software. Our team, including student members with disabilities, will further develop custom configurations of NeatTools to work in conjunction with the interface modules, specifically for the science education applications in the proposed work. Using the Internet sockets already built into NeatTools, individuals with disabilities will be able both to construct and to employ interactive applications for use via the IKN.
- For science education applications, at precollege and college levels, enable students with physical disabilities to perform science experiments using appropriate robotic and interface tools). Students will be able to analyze and graph data via spreadsheets and custom NeatTools configurations. The initial thrust will be on physics experiments, but this scope will be broadened to include chemistry and biology. The modularity, customizability, and extensibility of our hardware and software solutions should allow the technologies, applications, and core extensions we develop to be applied to individuals with a wide range limitations and needs. The added functionality included to accommodate users with disabilities will also offer exciting new educational opportunities and perspectives to general users. We will continually assess and refine this effort in close consultation with educators at the high-school and university levels. The assessment will be applied to the technologies and to the expected improved learning outcomes afforded by active participation by students with disabilities in the science experiments and other educational activities. Given the increasing availability of scientific educational simulations, notably as Java applets (e.g. see PI's *Results from Prior NSF Support* section), the way is clear to extend this classroom-based active learning experience to the IKN for the benefit of all students.
- As we develop and refine expressional and perceptual interfaces along with the core software, we will adapt and test these in Tango collaborative sessions (sometimes local, often long-distance). These will link researchers and users with disabilities, often as members of the research team themselves, to develop and evaluate knowledge-networking methods. A recurrent topic in these sessions will be performance evaluations of our interface and interactive systems. Science education topics and activities (conceptual, experimental, and simulated) will also be incorporated into such IKN communications for this project.
- The IKN, using Tango and optionally NeatTools, will constitute the essential communication and coordination environment for this project. At the same time, though, this IKN will be a subject of investigation itself. Thus the project will be iteratively refining its own interface technology and its distributed computing and communication environment for optimal methodology, performance, and inclusion.
- We will disseminate the results during the course of the project by traditional academic publications and conference presentations, as well as by conference exhibits and Web distribution of NeatTools software (downloadable at no cost) and hardware. Publications and presentations will be submitted and presented on our core technologies and applications, as well as on the development and optimization of our Tango-based IKN as a prototype knowledge network with unique technology and also core features for optimal inclusiveness. Using hypermedia (multimedia hypertext) formats, the project results and forthcoming plans

will be maintained continually on the Web sites of the participants at their respective institutions in the United States and Kuwait (see below).

Background

World Wide Web Access

The importance and challenges of Web access for persons with disabilities have been pointed out by Laux et al. (1996), who estimate there are over 26 million Americans with physical and sensory disabilities and over 23 million others with cognitive and literacy disabilities. For additional data and other specifics, see the Disability Statistics Center site at dsc.ucsf.edu. Although the Web and associated technologies have been developed to date with inadequate attention to the access needs for the disabled, they nevertheless offer access to excellent resource information. Our own Pulsar Web site (www.pulsar.org; follow link for “Disability Resources”) offers a sample of sites, as well as a list of lists from other sites, offering resources and services to people with disabilities and their families.

The World Wide Web Consortium (W3C; www.w3.org/pub/WWW/Disabilities/) is increasingly giving special attention to disabilities issues. The W3C position statement www.w3.org/pub/WWW/Disabilities/Activity.html includes the following text: “All the protocols and languages we issue as Recommendations should meet or exceed established accessibility goals. In addition, we will actively encourage the development of Web software and content that is accessible to people with most disabilities.” The present project is tightly integrated with the Web. In particular, our software (NeatTools and Tango) is freely downloadable via the Web, and we will be able to offer interface modules together with sensors at minimal cost (usually no more than the price of a video game cartridge). We can also recommend or provide mounting hardware components as needed.

TangoInteractive

Tango Interactive is an advanced, powerful, and extensible Web collaboratory.
The system extends capabilities of Web browsers towards a fully interactive multimedia collaborative environment. Tango is also a framework for building collaboratory systems. The publicly available version (trurl.npac.syr.edu/tango) is just one implementation using Tango runtime. It is possible to build collaboratory systems of arbitrary complexity using the Tango framework

Tango Interactive is written in Java. Most system modules are implemented as applets. The applets interact and control one another’s behavior. Applet interaction in Tango goes much further than simple communication among applets on an HTML page. Tango applets can come from different name spaces. There is no requirement that all applets, or even different instances of the same applet, come from the same http server. The applets can be loaded when needed and released at any time, ensuring that the system is lean and agile. Tango Interactive is the first, and so far only, system implementing this very flexible, powerful architecture

To run Tango, one starts the system from a browser and connects to a Tango server. Once in the system, the user can select from over 25 collaboratory applications to work on projects with partners, take a class at a virtual university, create and use a public or private chat room, conduct a videoconference, view a movie, surf with friends, or play a game. It is possible to do all this at the same time, in any combination, in as many chat rooms as desired. No other collaboratory system, public domain or commercial, gives you so many applications under such consistent and simple session and floor control.

Besides running Java applets under Tango, one can run JavaScript-based client-side Web applications. Moreover, in Tango the user can take an arbitrary HTML page and automatically turn it into a shared entity. To build a 3D VRML world, populate it with avatars, and let them interact, Tango provides support via two integration modes: VRML JavaScript nodes and External Authoring Interface. Applications written in C or C++ (e.g. PowerPoint) can also be readily adapted to run collaboratively under the Tango API.

NeatTools

NeatTools constitutes an application programming interface (API) and, specifically, a visual-programming environment kit (from www.pulsar.org, follow link to NeatTools download and resource page). It is written in C++ but in a Java-like way so as to operate on multiple platforms (Windows 95/NT, Irix (SGI), Linux, and soon Macintosh, once its 32-bit multitasking, multithreaded operating system is released). To construct a "dataflow network", the user drags and drops modules (objects) from toolboxes to the desktop and then interconnects them with input, output and control lines. Properties of the desktop and many of the modules are set via a right-mouse-click. In this way, users are in effect developing elaborate interface programs without having to know C++ or the fundamental structure of NeatTools. On the other hand, the system is open, so that programmers can develop external modules at will by following instructions in an online developer's kit. Currently, it includes serial, parallel, and joystick port interfaces; multimedia sound (video in progress); MIDI controls; recording and playback; Internet connectivity (sockets, telephony, etc.); various display modalities including for time signals; time generation functions; mathematical and logic functions; character generation; relational database system; and much more.

An advanced example of the power of NeatTools is the JoyMouse network, which was developed by the PI. For details, manual, images, and downloads, see http://www.pulsar.org/neattools/edl/joymouse_docs/JoyMouseManual.html. With this network, and associated facial switches, we have enabled a brainstem quadriplegic teenager (Eyal Sherman) to precisely control mouse motion by means of a custom chin joystick, and thereby control graphical user interfaces, such as Windows 95. Using this in conjunction with low-cost commercial utility programs, he has been able to type and generate speech, dial in to NPAC, invoke and use Web browsers and other application programs, and compose and send e-mail messages; he has used this at home and at school. Briefly, the JoyMouse generates a mouse-cursor velocity that is related to the analog joystick displacement according to linear, quadratic, or cubic relationships. The idea is to provide fine control for modest deflections and rapid motion for major deflections, without discontinuities or parameter changes. There is also a dead zone, or free-play zone, near the origin so that the mouse cursor is not subject to jitter when the joystick is physically at rest. Normally, we employ the cubic option, because it provides the best overall performance. The JoyMouse app can be minimized during use so that no screen "real estate" is occupied. The details of such a network will be concealed from general users as we develop, in the near future, aesthetic and functional end user interface overlays. In such applications, we will be guided by the experience of Dr. Vanderheiden and others at the Trace Center. Already we have begun a step in this direction by interim use of "sockets" to allow for an optional separate control window (second instance of NeatTools with small control network interacting with the main window).

Hardware Devices

The system hardware consists in general of mounting components, sensors, interface modules, computer, and optional output interfaces and devices. For illustration, we describe the types of systems we use for Eyal, who is a brainstem quadriplegic unable to move his head or to vocalize. We have developed a number of arrangements for mounting sensors near the expressive facial regions, most recently lightweight adjustable mounts that can be clamped to eyeglasses. This highly functional system allows very rapid setup by family members.

Among the sensors (Fraden, 1996) we have experimented with so far are light-weight switches, cadmium-sulfide (CdS) photocells, Hall Effect transducers (magnetic sensors to detect position), rotary as well as linear-displacement potentiometers, bend sensors, piezo film sensors, strain gauges, and electroconductive-plastic pressure sensors. We are currently developing and testing capacitive proximity sensors (Baxter, 1997). Most of these sensors are inexpensive, some under a dollar and some costing a few dollars. In the industry serving people with disabilities, even simple devices (like individual switches) tend to retail for $50 and up. Note, though that certain types (Hall Effect and capacitive), when necessary, require preamplifiers and/or signal processing electronics, which we can readily produce but at some additional cost (under $50 in parts for several channels in one extra interface box). Incidentally the current small-profile "custom joystick" mentioned above is extracted from a game controller we obtain at a national discount retailer for under $20; the performance with this component and the JoyMouse network has been excellent.

Our current electronic interface module (TNG-3), developed by the PI, connects up to 8 analog and 8 digital (switch) sensors to the serial port of a computer. This device employs a programmable microcontroller (Microchip PIC16C74A; Peatman, 1998) integrated-circuit chip. It derives 5 volt power for the onboard circuitry and sensors (requiring only modest power) by using a standard trick with some of the unused serial port lines—a technique commonly used to power a serial mouse on a PC. See www.mindtel.com/mindtel/anywear.html. We plan to develop a new version that will work with the Universal Serial Bus (USB) and contain other improvements. However, TNG-3 will remain useful for some time. When Eyal uses the chin joystick and two cheek switches, he is using only 25% of the capacity of TNG-3 and, with the 19.2 kbps data streaming rate, the system including the JoyMouse network (above), the system is very responsive and robust.

Human-Centered System Design

Despite the exponential growth in the number of clinical projects involving complex technological systems, such as the IKN described here**,** relatively little attention has been paid to the human factors issues associated with such systems. Human-centered system design is a growing focus with the recognition that the human-technology interface is the key to optimizing human performance. The goal of human factors engineering is to apply knowledge about the human sensory, mental, and physical characteristics to the design of physical aspects of systems and equipment (the human-technology interface). This perspective will be applied to key aspects of this project, especially by our partners who are investigators and educators in the human-factors field (Lathan and Vanderheiden).

Kuwait Collaboration

During a visit to Kuwait in November 1997 (at the invitation of the Kuwait Foundation for the Advancement of Science) the PI was able to arrange visits to the Kuwait Institute for Scientific Research (KISR) and the Kuwait Special Schools (KSS). These institutions have longstanding close ties for projects in the disabilities area, for example the successful development and international deployment of a bilingual (Arabic/English) Braille system. As a result of that visit, a collaboration has been established to assist some severely disabled children at KSS, beginning with a teenager (Bader Al-Khamees) who has a rare progressive neuromuscular disorder (progressive lateral sclerosis with glutaric aciduria), which unfortunately also afflicts his two younger brothers. The PI met in private with their father (a petroleum engineer who quickly appreciated the power of NeatTools and TNGs as they were demonstrated to him) and he was left very hopeful that something significant would be forthcoming to help his sons.

Following a recent agreement with Hani Qasem, a department manager at KISR (see attached letter of collaboration), and Dr. Salwa Al-Waqin superintendent of KSS, we have sent (May 1998) a TNG-3 interface, a custom joystick, and various sensors for use with our freely downloadable NeatTools software. We will expand this collaboration to encompass other areas including assistive devices for the blind, areas of expertise at both the Trace Center and KISR. This Kuwait collaboration will additionally provide an excellent IKN testbed for very long distance training and interaction using Tango and NeatTools. This collaboration will span the two focus areas of physical disabilities (quadriplegia) and blindness, with initial effort on the former. In recent years, Kuwait has played a proactive role concerning information technologies and recently (March 1998) held a conference on the "Information Highway" for which KISR was among the lead sponsors (see www.kisr.edu.kw). The extension of our IKN to the Persian Gulf will provide ample opportunities to test its robustness, particularly for synchronous communication sessions.

Research Plan

Universal Access Perspectives and Plans

Access to visual direct-manipulation-based tools.

Increasingly, direct manipulation and collaborative direct manipulation tools are being used to advance the constructivist learning model in educational programs, particularly in the sciences. A system such as NeatTools allows students to manipulate, interconnect, and create. It allows them to experiment, hypothesize, test, play, and invent in a fashion that is difficult or expensive to do with real apparatus, wires, meters, signal generators, etc. (although NeatTools can be easily interfaced to such apparatus, when available). Students are allowed to combine logic, analog circuitry, and transcendental functions at will. It allows them to start at a very basic level and to advance at their own rates. Together with the collaborative mechanisms of Tango, it allows them to also interact with other's work on group projects and to receive remote tutoring.

But only if they can see! And only if they can manipulate the elements. If they cannot, then, as things now stand, they will be unable to participate in the educational environments using such tools. A different special set of tools might be created for them but a) it would always have the subset of the functionality, b) it would always come out later, c) they would be unable to participate side-by-side with their colleagues since their version would be a different, "nonvisual" version which may make little or no sense to their peers using the standard visual version.

This leads to the following hypotheses that we will test as indicated below:

Hypothesis 1. Such visual-based direct manipulation tools can have their interface enhanced so they can be operated by individuals who are blind and individuals with no ability for direct manipulation.

Hypothesis 2. The enhanced version of the tool will allow collaboration between individuals who can see and individuals who are blind.

Hypothesis 3. The tools with the enhanced interface will be more usable by individuals who can see and manipulate than the version of the tools without the enhanced interface.

Approach: Using techniques developed at the Trace Center (Wisconsin) as a part of its seamless human- interface protocol work (Vanderheiden, 1994) and the touchscreen-access work (Vanderheiden, 1997) as a basis, the investigators will develop strategies to allow individuals who are blind to successfully navigate the GUI interface, including the various toolboxes to select, place, and interconnect elements as a part of the NeatTools process. Using the nested navigation strategies developed through the seamless protocol, the individuals will be able to move about through the different contexts, elements, and sub-elements (e.g., connection points), exploring, positioning, and connecting or exploring interconnections. By allowing complete keyboard input, access can be provided not only for individuals who are blind, but individuals with any type of physical disability including individuals who are completely paralyzed and who might use a sip and puff or even eye-blink interface to control their computer. By embedding appropriate text information as a part of each object and allowing complete navigation to all aspects of each element, it should be possible to allow an individual who is blind not only to position and interconnect but also to explore complex constructions.

For example, an individual who is blind could navigate through the elements on a NeatTools desktop and stopping on each item would provide information about the item as well as the various inputs and outputs available. Walking around the inputs and outputs would allow them to begin or terminate the wire which they "carried." If a wire were already present, the system could indicate its terminations and allow the user to jump to any of those terminations as they were annunciated. Thus, an individual could trace the circuit in much the same way an individual with normal vision might trace the visible lines on a display screen.

The NeatTools system is complex enough that there are many problems that need to be solved. Among them are the effective auditory techniques for providing more global overviews (e.g. auditory greeking) that can be achieved, for example, using visual layout on the screen. We believe, however, that it will be feasible to create strategies for allowing individuals who are completely blind to effectively and efficiently use the NeatTools visual programming environment. In the process, we expect to identify a number of key techniques and strategies for addressing the issues faced by individuals who are blind in working with complex graphical user interfaces, such as found on most modern computer systems, as well as the even tougher challenge of their access to vision-based direct-manipulation interfaces.

Three tests are planned to evaluate the effectiveness of the strategies developed.

Test 1: Individuals who are blind will be asked to construct complex dataflow networks using NeatTools with its built-in enhanced interface that will become part of the standard program. Children who are blind and who show advanced aptitude in science and logic will be provided with NeatTools packages with the enhanced interface and asked to create both simple designs and free-form "inventions" with the tools. The experiment will involve children in the 5th, 8th, 12th grades, as well as undergraduate and graduate students. Individuals with severe physical disabilities that prevent their use of mouse will also be asked to carry out the same exercise.

Test 2: Individuals who are blind will be asked to help mentor and troubleshoot circuits constructed by younger children who can see. The ability of individuals to collaborate will be tested using older individuals who are blind, who can act as mentors to less experienced (perhaps some younger and some the same age) individuals who are sighted. The goal is to determine whether the individuals who are blind can truly work collaboratively on a NeatTools desktop, where the individual who is blind can analyze and provide meaningful and constructive advice to the individual who is sighted and using this visual programming tool.

Test 3: The individuals who are sighted will be shown the tool with the enhanced features disarmed. After they have used it for a while, the enhanced features that allow individuals with disabilities to more easily access the product will be enabled. Then, after the individuals have used it for a while more, they will be observed to see whether or not they turn the features on when they use the product or if they leave them turned off when on subsequent exploratory or play operations.

Test 4: A controlled study will include a large number of individuals. This will be arranged in classes in local schools in Syracuse (where the PI and his department have strong ties with science teachers in the area) as well as in the Washington DC area (coordinated by co-PI Lathan). Some students, chosen at random, will use NeatTools with the enhancements turned on, and the others with them turned off. The goal will be to see which ones find it easier to use the tools, as measured either by their speed in constructing a network or troubleshooting an imperfect network, or by their ability to correctly construct a system.

Access to Knowledge Networks with TangoInteractive

With the progressive increase in computers and networks in schools and colleges, we are in the early stages of a technological revolution in education delivery and in modes of learning. Interactive collaborative systems such as Tango will play a significant role in education, notably in science education. Because of the multimedia nature of the systems, however, individuals with disabilities, such as hearing impairment or deafness and visual impairment or blindness, are in danger of being excluded. Systems that require fine motor control and direct manipulation may also exclude individuals with physical disabilities. Since it is highly unlikely that the nation will build a second science education system for these different disabilities, it is important to figure out how to create systems that can be used by individuals with physical and sensory disabilities. At the same time, though, we can maximize the use of the senses and manipulative abilities of those who possess them.

It is interesting to note that individuals with disabilities are at no more of a disadvantage in these new virtual interaction spaces than they would be in a regular education space. Individuals who are deaf would have the same difficulties interacting easily in classrooms where the teachers and others are not able to sign and where real-time captioning is not provided. Individuals who are blind would have the same difficulties interacting in classrooms with printed books and teachers writing on the blackboard. As interactions on the Web are increasingly made to imitate interactions in daily life, the problems faced by individuals with disabilities on the Web increasingly mirror the problems they face in the real world—with one exception.

That exception is that, in the electronic world, all the information is being mediated electronically. As a result, it is easier to inject modifications into the data streams, and even translations of them. For example, in an environment where workers in their offices are talking back and forth using telecommunication, it is much easier to isolate clear signals from the individual participants and run them through voice recognition software to generate a visual representation of what they are saying. Even if two people are talking simultaneously, it is possible to carry out voice recognition in this environment, since it is usually possible to separate their individual auditory data streams. As the usage and quality of recognition software steadily increases, possibility is opened for practical use of speech recognition in this limited environment, perhaps even before it would be possible in real life environments. Also, in real life environments, it would require instrumenting the various speakers, whereas in this environment, they already are.

Similarly, information that is presented visually, papers that are exchanged, and information presented in slides or other visual media can all be much more easily processed through OCR and, perhaps some day, image description processes that could instantly render printed text into auditory or Braille form for individuals who are blind. Small text can be enlarged for individuals with low vision. Even individuals who have reading disabilities, from dyslexia or for other reasons, can access printed information by having it rendered vocally. All of the visual presentations of text, which would otherwise be inaccessible in real life situations, can be made accessible in a transparent fashion.

Some types of information will remain inherently inaccessible because they are designed for the primary sense that a user may lack. For example, if the Mona Lisa or the Guernica were included on a slide in someone's presentation, an individual who is blind would not have any easy mechanism for rendering it in a form that they could perceive. However, this would be no more of a problem in this interactive collaborative environment than it would be in real life. They may, however, be able to print Guernica on swell paper which would give them a raised image representation of it and have, in a matter of seconds, a much better idea of what was being discussed than they would otherwise.

Of course, this is all much easier to talk about in theory than to put into practice. Signal levels are poor, voice recognition is not yet good enough, and the architectures do not necessarily support easy separation of data streams for analysis or translation. Gestures and pointing are often used and effective mechanisms have yet to be demonstrated (although they can be envisioned) to allow individuals who are blind to quickly ascertain what objects or words are being pointed to, what gestures are being made, etc.

The purpose of this portion of the project will be to examine the problems faced by individuals with different disabilities in collaborative environments and to draw up a series of requirements for the infrastructure to better support cross disability accessibility and translation. Specifically, individuals who are blind and individuals who are deaf, as well as individuals with physical disabilities, will participate in collaborative work sessions along with individuals who have no disabilities. Each individual will have an assistant and an observer. The assistant will continually provide information to the individual with a disability to help cover for the information that they are unable to perceive (or, for the individual with physical disabilities, the activity which they are unable to perform at all, or quickly enough). The observer will note the type and character of the assistance needed (the sessions will also be videotaped). Care will be taken to separate information the individual truly needed for the interaction from the excess information that might be provided by the assistant.

The various types of information or physical functions that require assistance would be noted. The source of the information (software vs. a person), its characteristics (text, handwriting, voice, gesture), and the way it is transmitted would also be noted. The project teams will then try to theorize strategies that could be used today or in the future to make this information accessible to individuals with disabilities. For example, text displayed on the screen might be run through OCR. When someone points to text, a gesture recognition engine might recognize an elongated object showing up over the top of printed text and automatically alert the individual as to the block of text, located at the end of the oblong object, at the end of the object that does not run off screen, etc. The team will then try to identify changes that would need to be made in the architecture to help support this capability. For example, if voice recognition were used to translate voice into visual presentation, then the architecture should be able to request and receive a higher quality audio text stream. It should also keep the text streams separate so that they could be individually run through voice-recognition algorithms. The structure also needs to be able to handle the simultaneous display of the speech and the recognized text as a standard part of the display functionality. Those hard of hearing could select which to listen to.

Where possible, the actual hypothesized mechanisms will be tested, that is changes made to the architecture and filters or translators introduced to test the ideas. Wizard of Oz simulations (i.e. a human “behind the scenes” in effect simulating an electronic simulator) may be used to stand in for speech recognition or OCR activities that are on the horizon but not yet ready for this difficult an application.

Results of this phase of the project will be threefold: a) a report delineating the strategies and the required infrastructure features needed to support this type of accessibility, b) a report delineating the success of individuals with disabilities participating in interactive environments with real or simulated (Wizard Of Oz) filters and translators in place, and c) changes to the Tango infrastructure to better support accessibility now and in the future.

Cognitive Development and Access to the IKN

Cognitive development depends strongly on learning through observation and direct manipulation of one’s environment. However, cognitive development tends to be impaired in children with motor disabilities, because current devices provide limited direct control over their environment for lack of reliable interface technology. Giving children such control is a key functional goal in the clinical service delivery of assistive technology. For example, powered mobility vehicles allow disabled children to experience movement and control and can facilitate their social and cognitive perceptual and functional development (Cook and Hussey, 1996)

Flexible devices are needed that are able to accommodate a range of cognitive skills, thus unlocking functional abilities through giving kids a way to interact with and control their environment. Mastery of the agent device, requiring adaptation to its sensitivity and dynamics would in itself be an experience promoting development of motor control.

The shared environment of TangoInteractive and the versatility of NeatTools will allow children with severe disabilities to interact in a virtual collaborative environment, including with others at remote locations via the IKN. Virtual personal devices (VPDs), such as avatars, will be controlled by physiological signals for the purpose of providing children with severe motor disabilities a device with which they can navigate and manipulate the collaborative environment. The impact of such VPDs would be to provide exploratory agents that would allow the children to tele-interact, thereby unlocking their cognitive abilities, promoting curiosity and a sense of entitlement to explore, and allowing development to continue. The VPD thus offers new tools and means for working together over distance and time.

Hypothesis 4: A remote virtual personal device (VPD) under the control of a child with a severe disability can *promote cognitive and motor developmen*t.

Scenario: Jane is a 14-year-old girl with severe cerebral palsy. Her expressive skills are limited speech and some consistent foot motion. She responds to visual and auditory stimulation and has been tested to have low but normal receptive cognitive abilities. *Vision*: The VPD system designed for Jane is a virtual grasper manipulator on wheels that she controls with a foot switch. A physical device transmits enhanced speech signals and visual and auditory feedback is provided on a monitor or through a headset. With this manipulator Jane participated in a series of Tango/NeatTools-based science experiments on-line. A year after Jane started using the VPD, she tested for high receptive cognitive abilities for her age.

Hypothesis 5: The interface can be optimized by using subtle physiological signals to control the device and multisensory feedback.

Scenario: John, a 12-year-old boy with quadriplegia, has some controlled facial movements. He is nonverbal but responds to auditory and visual stimulation and his cognitive abilities seem normal. *Vision*: The VPD designed for John through NeatTools harnesses his facial movements to give him a library of interactive signals to control the VPD and initiate pre-recorded voice comments.

Hypothesis 6: The actions of the device, which is intimately tied to the user, can be used as a new technique to evaluate children whose capabilities have not been elucidated.

Scenario: Matt, a 16-year-old boy with cerebral palsy, has very limited speech, but good large motor control. He responds well to tactile stimulation, which seems to improve his directed movements. Cognitive testing has been inconclusive. *Vision:* The VPD designed for John through NeatTools uses a haptic (force) interface which provides enough feedback for him to make controlled movements. Through Matt's participating in simple science experiments involving forces and masses, we are able to assess his perceptual and cognitive abilities. Using experiments with large haptic sensory components, the tasks will progress as his abilities and interests are discovered.

The scope of this phase of the research will be to develop the human interface and control signals, and prototype a class of exploratory agents with audio, visual, and navigational capabilities. Further research will define the exploratory environment and collect human performance data to implement the clinical tool for evaluating cognitive development. The long term goal of this project is to test the hypotheses that exploratory agents will facilitate cognitive development in children with severe mobility problems, and that through evaluation of the tele-interaction we can set and implement ambitious functional goals for severely disabled children.

Vision of the Intermental Knowledge Network

Our basic goal is to develop an Intermental Knowledge Network (IKN), where the minds of collaborating individuals are linked among themselves and to distributed electronic information resources. This IKN will use a variety of sensors and actuators to enhance the rendering and expression of information to and from the collaborating minds. This will enable minds to have universal access to the IKN independent of most physical disabilities. In our Knowledge Network, computers play three distinct roles. First, there is the powerful but rather conventional role as Web and other types of servers dispensing and creating knowledge on demand: they create an electronic information world with universal access in which fertile medium our IKN is built. Our project IKN will specialize in bootstrap fashion on the study of information aimed at building IKNs like ours. Second, computers serve the human minds in linking them to this world: here we use our NeatTools software to rapidly prototype and optimize the universal access for particular individuals. Third, our IKN will enable more than the traditional incoherent asynchronous interactions of minds with Web based information systems. Conventionally each client (human mind) links essentially independently to a single (Web) server in a given transaction. The IKNs wisdom is obtained by the incoherent but interacting sum of individual contributions. As in a parallel computer, our proposed IKN will, as needed, enhance this asynchronous activity with the coherent and synchronous linkage of minds together to tackle a single problem. This coherent linkage is achieved by developing our collaborative system, TangoInteractive, to support universal access. Already Tango supports both synchronous and asynchronous activities, but this feature will be further extended in this project. Note that our concept is a major extension of the interesting and still developing shared immersive virtual environments. In the latter, one represents the world classically by the actions of other people on it. In contrast, an IKN directly represents other participants through a rendering of their perceptual states. Similarly, an IKN reverses the traditional role of the human and computers. Rather than the human, as the usually asynchronous viewer of the computer's possibly parallel computations, the digital computer network serves as the fertile medium supporting the truly powerful computer corresponding to the synchronous interactive IKN of *linked minds*. Note how designing our universal access knowledge network has naturally led to the novel concept of an intermental network which can be used in essentially all Knowledge Networks—whether or not they feature the use or study of universal access.

IKN Technology Summary

There are three major distinctive technologies needed to implement our IKN. First, there are the sensors and hardware interfaces needed to implement the linkage of individual minds to the IKN via universal access. Second, there is the software system NeatTools that implements a powerful rapid prototyping dataflow paradigm to integrate the hardware components into complete client systems. Finally, we form the coherent synchronous IKN using the TangoInteractive collaboratory which formally supports the sharing of distributed objects which are either the linked minds or information "nuggets" from an underlying web.

TangoInteractive for the Universal Access IKN

Currently TangoInteractive, like the pioneering Habanero system on which it was based, supports the powerful event-sharing model for replicated objects which appears to be most appropriate for any KN supporting synchronous object sharing. In this proposal, we extend Tango in two critical ways. Tango is built around core client and server infrastructure, which is exposed to the user as a “Control Application.” This graphical user interface allows overall control of and access to the linked users and applications. This information naturally must be universally accessible to all the minds involved in an IKN synchronous session. We will extend our current Java GUI to support universal access. This should be quite straightforward, as this applet has rather limited and well-defined scope.

Universal access to other shared objects will be handled differently and will exploit Tango's ability to support the linkage of different views of a given object. Any object can be automatically mapped through filters embedded in Tango's core infrastructure, and so customized separately for each client. We will design a suite of filters that will provide access to chosen classes of users. Note that support of different views is already implemented in Tango, but for cases where clients have different roles, such as teacher and student, rather than different interface requirements. Note too that support of different views requires cooperation between server and client. For instance, a user who is blind would download an audio-enriched version of the object, while a client who is deaf would download the image-rich version. On the client side, we would use NeatTools to interface the chosen object views with the available sensors. Note that we will develop some filters such as sonification (sound generation) for general HTML pages that will be useable on a broad class of objects. Other filters will be specialized to particular objects, such as a shared Java educational applet illustrating a physical simulation.

Any KN will need both synchronous and asynchronous collaboration. Tango’s capabilities will be extended in this respect as part of ongoing activities outside this proposal. Already Tango supports several versions of a shared Web browser, and we are adding a database backend for recording synchronous sessions for later playback. We are also linking Tango with Lotus Notes, so as to be able to exploit its well-known workflow and asynchronous tools, such as calendars and threaded discussion lists. Other relevant Tango extensions include support of a classic multi-room paradigm with possible persistent applications and users, and appropriate security.

NeatTools Enhancements and Additional IKN Applications

NeatTools will be modified progressively towards the goal of universal access. Already a user who is physically disabled, for example Eyal, can use a NeatTools network like the JoyMouse (see above) to open a second instance of NeatTools to do his own design and editing. Eyal is already accustomed to drag-and-drop and cut-and-paste operations. The zoom features of NeatTools facilitate fine editing. Still, we need to make some straightforward changes to make it easier and safer (e.g. see comments below about clicking on links) for such individuals to compose and edit in NeatTools.

Our work with Eyal will continue along the lines described above to continually improve performance parameters and his active role in a range of educational and other activities. The new thrust will be to involve him actively in the IKN both from school (see commitment letter by Dr. James Stacey, Eyal's physics teacher) in the science education context, and from home. We intend to get him directly connected with Bader and other students of similar age in Kuwait (see *Kuwait Collaboration*, above), particularly to test laboratory science collaboration at a distance, using NeatTools (and Tango) at both sites (multiple instances as assistive software and as lab interface and control software with Internet sockets). In the likely event that Eyal stays in Syracuse for college, we expect to keep him involved in our research to mutual benefit. We will also enlist other high school students to succeed him.

The most exciting challenge in extending NeatTools will be to introduce core functionality to accommodate users who are blind, so they can effectively use what for others is a *visual* programming environment. This will be necessary for learning NeatTools, studying existing networks, and creating and editing networks.

Given the multimedia and database capabilities of the current version of NeatTools this challenge is not as difficult as it would at first seem. Among the plans for this core extension are a) using sound cues to indicate, on demand, the absolute 2D mouse position on the desktop. (x and y coordinates would be represented by different instrument sounds and the actual values would be indicate by pitch); b) synthetic speech clips, maintained in a NeatTools database would indicate explicitly that the mouse cursor is over a particular module (or group thereof), and then which connection zone at the boundary it is over, if any (data types, parameters, properties, etc. could also be enunciated on demand); c) adding speech to represent existing visual highlighting of links from the current module that the mouse is over to tell which others it is connected to (and exactly how; also, similarly when the mouse is over a link to announce which modules it connects to); and d) adding voice announcements when certain display modules like LED indicators and pushbutton switches change their representation (brightness, high/low relief, etc.) as a result of input signal changes and/or mouse click actions. In the current NeatTools, clicking on a link (connecting line) is the way to remove it (mouse-over is the way to identify its connections). For the user who is blind, and perhaps optionally for others (esp. new users) too, an explicit warning will be enunciated before the action is effected, and also undo operations will be available. For other reasons besides this accessibility extension, speech capability has been planned for the core of NeatTools anyway, and will be enabled/disabled as one of the global properties. To add the particular sound clips, especially (but not only) for users who are blind, will not take up much extra memory or disk space.

We will experiment with haptic feedback devices like the *Feel-It* Mouse from Immersion, Corp. to help the user sense the topography of the network modules and connections. We can also make our own transducers to offer perceptual (e.g. tactile) cues without requiring a special mouse system; we are about to do just that sort of R&D work on a DARPA contract.

The tutorial for NeatTools—currently in a partial draft in Shockwave and accessible online and also downloadable from the www.pulsar.org site—will be enhanced to accommodate training of users who are blind. This multimedia tutorial lends itself well to such enhancement. These audible and other enhancements will clearly benefit general users as well.

Eye-tracking System

Adaptive displays provide a sophisticated way to assist people with disabilities. In an adaptive display, the system monitors performance (reading, tracking, manipulation) and then adjusts parameters (font size, speed of movement) to improve performance. The user monitor will also measure fatigue levels to assist in performance optimization.

In this project, an inexpensive eye-tracker, based upon off-the-shelf components will be developed into a much more affordable form than current commercial eye-tracking systems that have typically been priced in excess of $10,000. Our unit component costs will be roughly $400 for a video-capture card, $100 for a camera, and $50 for electronic and optical components. Given the Syracuse team's ability to produce, in small quantities, an analog-plus-digital serial interface at a parts and assembly cost of about $50 (TNG-3; designed to be used in conjunction with freely downloadable NeatTools software and various sensors; see above) the system cost would amount to only about $600, and could eventually be licensed and marketed at a price far below those of existing eye trackers.

Another difficulty with the current eye trackers, beyond price, is poor functionality, including onerous set up time for calibration, and subsequent drift of calibration. We will pursue several approaches to reduce the need for calibration (by automated protocols, driven by a reset) and by the use of relative measures that will provide functional controls in a mode other than gaze pointing. Drivers will be developed for specific applications: word processing, arithmetic operations (spreadsheets), and Web surfing. The NeatTools environment will allow us to integrate eye tracking with other applications, such as voice recognition and button presses. Further, Tango will allows researchers and users to develop and test this system for long-distance collaboration and education in the IKN framework.

Dr. Viirre has extensive experience in research on the brain's control of eye movements, development of eye movement monitoring equipment, and software integration. The development of eye-tracking control systems must be undertaken with the understanding of what functions the brain is doing with eye movements, before one can impose new demands.

An artificial intelligence tool kit will be built for NeatTools that will allow it to monitor the user. Physiologic parameters will be monitored, such as heart rate, breathing rate as well as specific performance measures, including eye-tracking parameters and button presses. These performance measures will be correlated with specific activities in any task domain to allow the system to determine performance. For example, reading rates will be measured and, if they are slow or if there is a great deal of line repetition, the font size will be increased or the word spacing altered. The AI engine will be custom configurable to each user's ability. If the user has low vision or unstable eye movements, the control parameters will be altered for slower performance. Research will be carried out to assess more abstract conditions, such as level of frustration and this will be used again in more elaborate or abstract fashions. Ultimately the eyetracker and adaptive interface will be useful for people with no disabilities as well.

Results from Prior NSF Support — Edward Lipson (PI) and Geoffrey Fox (co-PI)
NSF award number: ASC-9523481   Dates: 11/1/95–10/31/98   Amount: $927,935 (total costs for three years, not including two supplements discussed below)
Title: "Integration of Information Age Networking and Parallel Supercomputing Simulations into University General Science and K–12 Curricula"

This Metacenter Regional Alliances grant is concerned with developing Web-based educational modules based on four supercomputing simulations projects: a) membrane fluctuations, b) fluid dynamics, c) crackling noise and associated hysteresis, and d) crack propagation in societal structures, such as dams. The former two projects are conducted at Syracuse University, respectively in the physics department and in aeronautics. The latter two take place at Cornell under a subcontract.The project is progressing on schedule in all four areas. Because of space limitations, this report will focus on the physics department activity. Additional information on all four modules is available via our grant project Web site (physics.syr.edu/courses/mra and ice.syr.edu/simscience).
We have created Java applet versions of both our fluid- and crystalline-membrane simulations (which arise from representations of "string" theories in particle physics and cosmology). These can be downloaded (www.phy.syr.edu/courses/mra/devlog/demo6/demo6.html and www.phy.syr.edu/courses/mra/devlog/demo7/demo7.html) We have also written several other Java applets to illustrate other ideas in physics and principles behind the main simulations. For example, we have written an applet that simulates a simple spring—how the force and stored energy change with extension—to illustrate how the springs used in our crystalline membrane applet work. In addition to Java applets and digital video we have used virtual reality modeling language (VRML) to visualize the output of off-line membrane simulations. Some example "worlds" can be downloaded from www.phy.syr.edu/courses/mra/devlog/demo5/demo5.html. We are using examples from everyday life and biology in particular to motivate explanation of the concepts underlying membrane physics. We have also demonstrated collaborative versions of some applets using NPAC's innovative Tango collaboratory system (www.npac.syr.edu/tango/).

The project is carried out with the participation of one postdoctoral research associate at Syracuse and several graduate and undergraduate (REU) students at both institutions. We were awarded a $25,000 REU supplement in the summer of 1997. In addition, we have been awarded a $350,000 supplement for integration of this project with vBNS/Internet II. However, these funds will be spent only after connectivity is achieved; Syracuse University is currently negotiating connection arrangements with MCI, NYSERnet, and NSF.

The project Web site is undergoing a facelift thanks to the participation of a team of students from the Computer Graphics program in the College of Visual and Performing Arts (http://creativity.syr.edu/~mra).

Publications

- Catterall, S., Goldberg, M., Lipson, E., Middleton, A., and Vidali, G. Implementation of information technologies in the teaching of "Science for the 21st Century" *Int. J. Mod. Phys. C* 8:49-66, 1997.
- Warner, S., Catterall, S., and Lipson E.D. Java simulations for physics education. *Concurrency: Practice and Experience*, 9:477-484, 1997.

Results from Prior NSF Support – Gregg Vanderheiden

A. NCSA Contract No. : ACI-96-19019 NSF Award No.: 8902829 (NSF through NCSA)
Total $: $1,055,735
Period: 10/01/97 - 09/30/02

B. Universal Design/Disability Access Program of NCSA-PACI Grant

C. Significant Results or Events: 1/1/98-3-31/98

* We have reviewed the Alliance '98 Research Demonstration Projects to identify and prioritize both the needs and opportunities for incorporating universal design or disability access. Are specifically targeting several projects for UD/DA contact and potential collaboration (esp. at Alliance '98).

* The Webmaster's Accessibility Toolkit (linked with efforts of the World Wide Web Consortium (W3C) is progressing. We are formalizing workscopes and budgets with members of the UD/DA Virtual Team to perform work on specific elements of the toolkit. We are also in the process of securing supplementary funding to support additional people and components of the toolkit.

* Formal reviews for accessibility have been initiated for the Tango Interactive (http://tango.npac.syr.edu/tango/), Tenet (http://www.tenet.edu/), Alliance Intranet (http://aim.ncsa.uiuc.edu/), Chickscope (http://chickscope.beckman.uiuc.edu/), and ChemViz (http://www.ncsa.uiuc.edu/edu/chemviz) web sites. We have also been working informally with members of the webmaster groups at the NCSA (http://www.ncsa.uiuc.edu/), Alliance (http://alliance.ncsa.uiuc.edu) and NPACI (http://www.npaci.edu/) sites. Because each site presents unique challenges due to its complex structure, we have used an collaborative approach to develop appropriate accessibility enhancements.

* The November 1997 ACM articles about the Alliance were converted into an accessible format and distributed to our 12 member UD/DA virtual team to aid them in understanding the goals and scope of the Alliance. These are also available to others who would like to share this information with colleagues who have difficulty with printed materials.

Expected results, progress and/or events in the coming quarter: 4/1/98-6/30/98

* Four members of the UD/DA team will attend the Alliance '98 meeting. Gregg Vanderheiden will be making 2 presentations at the conferenceOur specific objectives are to observe, experience, and learn more about the various Research Demonstration Projects, and to establish collaborative relationships with the P.I.'s and project teams that were specifically identified by our UDDA Advisory Team as having high potential (or high need) for UD/DA development. We will begin a review of NPACI (and continue to monitor NCSA-Alliance) programs for similar UD/DA prospects.

* Continue to add information and resource material for the UD/DA website, such as the accessible version of the November 1997 ACM articles about the Alliance, to expand it's usefulness to both Alliance members and the public. We have asked for permission from ACM to post these accessible forms of the articles to the web. If permission is granted, these documents will be posted on the UDDA web site: http://www.trace.wisc.edu/world/udda (with possible links from other sites on the NCSA and Alliance sites as well).

* On the Webmaster's Accessibility Toolkit, our goals for the 3rd Quarter are: to secure supplementary funding for additional personnel and components of the toolkit (at approximately 3 times our PACI-EOT resources for this task); identify current tools and components of the toolkit; establish functional specifications for those components; and define sub-contracts for the development work on the components.

***** We expect to complete the formal web site reviews initiated in the 2nd Quarter for the Tango, Tenet, and Alliance Intranet sites. We will continue to cooperate with webmasters at all sites we have contacted to assist them in making their sites accessible.

* Hold full virtual-team teleconferences to address specific UD/DA issues in Distributed Learning and Collaborative Environments, and on the accessibility of data structures.

* Continue to participated in bi-weekly teleconferences with National EOT Steering Committee members to provide input on relevant UD/DA issues, both within the EOT Program, and across the PACI & NPACI Alliances.

D. No publications, to date

E. See above.

F. N/A

Results from Prior NSF Support — Corinna Lathan

D. Past NSF research

PI on Current planning grant
IRI-9712526, $18,000, Aug 15, 1997—December, 1998
Quantitative assessment in complex multisensory human-interface environments

This is a planning grant to identify and assess advanced input and output devices associated with complex multisensory interfaces from a *human computer interface design* perspective and explore potential methods for *measuring performance* in environments that use these interfaces in the rehabilitation community.

Number of Students Supported: 1
Number of Papers Generated: 2 in progress

Results from Prior NSF Support — Erik Viirre

Award Date April 17, 1997
Grant No. IRI-9703598
Award Amount: $296,979
This project, under the direction of Thomas A. Furness III and Erik Viirre, Human Interface Technology Laboratory, is entitled:

"Optimization Studies for Applications of a Scanned Light Display."

This award is effective May 1, 1997 and expires April 30, 1998.
This is a continuing grant which has been approved on scientific /technical merit for approximately 3 years.

Viirre E. 30% time for 12 months.

The first year of this three year project has been successfully completed with the construction of our research devices and initial research studies commenced. We have completed our objectives for the first year. A abstract on the flicker frequency of the scanned light display has been accepted for a national vision research meeting. This research has contributed to development of a new visual display for medical research.

Publications: Viirre E.S. The Virtual Retinal Display: a new display technology for medicine. Proceedings of Medicine Meets Virtual Reality VI, 1998

Kelly J.P., Pryor H.L. Viirre E.S., Furness III T. Decreased flicker sensitivity with a scanned laser display. Investigative Ophthalmology & Visual Science (Suppl), 1998, 39, S399.

PLANS FOR DISSEMINATION OF RESULTS

Results will be continually posted on our Web sites. Access to freely downloadable software will be maintained by the NPAC Web server, as is already the case for the current versions of TangoInteractive and NeatTools software. When appropriate, software licencing agreements will be made through Syracuse University.

Hardware items (sensors, transducers, computer-interface boxes like TNG-3) that cannot be freely distributed will be made available at low cost through the following two affiliated companies: MindTel, LLC and WebWisdom.com, LLC. Both companies were formed in 1997 in association with Syracuse University under the auspices of a) the CASE Center (Computer Applications and Software Engineering), a New York State Center for Advanced Technology, and b) InfoMall, the technology-transfer program of NPAC. The partners of MindTel are Edward Lipson and David Warner; Geoffrey Fox is a principal of WebWisdom.com. For additional information, see www.mindtel.com and www.webwisdom.com. These companies will market these products to help ensure the widest possible dissemination. We will however continue to donate, or sell at cost, systems to those in need. Mass markets will be sought (e.g. science education kits) to help provide a wider profit margin so that we can continue to offer our devices to people with disabilities at the lowest possible cost.

The Trace Center (G. Vanderheiden, Director and project co-PI) has excellent connections in the disabilities field and will play a major role in progressively publicizing and disseminating the results of the project as they become available.

INSTITUTIONAL COMMITMENT AS TO SPACE AND EQUIPMENT

As described under *Facilities, Equipment and other Resources*, the participating institutions have ample space and equipment resources for the conduct of the project.

PERFORMANCE GOALS

First Year

- Establish all preliminary specifications for software and hardware systems.
- Define the essential architecture, functionality, of the Intermental Knowledge Network (IKN) that will both underlie the research of the project and serve as a basis of the research
- Test the IKN among the US Institutions and those in Kuwait
- Incorporate preliminary core extensions into both NeatTools and TangoInteractive software, so that users who are blind or otherwise disabled can construct their own designs and configurations
- Focus on individuals (as team members) who are quadriplegic or blind
- Begin expert user testing of systems
- Develop base version of eye-tracking system

Second Year

- Complete the base functionality of NeatTools and TangoInteractive
- Redefine and reconfigure IKN as needed
- Begin novice user testing (more stringent than with experts, above)
- Complete eye-tracking system hardware and software

Third Year

- Launch full-scale collaborative testing of software and hardware under the IKN
- Include open field testing including new individuals at remote sites who will be unaware that some users in a given session have disabilities
- Include objective controlled testing comparing sessions including or not including users with
- Publish and present ongoing and final results of the project at conference, on the Web
- Proceed with full-scale dissemination of results and products, including plans for continuation after end of funding for this 3-year project
- Apply for funding for project continuation

PROJECT MANAGEMENT AND MODES OF COLLABORATION

The PI and co-PIs will together constitute an executive committee that will jointly coordinate the project. They will meet at least monthly using TangoInteractive in a multimedia videoconferencing mode; the meeting agendas will posted in advance on the Web. When appropriate, other team members at the various sites—including those with disabilities—will participate during part of these meetings to present results and raise any issues of general concern. In any case general meetings will be conducted online at least bimonthly. Continual communications among all participants will take place by e-mail, telephone, and Web page postings (with e-mail alerts). A enlarged technical committee will also be formed and will communicate similarly.

In addition, the results, and plans of the project will be maintained on Web sites at all participating institutions to compare notes and progress at our various sites. As stated in the project description, the mode of collaboration itself will constitute a knowledge network, as we perform research on knowledge networks that maximally include people with severe disabilities.

The main project will be divided into subprojects in the following areas:

- Knowledge Network Design
- Software Infrastructure (Tango & NeatTools)
- Sensors and Transducers, Interface Electronics, and Mounting Hardware
- Science Education
- Assessment
- Deployment

Individual members of the executive committee will be assigned to be in charge of one or two of these respective areas. The PI will take at least one and will also oversee and coordinate the entire project. Overall management will be organized and tracked using the program Microsoft Project to establish goals, targets and assigned roles to the various individuals at each participating institution including the group in Kuwait.

بسم الله الرحمن الرحيم

Kuwait Institute for Scientific Research معهد الكويت للأبحاث العلمية

Date :
Ref. No. :

التاريخ :
المرجع رقم :

Professor Edward Lipson
Department of Physics
Syracuse University
Syracuse NY 13244-1130
USA

fax 315-443-9103

Dear Professor Lipson

I reviewed the information you sent me regarding your proposal of the "Knowledge Network" and I consider that it will be an excellent project and a good global chance to all people with severe disabilities to make use of and participate in. On the behalf of every one at the Department of Systems & Control (SCD) at the Kuwait Institute For Scientific Research (KISR), I strongly support your ideas about KN and Distributed Intelligence and including us as an active part of the "testbed".

We here at KISR have been conducting applied research on providing technical support to the disabled people at the Kuwait Special Schools for the past 15 years. In the past, we had a number of projects concerning the Deaf and the Blind students at KSS. With your support of NeatTools, we hope to extend our services to those with Quadriplegia as well. A web page for our projects with the disabled will be added soon to KISR's Web site (http://www.kisr.edu.kw/) under the Engineering Division's System & Control Dept.

I enjoyed meeting with you last November and seeing your demos at KISR and KSS. We are awaiting the receipt of the TNG-3 interface, custom joystick and sensors which you are donating and shipping to us this month. We have downloaded NeatTools and begun our study of it. At KISR we have excellent electronic and machine shop

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Kuwait Institute for Scientific Research معهد الكويت للأبحاث العلمية

facilities where we can make sensor devices and mounting apparatus as we need them.

I hope to see you again in person during the next year. Meanwhile we will proceed with our long distance collaboration as we have recently confirmed. I hope that the NSF will be able to support your work with us. I am on the process of obtaining an approval of our work through the official channels with the Ministry of Education, including assistant deputy undersecretary Mohammad Al-Humaidi, who oversees KSS and who you gave a demo of NeatTools and evices to. I expect enthusiastic support from MOE.

Please accept my best regards.

Yours sincerely

Hani D. Qasem

Hani D. Qasem
Manager
System & Control Dept.

SYRACUSE
CITY SCHOOL DISTRICT

WILLIAM NOTTINGHAM HIGH SCHOOL
3100 East Genesee Street
Syracuse, New York 13224

May 9, 1998

Edward Lipson, Professor
Department of Physics
Syracuse University
Syracuse, NY 13244-1130

Dear Dr. Lipson,

I am writing to express commitment to your NSF proposal on universal access and knowledge networking. My students, science faculty colleagues, and I are eager to continue participating as part of your expanding team to promote science education for all students. I am pleased that your team is increasing its scope to other American institutions and even to Kuwait. We will be pleased to participate on such research on interactive science education with other schools in the area here, and with Kuwait special schools.

During this year, my Regents Physics students and I have enjoyed participating in your assistive technologies project. We have all benefited greatly. It has given us all the opportunity to do "cutting edge" research and to enable one of our most physically challenged students, Eyal Sherman, to participate more fully in his science classes. I have personally enjoyed working closely with you in planning this project and in its implementation. We are all grateful for the generous equipment donations you have made, as well as the training sessions. We all are looking forward to continuing work with you on the development and implementation of knowledge networking and assistive technologies for science education. To understand why my students and I are so enthusiastic about this project, let me review a few of the things that have happened lately.

This year has seen a tremendous growth in potential for Eyal Sherman through the application of NeatTools software, powerful personal computers, and allied equipment and training. Of the many successes we have had, three stand out for special mention: two focus on assistive technology in a non-networking environment and the other emphasizes knowledge networking and interactive science education. In the first example, Eyal and another student recently completed a reflection lab together. The lab involved the study of the number of images of a penny that were created when two vertical flat mirrors were progressively folded inwards. As the angle between the mirrors decreased, the number of images increased. Eyal's lab partner set up the lab so that Eyal could observe, comment on the process, and enter data into Graphical Analysis for Windows. As Eyal's partner did his part of the work, Eyal began his by using his custom joystick, facial switches, TNG-3, and your JoyMouse NeatTools network. After manipulating the graphs he had created, Eyal printed out the lab results. He was also able to participate in the analysis and writing of the report. It was the first time that Eyal had ever fully participated in a science lab. It was a thrill to see the joy in Eyal's eyes.

The second classroom example is even more complex and challenging. Using LEGO DACTA equipment and software (running under NeatTools), Eyal and another student are currently simulating the use of a microbot to travel arteries or veins to deliver pharmaceuticals to a tumor. They will use a LEGO robot to traverse some furnace pipe (the simulated artery) to deliver a syringe full of "medicine" to a simulated tumor. Eyal's lab partner is constructing the robot in consultation with Eyal, and Eyal is in control of the software that guides the robot through the artery. Eyal is typing the report.

One of the impressive things about your system is not only its ability to increase the range of control it allows a physically challenged person, but also its cost. What we have experienced is that many of the input devices may be made quite inexpensively and easily. Consequently the monetary costs of this assistive technology appear to be quite low. Compared to other assistive technologies, the range and number of students able to use this technology thus appears to be much greater. Our use of student partners for Eyal obviates the need for trained professionals to interpret or otherwise enter information he generates. Consequently, the NeatTools system has great potential for maximizing independent functioning of disabled students.

The third area of activity focuses on using the NeatTools and Tango systems to increase connectivity for students who traditionally would be excluded from using Internet resources for science education. Since Nottingham High School has been connected to the Internet and the Web, the inclusion of nontraditional students in knowledge networking has become a major goal. Nottingham High School is a center for the Syracuse City School District for the education of special needs students. I am on the school's Technology Committee, which is charged with the development and implementation of technologies for including more students into the educational experience. What we are currently working on in science is the ability for Eyal and other physically challenged students to do their research using Internet resources, to perform interactive experiments, and to perform more complex knowledge networking, such as participating in the Red Rover LEGO Mars Lander project. In this project, each school maintains a site simulating a Martian landscape with a robotic rover (with video link) which is controlled remotely by another school. We will be testing our networking locally by trying interactive experiments with a neighboring school district. The possibility of knowledge networking to enhance Eyal's, and similar students' connectivity with a larger world is becoming the most exciting part of our work with your team.

Even though Eyal will complete his physics requirements next month, and will move on to chemistry in the next, his senior, year, we have all agreed to continue participating together in the research project next year involving physics as well as chemistry experiments. We hope to include some biology as well. Eyal will be available during some of the study hall periods, and occasionally after school. In addition, we are actively seeking other students at Nottingham High School who would be appropriate participants in this research. While Eyal may be the first at Nottingham High School to participate, he will not be the last. Based on our initial inquiries with the Special Education Department, there are several other students at Nottingham High School with a range of disabilities who would like to participate. The science teachers and selected students are enthusiastic about participating as needed in this research.

I have taught for many years at the college and high-school levels, and have often acted as the advisor to physically challenged students. As a participant in this important research, I see a chance to assist many of our disabled students in becoming more fully participating in the classroom. The potential benefits of this research extend well beyond Eyal Sherman, the student initially involved in this study. Every day, one can see students at Nottingham High School who would benefit from the results of this proposed research.

My students are excited not only because of the chance to do this type of research, but also by the possibility of helping one of their classmates. We all strongly recommend your project to the National Science Foundation.

Yours sincerely,

James E. Stacey

James E. Stacey, Ph.D.
Physics Teacher

D. REFERENCES CITED

Baxter, L.K. *Capacitive Sensors: Design and Applications*, IEEE Press, New York, (1997)

Cook, A.M. and Hussey, S.M. Assistive Technologies: Principles and Practice, Cook and Hussey, Mosby-Year Book, 1996

Fraden, J., *AIP Handbook of Modern Sensors; Physics, Designs, & Applications*, 2nd ed., American Institute of Physics (A I P Press), Woodbury (1996).

Laux, L. F., McNally, P. R., Paciello, M. G., and Vanderheiden, G. C., Designing the World Wide Web for People with Disabilities: A User Centered Design Approach, in *Assets '96 : the second annual ACM Conference on* Assistive *Technologies*, Association for Computing Machinery, New York, N.Y., pp. 94 (1996).

Peatman, J. B., *Design with PIC Microcontrollers*, Prentice-Hall, Upper Saddle River, NJ (1998).

Vanderheiden, G. Use of multiple parallel interface strategies to create a seamless accessible interface for next-generation information systems. RESNA 17th Annual Conference, Nashville, TN, (1994).

Vanderheiden, G. Anywhere, anytime (+anyone) access to the next-generation WWW. Proceedings of the 6th WWW Conference, San Jose, California, (1997).

Edward Lipson, Professor of Physics, Syracuse University

EDUCATION

Ph.D. Physics, California Institute of Technology, Pasadena, CA (1971)
B.Sc.(Hons.) Physics and Mathematics, University of Manitoba, Winnipeg, Canada (1966)

ACADEMIC EMPLOYMENT

1996-97	Interim Chair, Department of Physics, Syracuse University
1995-96	Acting Chair, Department of Physics, Syracuse University
1994-	Faculty Associate, Northeast Parallel Architectures Center, Syracuse University
1990	Compton Visiting Professor, Department of Biology, Technion (Haifa, Israel; January-May)
1989-1995	Associate Chair, Department of Physics, Syracuse University
1985-	Professor of Physics, Syracuse University
1983-89	Director, Graduate Biophysics Program, Syracuse University
1980-85	Associate Professor of Physics, Syracuse University
1976-80	Assistant Professor of Physics, Syracuse University
1974-76	Senior Research Fellow, Caltech
1971-74	Research Fellow, Caltech

HONORS

1979-83	Alfred P. Sloan Foundation Fellow
1972-74	NIH Postdoctoral Research Fellow
1966-69	NSF Predoctoral Fellow
1966-67	Woodrow Wilson Fellow (Honorary)

PUBLICATIONS

Five publications most closely related to the proposed project

Warner, S., Catterall, S., and Lipson E.D. Java simulations for physics education. 1997. Concurrency: Practice and Experience, 9:477-484.

Catterall, S., Goldberg, M., Middleton, A., and Vidali, G. 1997. Implementation of information technologies in the teaching of "Science for the 21st Century" Int. J. Mod. Phys. C 8:49-66. Pratap, P., Palit, A., and Lipson, E. D. 1986. System analysis of *Phycomyces* light-growth response with sum-of-sinusoids test stimuli. Biophys. J. 50:645-651.

Lipson, E. D. 1995. Action Spectroscopy. In: Handbook of Organic Photochemistry and Photobiology (Horspool, W. and Song, P.-S., editors), CRC Press, Boca Raton, pp. 1257-1266.

Chen, X., Xiong, Y., and Lipson, E. D. 1993. Action spectrum for subliminal light control of adaptation in *Phycomyces* phototropism. Photochem. Photobiol. 58:425-431.

Lipson, E. D. and Horwitz, B. A. 1991. Photosensory reception and transduction. In: Sensory Receptors and Signal Transduction. (J. Spudich and B. Satir, editors), (Modern Cell Biology, Vol. 7, B. Satir, series ed.) Wiley-Liss, New York, pp. 1-64.

Five other significant publications

Sineshchekov, A. V. and Lipson, E. D. 1992. Effect of calcium on dark adaptation in *Phycomyces* phototropism. Photochem. Photobiol. 56:667-675.

Palit, A. and Lipson, E. D. 1989. System analysis of Phycomyces light-growth response in single and double night-blind mutants. Biol. Cybern. 60:385-393.

Palit, A., Galland, P., and Lipson, E. D. 1989. High- and low-intensity photosystems in Phycomyces phototropism: effects of mutations in genes madA, madB, and madC. Planta 177:547-553.

Cerdá-Olmedo, E. and Lipson, E. D., eds. 1987. *Phycomyces*. Cold Spring Harbor Laboratory, New York (430 pages).

Poe, R. C. and Lipson, E. D. 1986. System analysis of Phycomyces light-growth response with Gaussian white noise test stimuli. Biol. Cybern. 55:91-98.

COLLABORATORS (last 48 months)

Syracuse University

Simon Catterall; Geoffrey Fox; Marvin Goldberg; Alan Middleton; Marek Podgorny; Gianfranco Vidali; David Warner; Simeon Warner

Queens University (Kingston, Ontario, Canada)

Michael Korenberg

ADVISEES (last 5 years)

Syracuse University

<u>Graduate students</u>

Jiangang Guo; Xiyin Chen; Michael Dowler; Taviare Hawkins

<u>Postdoctoral Research Associate</u>

Simeon Warner

MY GRADUATE AND POSTGRADUATE ADVISORS

California Institute of Technology

<u>Graduate:</u> Felix Boehm (Nuclear Physics; professor emeritus)

<u>Postdoctoral:</u> Max Delbrück (Biology; deceased)

Geoffrey Charles Fox

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Citizen Status: Permanent Resident Alien; Citizen of United Kingdom

Education:
B.A. in Mathematics from Cambridge Univ., Cambridge, England (1961-1964)
Ph.D. in Theoretical Physics from Cambridge University (1964-1967)
M.A. from Cambridge University (1968)

Professional Experience:

1990-	Professor of Computer Science, Syracuse University
1990-	Professor of Physics, Syracuse University
1990-	Director of Northeast Parallel Architectures Center
1979-1990	Professor of Physics, California Inst. of Tech.
1986-1988	Associate Provost for Computing, California Inst. of Tech.
1983-1985	Dean for Educational Computing, California Inst. of Tech.
1981-1983	Executive Officer of Physics, California Inst. of Tech.
1974-1979	Associate Professor of Physics, California Inst. of Tech.
1971-1974	Assistant Professor of Physics, California Inst. of Tech.
1970-1971	Millikan Research Fellow in Theoretical Physics, Caltech
1970	Visiting Scientist (April-May), Brookhaven National Laboratory
1969-1970	Research Fellow at Peterhouse College, Cavendish Lab.,Cambridge
1968-1969	Research Scientist, Lawrence Berkeley Lab., Berkeley, Calif.
1967-1968	Member of School of Natural Science, Inst. for Advanced Study, Princeton, New Jersey

Awards and Honors
Senior Wrangler, Part III Mathematics, Cambridge (1964)
Alfred P. Sloan Foundation Fellowship (1973-75)
Fellow of the American Physical Society (1990)

Journal Editorships

Principal:	Concurrency: Practice and Experience (John Wiley, Inc.)
	Physics and Computers (International Journal of Modern Physics C - World Scientific)
Associate:	Journal of Supercomputing,

Selected List of Publications - Geoffrey C. Fox

1. Fox, G.C., Johnson, M.A., Lyzenga, G.A., Otto, S.W., Salmon, J.K., Walker, D.W., Solving Problems on Concurrent Processors, Vol. 1, Prentice-Hall, Inc. 1988; Vol. 2, 1990.
2. Fox, G. C., Messina, P., Williams, R., Parallel Computing Works!, Morgan Kaufmann, San Mateo Ca, 1994.
3. Fox G.C., Furmanski W., “Computing on the Web,New Approaches to Parallel Processing,Petaop and Exaop Performance in the Year 2007 IEEE Internet Computing, 1997 (to be published)
4. Fox G.C., Podgorny M, Cheng G. et al., “Web Technologies for Collaborative Visualization and Simulation”, SIAM Parallel Processing Conference, 1997 (to be published)

5. Fox G.C., Dincer K.,"Using Java and JavaScript in the Virtual Programming Laboratory: A Web-Based Parallel Programming Environment" Special Issue on Java, Concurrency:Practice and Experience 1997.
6 Fox, G. C. "Parallel Computing and Education," Daedalus, Journal of the American Academy of Arts and Sciences, Vol. 121, No. 1, pps 111-118, Winter 1992. C3P-958, CRPC-TR91123.
7. Fox G.C., Mills K., "InfoMall: an Innovative strategy for high-performance computing and communications application development", Internet Research, 4:31- 45, 1994.
8 Fox, G.C., Hiranadani, S., Kennedy, K., Koelbel, C., Kremer, U., Tseng, C.W., Wu, M.Y., "FortranD Language Specifications", Rice COMP TR90079, December 1990, Revised, April 1991.
9. Fox, G. C. "Approaches to Physical Optimization," in Proceedings of 5th SIAM Conference on Parallel Processes for Scientific Computation, pp 153-162, March 25-27, 1991, Houston, TX, J. Dongarra, K. Kennedy, P. Messina, D. Sorensen, R. Voigt, editors, SIAM, 1992.C3P-959, CRPC-TR91124
10 Fox, G, Bozkus, Z., Choudhary, A., Haupt, T., and Ranka, S. A compilation approach for Fortran 90D/HPF compilers on distributed memory MIMD computers," in Proceedings of the Sixth Annual Workshop on Languages and Compilers for Parallel Computing. Lecture Notes in Computer Science, Springer-Verlag, pp. 200--215. U. Banerjee, D. Gelernter, A. Nicolau, and D. Padua (editors).

Summary of Interests

See: http://www.npac.syr.edu/DC

JAVA based Computation: http://www.npac.syr.edu/projects/javaforcse

For education: http://www.webwisdom.org

And for recent distance education: http://www.webwisdom.org/papers/jsu/jsuexpt.html

Fox is an expert in the use of parallel architecture and the development of concurrent algorithms. He leads a major project to develop prototype high performance JAVA and Fortran compilers and their runtime support. NPAC has pioneered use of CORBA and JAVA for both collaboration and distributed computing. Fox is a proponent for the development of computational science and its follow on "Internetics" as an academic discipline and a scientific method. He has established at Syracuse University both graduate and undergraduate programs in these areas. All course have been made available on the Web and his research includes HPCC technology to support education at both K-12 and University level. His research on parallel computing has focused on development and use of this technology to solve large-scale computational problems – such as numerical relativity and earthquake predication. Fox directs InfoMall, which is focused on accelerating the introduction of high speed communications and parallel computing into New York State industry and developing the corresponding software and systems industry. A recent set of activities center on Web collaboration technology and its application to synchronous distance education.

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PhD, Neuroscience, Massachusetts Institute of Technology, 1994
MS, Aeronautics and Astronautics, Massachusetts Institute of Technology, 1995
BS, Biopsychology and Mathematics, Swarthmore College, 1988

1996-Present Adjunct Assistant Professor, Department of Radiology, Imaging Science and Information Systems Center **Georgetown University School of Medicine**, Washington, D.C.

1995-Present Assistant Professor of Biomedical Engineering, **The Catholic University Of America**, Washington, D.C.

1995-Present Consultant to the Medical Staff, **National Rehabilitation Hospital**, Washington, D.C.

1993-Present Founder, **Keys to Empowering Youth**, http://www.ee.cua.edu/~lathan/keys.htm

1996 Design Project Faculty, **International Space University**, Vienna, Austria.

1996 Consultant, National Photographic Interpretation Center (NPIC) Human Computer Interface Guidelines Project.

1995 Visiting Scientist, Laboratory of Perception and Action Physiology**, Centre Nationale De Recherche Scientifique/Collège de France**, Paris, France.

1994-1995 Research Assistant, Sensory Communications Group, Research Laboratory of Electronics, Department of Electrical Engineering and Computer Science, **Massachusetts Institute Of Technology**, Cambridge, MA.

1989-1994 Man-Vehicle Laboratory, MIT Center for Space Research, Department of Aeronautics and Astronautics/Department of Brain and Cognitive Sciences, **Massachusetts Institute Of Technology**, Cambridge, MA.

1990-1994 Research Assistant, Massachusetts Eye and Ear Infirmary, Boston, MA**.**

1989-1990 Consultant, Department of Biomedical Sciences, **Universities Space Research Association**, Houston, TX.

1987 Staff, Ashton Graybiel Spatial Orientation Laboratory, Department of Psychology, **Brandeis University**, Waltham, MA.

Reviewer. International Journal of Human Computer Interaction, American Journal of Public Health, IEEE, Systems, Man and Cybernetics.

Grant Reviewer. National Institute on Disability and Rehabilitation Research (NIDRR) (Panel Chair); National Science Foundation (Multiple Panels); National Institute of Mental Health, IRG: MHSB.

Selected Publications

Lathan, C.E., and K. Cleary, "Performance feedback in a spine biopsy simulator," Proceedings of the SPIE, Vol. 3262, Surgical-Assist Systems. (1998)

Lathan, C.E. and D.J. Newman, "Quantification of human performance in extreme environments," in *Design of Computing Systems: Social and Ergonomic Considerations*, M.J. Smith, G. Salvendy, and R.J. Koubek, Eds. Elsevier, Amsterdam. (1997)

Winters, J., C.E. Lathan, S. Sukthankar, T. Pieters, and T. Rahman, "Human performance and rehabilitation technologies" *Biomechanics and Neural Control of Movement*, Eds. J. Winters and P. Crago Springer-Verlag. *In press.*

Clément, G., S.J. Wood, C.E. Lathan, R.J. Peterka, and M.F. Reschke, "Effects of gravity on visual-vestibular interaction. 1. Comparison between pitch motions around Earth horizontal axis and Earth vertical axis," *J.Vestib.Res*. 8:1-13. (1998)

Lathan, C.E, "Human computer interface design principles for web-based telemedicine systems," *Telemedicine Journal*. 3:1:90 (1997)

Lathan, C.E. and G. Clément, "Response of the Neurovestibular System to Spaceflight," in *Introduction to Space Life Science,* S. Churchill, Editor. Krieger Press: Florida. (1997)

Lathan, C.E., C. Metzger, L. Nelson, and E. Sandberg, "Keys to Empowering Youth, A Science and Technology Mentoring Program for Adolescent Girls," Abst. Presented at the American Society for Engineering Education (ASEE), Washington, D.C., 1996.

Lathan, C.E., C.Wall III, and L.R. Harris, "Human eye movement response to z-axis linear acceleration: The effect of varying the phase relationships between visual and vestibular inputs," *Exp. Brain Res.* 103(2):256-266. (1995)

DiZio, P., C.E. Lathan, and J.R. Lackner, "The role of brachial muscle spindle signals in assignment of visual direction," *J. Neurophys.* 70(4):1578-1584. (1993)

Clément, G. and C.E. Lathan, "Effects of static tilt about the roll axis on horizontal and vertical optokinetic nystagmus and optokinetic afternystagmus in humans," *Exp. Brain Res.* 84:335-341. (1991)

Collaborators

Dr. Joseph Bleiberg, Dr. Nathaniel Durlach, Dr. Mike Rosen, Dr. Dave Warner

Graduate Students

Adrian Blanarovich (M.S., in progress), Zuyi Wang (Ph.D. in progress), Josh Davies (M.S., 1998), Nassib Khanafer (M.S., 1997)

Graduate Advisors

Dr. Emilio Bizzi, Dr. Dava Newman, Dr. Conrad Wall III, Dr. Larry Young

GREGG C. VANDERHEIDEN

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RESEARCH INTERESTS

Research and development in the area of universal design and "everyone interfaces," particularly in the area of information systems, to allow their use by people with the broadest possible range of abilities and disabilities.

EDUCATION

B.S. Electrical Engineering (1972), University of Wisconsin-Madison
M.S. Biomedical Engineering (1974), University of Wisconsin-Madison
Ph.D. Technology in Communication Rehabilitation and Child Development (1984), University of Wisconsin-Madison

PROFESSIONAL EXPERIENCE

1986-Present: Faculty, Human Factors Program, Department of Industrial Engineering, University of Wisconsin-Madison.

1972-Present: Director, Trace R&D Center; a rehabilitation engineering center with a focus on design of communication control and computer access systems. The center currently operates under a 5-year core grant of $3.5 million from the National Institute of Disability and Rehabilitation Research, plus other funding, with a project agenda of 33 projects & programs (affiliated Clinic not included).

1971-Present: Principal investigator on 140+ grants and projects, totaling $15+ million, in the area of Rehabilitation Engineering, Access to National Information Infrastructure and Next-Generation Information Systems, Computer Access Systems, and Augmentative Communication & Writing, Systems for children and adults with disabilities Activities included research, development, commercial facilitation, information summary, and training (pre-service and in-service). Funding sources included, among others:
National Institute of Disability and Rehabilitation Research (US DOE), National Science Foundation, Rehabilitation Services Administration, National Institutes of Health, IBM, Apple Computer, Pacific Telesys, AT&T, American Association for the Advancement of Science, US Government Accounting Office, US General Services Administration, Office of Special Education (US DOE).

SELECTED PUBLICATIONS (More than 150 books, book chapters, journal papers, conference publications, and other articles)

- Vanderheiden, G. (1997) Position Paper: Nomadicity, disability access and the every-citizen interface. In *More than Screen Deep: Every Citizen Interfaces to the National Information Infrastructure. Science and Telecommunication Board*, pp. 297-306. National Research Council, National Academy of Science. Washington, DC. 1997.
- Vanderheiden, G. (1997) Design for people with functional limitations due to disability, aging, or circumstances. In Gavriel Salvendy, Ed., *Handbook of Human Factors and Ergonomics*, pp. 2010-2052. John Wiley & Sons.

- Vanderheiden, G. (1996) Development of a multisensory visual interface to computers for blind users. In *Human Factors Perspectives on Human-Computer Interactions: Selections from Human Factors and Ergonomics Society Annual Meeting Proceedings, 1983-1994*. Santa Monica, California: Human Factors and Ergonomics Society.
- Vanderheiden, G. (1997) Design for people with functional limitations due to disability, aging, or circumstances. In Gavriel Salvendy, Ed., *Handbook of Human Factors and Ergonomics*. John Wiley & Sons.
- Making information systems accessible. *Universal Design*, Volume 2, No. 4, October 1995.
- Access to the global information infrastructure (GII) and next-generation information system. *Proceedings of the 18th International Congress on Education of the Deaf*, Tel Aviv, July 1995. Tel Aviv, Israel: International Congress on Education of the Deaf.
- Symposium on High Resolution Tactile Graphics: Invited presentation, "Dynamic and static strategies for nonvisual presentation of graphic information." Los Angeles, March 1994.
- Vanderheiden, G. Use of seamless access protocol to expand the human interface of next-generation information systems and appliances. *Proceedings of 5th International Conference on Human-Computer Interaction*, August 1993, Orlando, FL.
- Vanderheiden, G. (1990). "Thirty-something million: Should they be exceptions?" *Human Factors*, 32(4), 383-396.
- Lee, S., Wiker S.F., and Vanderheiden, G. Interactive haptic interface: Two-dimensional form perception for blind access to computers. *Proceedings of 5th International Conference on Human-Computer Interaction*, August 1993, Orlando, FL.

COLLABORATORS

Larry Goldberg, CPB/WGBH National Center on Accessible Media
Deborah Kaplan, Issue Dynamics (formerly with World Institute on Disability)
Judith Harkins, Gallaudet University
Judy Brewer, CAST Center, Boston MA
Gavriel Salvendy, Purdue University
Marcia Scherer (private consultant)
Jan Galvin (private consultant)
Al Gilman (private consultant)
Jutta Treveranius (U of Toronto)
Jon Gunderson (Univ of Ill Urbana Champaign)
NCSA
Center for Applied Special Technology (CAST)

GRADUATE STUDENTS

Raphael Acers
Steve Arndt
Wendy Chisholm
Cynthia Cress
Jon Gunderson
Katie Husted
Pamela Laikko
Christopher Law
Seongil Lee
Mei Li Lin
John Mendenhall
Seoungyeon Oh
Yoshihiro Saiko
John Schaab
Angela Seongyeon
Roger O. Smith
Thomas Yen

PH.D. COMMITTEE FOR GREGG VANDERHEIDEN

David E. Yoder
Ronald C. Serlin
John G. Webster

BIOGRAPHICAL SKETCH

NAME	POSITION TITLE
Erik S. Viirre M.D. Ph.D.	Research Scientist

EDUCATION/TRAINING

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	YEAR(s)	FIELD OF STUDY
U. Western Ontario, London, Canada	M.D. Ph.D.	1988	Vestibular Physiology
St. Joseph's Health Center, London, Canada	Intern	1989	General Internship
ENT dept and Robarts Res Inst.UWO London,	fellow(part-	1990-4	Vestibular dis and MRI
Neurology and Ophthal, Sch. of Med, UCLA	visit prof	1995	Vestibular Disorders

Professional Experience

1990-1994:

1.) Private medical practitioner in London, Canada. Operated medical practice for delivery of primary eye care.

2.) Emergency Medical Care: Served as medical staff in emergency rooms.

1995:

1.) Research Scientist at Human Interface Technology Laboratory: Virtual Retinal Display, Vision tests and Low Vision application development of display technology. Supervision of Ph.D. candidate.

1996-7:

1.) Principal Investigator at Human Interface Technology Laboratory: VR-Vestibular project, funded by Washington Technology Center, development of technology for investigation of vestibular-oculomotor changes and motion sickness in users of virtual environments. Supervision of Ph.D. candidate Mark Draper.

2.) Research Scientist at Human Interface Technology Laboratory: Situation awareness in Virtual Environments, funded by Air Force Office of Scientific Research, investigation of motion sickness in virtual environments.

3.) Principal Investigator at Human Interface Technology Laboratory: Vestibular telemedicine Project, in collaboration with Madigan Army Medical Center and Seattle Veterans Administration Hospital, development of technology and protocols to deliver consultations via video technology.

1998:

1.) Appointed as Clinical Instructor (Vestibular Disorders specialist) to the Division of Otolaryngology, University of California, San Diego, School of Medicine.

Honors and Awards

1995 Travel Fellowship, Three Dimensional Kinematic Principles of Eye Head and Limb Movements in Health and Disease. Meeting, University of Tuebingen, Germany.

1995 Travel Fellowship, New York Academy of Sciences Meeting: New Directions in Vestibular Research. Rockefeller University, New York, New York.

1994-5 Fellowship Funding through Charles Feldman Professorship Fund, Jules Stein Eye Institute, University of California, Los Angeles.

1994: McLaughlin Foundation Award.

1992: Canadian Astronaut Program: Semi-finalist Candidate

1988: Full Scholarship to the Inaugural session of International Space University.

1988: Ames Associate At NASA Ames Research Center.

1985-1987: Medical Research Council Studentship: full funding for graduate study in the Department of Physiology.

1984: Medical Research Council Summer Studentship Award.

1983: National Sciences and Engineering Research Council Summer Studentship Award.

1982: Highest Standing in Undergraduate Physiology and Psychology Program, U.W.O.

1981: U.W.O. Continuing Scholarship
1980: U.W.O. Admission Scholarship

5 Most Relevant Publications

(39) Viirre E. Virtual Reality and the Vestibular Apparatus. (1996) IEEE Engineering in Medicine and Biology. 15:41-43.
(36) Viirre E. (1996) Virtual Environments: a new technology for vestibular research. J. Vestibular Res. 6:S74
(35) Martens W., McRuer R,, Childs T., Viirre E. and Williamson J. (1996) Physiological Approach to Optimal Immersive Game Programming: A Technical Guide. IS&T/SPIE Proceedings 2653: Stereoscopic Displays and Virtual Reality Systems III.
(29) Viirre, E. S. and Demer, J. L. The human vertical vestibulo-ocular reflex during combined linear and angular acceleration with near target fixation. Exp. Brain Res 112:313-324, 1996.
(18) Cadera W., Karlik S., Viirre E., and Bloom J. (1994) Ocular Pursuit Movement Assessment by Magnetic Resonance Imaging. J. Ped. Ophthalmology & Strabismus. 31: 265-266.

5 Significant Publications

(2) Viirre E., Tweed D., Milner K. and Vilis T. (1986) A Re-examination of the gain of the vestibulo-ocular reflex. J. Neurophysiol. 56:439-450.
(3) Viirre E., Cadera W. and Vilis T. (1987) The pattern of changes produced in the saccadic system and vestibulo-ocular reflex by visually patching one eye. J. Neurophysiol. 57: 92-103.
(10) Viirre E.S. and Baloh R. (1996) Migraine as a Cause of Sudden Hearing Loss. Headache. 36: 24-28.
(17) Viirre E.S., Johnston R.J., Pryor H.L. and Nagata S. (1997) Laser Safety Analysis of a Scanned Light Display. J. Laser Apps. 9:253-260.
(18) Viirre E.S. (1997) Health and Safety Issues for VR. (1997) Communications of the ACM 40:40-41.

Collaborators

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Miller, David University of California, San Diego
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Warner, David, Syracuse University

Graduate Students

Draper M. H. Air Force Insitute of Technology
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Graduate and Post-Graduate Advisors

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Demer Joseph L. UCLA, Jules Stein Eye Institute
Karlik, Stephen, University of Western Ontario
Vilis, Tutis, University of Western Ontario

David Jay Warner, M.D.

EDUCATION

Doctor of Medicine: Loma Linda University, Spring 1995.
Bachelor of Arts: Physical Science, San Diego State University 1986.

CURRENT POSITIONS

Professional:

Director/CEO of the Institute for Interventional Informatics, 94-Present.
Director of the "Technology Task Force" for the American Telemedicine Association, 96-98
Director of Medical Intelligence for International Telemedicine Associates Inc., 96-Present.

Academic:

Nason Fellow at the Northeast Parallel Architectures Center-Syracuse Univ., 95-present
Adjunct Professor of Pathology and Clinical Informatics-SUNY HSC-Syracuse, 96-present.
Visiting Scholar for the Human Interface Technology Lab-Univ. of Washington, 96-present
(Physiologically based Interface Design).
Adjunct Professor of Plastic Surgery-UCSD San Diego 97-present
(Medical interfacing for assessing task performance).

PUBLICATIONS

<u>Publications most closely related to the proposed project</u>

Warner D, Tichenor J.M, Balch D.C. (1996) Telemedicine and Distributed Medical Intelligence. *Telemedicine Journal* 2: 295-301.

Warner, D., Sale, J., (1995) Interventional Informatics: Healing with Information. In Proceedings of Medicine Meets Virtual Reality III. San Diego, CA: Aligned Management Associates.

Warner, D., Anderson, T., and Johanson, J. (1994). Bio-Cybernetics: A Biologically Responsive Interactive Interface. In Medicine Meets Virtual Reality II: Interactive Technology & Healthcare: Visionary Applications for Simulation Visualization Robotics. (pp. 237-241). San Diego, CA, USA: Aligned Management Associates.

Warner, D., Sale, J., Price, S. and Will, D. (1992). Re-enabling Technologies: Immediate Medical Applications for Virtual Reality Interfaces. In Proceedings of Medicine Meets Virtual Reality. San Diego, CA: Aligned Management Associates.

Warner, D., Sale, J., Price, S. and Will, D. (1992). Remapping the Human-Computer Interface for Optimized Perceptualization of Medical Information. In Proceedings of Medicine Meets Virtual Reality. San Diego, CA: Aligned Management Associates.

Other significant publications

Warner, D., Sale, J. and Price, S. (1991). The Neurorehabilitation Workstation: A Clinical Application for Machine-Resident Intelligence. In Proceedings of the 13th Annual International Conference of the IEEE Engineering in Medicine and Biology Society. (pp. 1266-1267). Los Alamitos, CA: IEEE Computer Society Press.

Viirre E, Warner D, Balch D, Nelson J.R. (1997) Remote Medical Consultation for Vestibular Disorders: Technological Solutions and Case Report. *Telemedicine Journal* 3:53-57.

COLLABORATORS

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Erik Viirre Human Interface Technology Lab, University of Washington
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David Balch, East Carolina University School of Medicine
Jeff Sale, San Diego State University

ADVISEES

I have not advised nor sponsored any graduate students or postdoctoral fellows.

ADVISOR

Nason Postdoctoral Fellowship advisor: Geoffrey Fox, Syracuse University