MULTISENSORY INTERACTIVE NEUROERGONOMICS DEVELOPMENT

M.I.N.D

04/10/03

STREP
OUTLINE

NEST-2003-1 ADVENTURE
2-3 YEARS

Abstract:
The M.I.N.D project expects to explore the best combinations of sensory stimuli that create emotional connectivity, create techniques to evoke more effective emotional links and measure these stimuli and techniques for validity and develop guidelines for future emotionally encoded training scenarios. Just as the VRML97 standard advanced virtual environment development by creating a guideline to unify the work done in dozens of individually developed virtual reality development systems, neuroergonomics standards can help us develop systems that are compatible with natural human behavior for creating safe and comfortable environments. In addition, mental health research difficulties to exploit success stories of current virtual therapeutic environment design, due to inadequacy of standards to specify needed details for personalized emotional design, will be largely assisted. And methodologies and tools for measuring human behavior, understanding and accumulation of measured behavior, and assisting human behavior, will be developed. *This project does not fall within the domains of research of the FP6 thematic priorities.*

Introduction

Multisensory environments are environments that occupy more than one sense at the same time. One of the greatest outcomes and side effect of the 21st century technological advancement is the radical development and expansion of multisensory environments. To create living and social environments in which humans are able to attain more comfortable and fulfilling lifestyles, enhancement of the compatibility between environments, products, and machines with human senses is necessary. An evaluation procedure that could measure and evaluate human sensations quantitatively and an application technology, which enhances the use of data on human sensations in the design of consumer devices and environments by addressing emotional ergonomics or neuroergonomics, is nowadays essential more than ever. Are there things beyond sensory inputs we can take advantage of? *Can we provide certain cues that will enable the trainee to construct a story? Prime people to pay attention to certain things? Have parts of the environment exist in subjective time and space? Adapt techniques of other media (such as film) or create our own? Tap into people's memories? Learn from recent advances in cognitive science?*

On top of that, one of the latest World Health Organization reports, written by a Nobel Prize winner, stated that by the year 2050, the medical science would find a way to cure most of today's and future diseases, except from heart problems and depression. These two causes will be the most frequent causes of death by the year 2050 and beyond. Although the many advances of biological and computer sciences in the field of medicine, genomic research, neuroscience, biotechnology and bioinformatics the emotional interplay between multisensory environments and human behavior is largely unexplored. The recent trends of "pervasive" and "proactive" computing or even "Presence[1]" that fall within the domains of research of the FP6 thematic priorities are urgently depended from standards derived by an ***emotional ergonomics theory***.

As an outcome, by the development of such standards, not only will we be able to develop safe and comfortable multisensory environments, but also assist human behavior, augment cognition, prevent mental illness, adapt to novel and extreme situations and create really effective training scenarios. This can be achieved by integrating scientific knowledge on various human characteristics, including body shapes, physical movements, sensations, cognition, emotion and behavior, into the design process. Consequently, human life multisensory environments evaluation, which is a study of human beings in relation to the design of products, environments, and social systems, is becoming the center of attention.

Among the many approaches available within the field of sensory environments evaluation, this project adopts as its basis, virtual reality therapy and ergonomics, and arms to bring light to the significance of human emotional connections. In particular virtual reality therapy and ergonomics can, create emotionally evocative environments of different intensities and set up testing and evaluation environments with specific combinations of sensory stimuli.

[1] Project VIEW – Nottingham University, Emotionally biased cognition – CATLab, Aristotle University

Objectives

The emotional connection is proven enhance learning and retention. We are going to look at the role our senses play in providing an emotional connection. Among the questions that we are going to try to answer are:

- What threshold levels of each sense are necessary to stimulate emotional connectivity?
- Can we determine the most effective combinations of these levels?
- What else can we do to create environments with more emotional links?

The M.I.N.D project is creating rich, multi-sensory virtual environments in order to investigate how environments themselves can evoke a range of emotional responses from participants who experience them. Research indicates that we become more involved with emotionally charged situations and remember them better than emotionally neutral ones. Thus, more effective training scenarios can be designed by incorporating key emotional cues.

Just as so many years of research in Cognitive Science and HCI have recently produce ergonomic guidelines and the GOMS model (1997) in order to capture the complex cognitive interactions between a user and it's environment, with M.I.N.D we aim to develop an ***emotional GOMS model*** to index and capture the feelings and sensations existing in a multisensory human-centered environment. These heuristics will be used the same way that we use computer language to construct and evolve multisensory experiences that encode specific situations. The data captured can be used to develop multi-agent mission critical systems, artificial emotional intelligent agents, affective computing appliances, safe and comfortable human environments, mission rehearsal exercises and next generation virtual reality simulations with somatic feedback.

In addition, we are investigating levels of different sensory stimuli needed for the most effective multisensory experience. We expect that our efforts in providing emotional realism will be an enhancement factor for the resolution of other sensory inputs, without additional processing power. Through our studies we hope to determine the most effective and efficient combinations of graphics, sound, smell and emotional cues.

State-of-art

Emotions play a central role in our lives. A wealth of empirical research has revealed a complex interplay between emotions, cognition and behavior. Emotional state may impact decision-making, actions, memory, attention, voluntary muscles, etc., which, in turn, can influence emotional state. Teasing apart and understanding these complex relationships is not an easy undertaking.

The focus of the research at EU is on general software agents that model human performance in rich simulated worlds, such as the Mission Rehearsal Exercise, where intelligent agents interact with a human participant to facilitate the training objectives. Project VIEW for example focuses in creating advanced visualization technologies that

can be used for education, rehabilitation and training. In addition there is work done in United State's Universities, in collaboration with the army regarding Emotionally Evocative Environments for Training.

In more detail, project MRE currently in progress at the University of Southern California's Institute for Creative Technologies (ICT), involves developing better graphics, sound and artificial intelligence to be used in creating the next generation of training tools for the United States Army. This project focuses on the use of emotional responses as an enhancement for training. Described as "Lush VR", the MRE Project provides an amalgamation of detailed sensory input for extremely compelling training scenarios.

In Japan, there is the work of Professor Chan-Sup Chung and Behavior-Based Human Environment Creation Technology (1999-2003). This project uses new approaches to human-oriented technology and analysis of a variety of human functions. The project focuses on two basic action groups: "operating behavior" (driving and mastering working skill) and "moving behavior" (human behavior at construction sites and within the home). The project has been commissioned by the New Energy and Industrial Technology Development Organization (NEDO).

It is clear that EU has a leading role regarding the use of emotions in design and computational modeling of behavior regarding complex situations and this can be seen in the various publications produced in the field of ergonomics, information systems, human factors, pervasive computing and multi-agent systems. The M.I.N.D projects aims to integrate and update the results produced by all of the above projects into a unified theory that will cover the requirements for ***standards*** and guidelines to create rich multisensory experiences and systems.

Scientific Approach

Our research involves the role sensory and emotional stimuli provide in the overall virtual experience effect. Our efforts examine detailed computer graphics, secondary sound cues, olfactory stimuli, and lighting effects, as well as associative memories to create heightened realism and believability in psychosocial systems. Secondary sounds, like distant convoys, barking dogs, fired rounds and other peripheral noises require the trainee to make order and sense out of potentially distracting environments. Enhanced graphics, including transparency and layered renders to simulate fog, rain, sleet, dust, and heat distortion, along with Hollywood-type effects techniques are incorporated into the simulation world for more "photo-realism". The addition of smells (olfactory cues) will incorporate researching the state and usefulness of current scent delivery systems. The role of memories and associative reasoning in training scenarios will also be investigated for their contribution for overall emotional content.

Evaluation studies in year 3 will determine the intensity of the emotional experiences for each participant, with and without specific emotional cues such as smells and ambient

sounds. Physiological data captured during the experience will be factored into the evaluations.

We are exploring design techniques to create worlds that take advantage of expectations, interest and natural world interactions to help structure a "narrative" both within and after participation in an open-ended Multisensory Virtual Environment (VE). I intend to take advantage of a participants' natural tendency to prefer interaction when possible, resulting in worlds that form their meaning out of intention and interaction – of the author as well as the participant – in a mutual form of authorship.

Sensory Stimuli
Visual
• 3D worlds with rich detail
• Subtle and believable lighting techniques
Auditory
• Ambient and peripheral noises that provide realism
• Spatialized sounds triggered by participant's actions
Olfactory
• Research the state of current scent delivery systems
• Determine effective olfactory cues for emotional connectivity
Tactile
• Low frequency sounds to induce and augment emotional states - "Visceral sound"

The mission sounds innocuous enough: "to see how information technology can be diffused into **standards** and **indices** for everyday objects and settings, leading to new ways of supporting and enhancing people's lives". However, one of the **risk elements** that exist in this project is the process for discovering biological and emotional signal signatures for group interactions or single user interactions. Since even in single user scenarios, there is still a lot of difficulty in identifying these signatures, due to intrinsic causes (e.g. non linearity of relationships) and extrinsic causes (e.g. sweating has an effect on GSR). The challenge of this project is not to rig up the set up but find a system configuration and use a plethora of statistical tools and "cognition technologies" in order to discover the relationships/signatures.

So in this project, the focus is NOT on a universal system design that will fit all users, but rather on a multisensory configuration or tools that will FOLLOW some **situational** ergonomic guidelines and will be able to MEASURE and ADAPT to individual awareness, therefore providing a more **Anthropocentric interface**.

Impact

The knowledge gained from the M.I.N.D project will contribute to the advancement of a highly complex and realistic Experience Learning System, providing a heightened sense of awareness for the users who use it. Context-aware and proactive systems will hide overall system complexity, and preserve human attention, by delivering to us only information, which is rich with meanings and contexts. Now maybe we are missing

something, but to us this translates as: build systems that are too complicated to understand and then, after they are deployed, find ways to master their complexity.

One of the problems with "open, unbound, dynamic and intelligent systems", says Greger Linden, a Finnish expert in "psychosocial computing", is that when direct brain-computer interfaces are implemented, "people will be the problem. Rather than concentrate on one thing at a time, which suits the software, people tend to think about other things. M.I.N.D plans to develop models for "disambiguating" users' vague commands, and anticipating their actions.

M.I.N.D guidelines and results could also help researchers that are developing machine vision systems that will scan us for "psycho physiological signals" and "sense and understand human actions". Eye-gaze, pupil-dilation and contraction, gaze direction through time, blinking, facial ticks, breathing and heart rates, will all be monitored remotely by systems designed to "understand our cognitive and emotional state of mind".

It may be a long way before we find a method or a tool to try to **map the unconscious**, however the development of **standards** and **indices** that can guide us to monitor the users and provide them with learning, and gracefully evolving capabilities, as well as self-diagnosis, self-adaptation and self-organization capabilities, maybe a step to the right direction. The M.I.N.D can impact the creation of a mental health knowledge base that can help greatly in mental disease prevention and have an enormous social and economical impact.

Serious dangers are often created by individuals who try to carry out critical activity when they are "not in a fit state to". The M.I.N.D project could develop agents that will monitor these users and decide on behalf of them for their welfare. We mention Space Exploration and Crisis Management Situations as some examples of critical activities. We have a reason to invest a lot of money into Deep Space or even Earth terra-forming projects and activities, we see no reason why shouldn't we invest the same amount in finding out some mind terra-forming techniques and activities, that all of the above activities are depended from.

This project is a collaborative, interdisciplinary research NOT within the domains of research of the FP6, which involves cognitive scientists, computer simulation experts, clinical and cognitive psychologists, virtual reality experts, human factor experts and ergonomists to say the least, in an ADVENTURE to achieve the following results:

- Development of human sensory indices
  (Indices for measuring stress, fatigue and arousal, indices for measuring environmental suitability, indices for measuring product suitability)
- Development of human sensory measurement methods and evaluation methods
  (Evaluation of physiological conditions, evaluation of thermal environments, prototype system for evaluating dimensional suitability, others)
- Development of Human Sensory Database Model and editing Human Sensory Measurement Manual