PORTABLE VIRTUAL ENVIRONMENT GENERATOR: InterFACE

David J. Frerichs

Future Vision Technologies, Inc.
Champaign, IL 61820 - Mountain View, CA 94041

Abstract

The relationship between people and computers is currently undergoing a rapid transformation. What was once an inert, complex tool is becoming a natural extension of the user. Current products in the form of personal data assistants and personal communicators are leading the way in this paradigm shift, but they also retain unnecessary barriers between the user and the device. In order to complete the transformation, the computer must become functionally transparent to the user. Ubiquitous computing holds promise toward this end but has severe limitations in terms of installation and upgrade costs. Virtual environment technology provides a viable alternative, if properly implemented, by seamlessly integrating the user's senses with the growing global information network.

This paper is an overview of the InterFACE project at Future Vision Technologies, Inc. InterFACE is a new type of computing device which merges portable computing, wireless communications, synthetic environments and telepresence into a wearable package. The technology is introduced in contrast to existing systems in terms of form, flexibility and ease of use and thereby a framework for market justification is formed. The evolution of the system is also described and major application types are detailed.

1.0 Introduction

InterFACE represents the merging of four different technologies to create a new model for personal computing. Portable computing, wireless communications, synthetic environments, and telepresence are combined to transform the computer from a useful gadget to a direct extension of the user's senses. By focusing on technology available today, InterFACE is designed to fill current application needs. InterFACE is not a vehicle for techno-gratification. It is a practical solution to specific problems with room to evolve for the future. Product solutions have been defined and molded around available technology. Implementations requiring technology which is "not there yet" have been put off for future generations. The applications as implemented will work without caveats. The goal is not to implement technology for technology's sake, the goal is to implement a meaningful product.

InterFACE was defined using a top-down market analysis. Although the basic technology of the system has been developed purely because it can be done, the later generation prototypes are designed with specific applications and market needs in mind. The top-down method of planning is crucial to the implementation of viable products based on synthetic environment technology. By designing a product for a specific end-user application, InterFACE satisfies direct consumer demands without depending on novelty to spontaneously generate a market.

2.0 A New Type of Computing Device

The InterFACE product line is a bold departure from current personal communications devices. The embodiment of the InterFACE product line merges portable computing, wireless communications, synthetic and/or augmented environments, telepresence, computer agents, and various input devices that respond to the human body to form a unique, wearable computing device. InterFACE will allow the user to perform a wide variety of tasks including communication with other people and computing devices (such as a fax machine or mainframe computer), document and media processing, and CAD/CAM design.

The basic function of InterFACE is to wrap an information space around the user. The user simply looks around and sees germane information floating in the air at locations appropriate to the application. This method of viewing information is much more useful than information tied to a small screen on the desk or in the hand. The information is visually tied to real objects, real viewpoints or grouped with other relevant information around the user. The user's natural sense of spatial arrangement enhances the storage, retrieval and comprehension of digital information. Through InterFACE, the world becomes the user's filing cabinet. This action has the side-effect of changing the relationship between the user and the computer. The computer is no longer a passive tool, but a direct extension of the user's senses. The computer becomes an efficient bridge between the user's central nervous system and the ever expanding world-wide computer network. People will be able to see what the network sees and know what the network knows in a truer fashion. By removing the limits of information access, InterFACE gives new meaning to "workgroup computing."

The power of InterFACE can be visualized through an example application. A field engineer wearing the InterFACE unit to a remote customer sight can evaluate the client's drawings and simultaneously transmit what he sees back to a team of architects at the main office. The field worker can interactively design a three-dimensional representation of the client's proposed model with the home office team while discussing specific changes with the client. As the client shows the field engineer around their facility, the remote team travels along. Meanwhile, the software agent (built into the InterFACE unit) can receive voice mail and faxes from other clients and sort them in order of importance. The agent can alert the worker to his/her messages based on the worker's defined preferences and bring them into view as desired.

InterFACE is in the research and development stage. Prototypes have been built which prove the concept is viable. These prototypes have generated preliminary feedback which is being incorporated into subsequent designs (see Figure 2-1). The next step is to integrate, refine and develop additional technologies that will mature into a meaningful product offering.

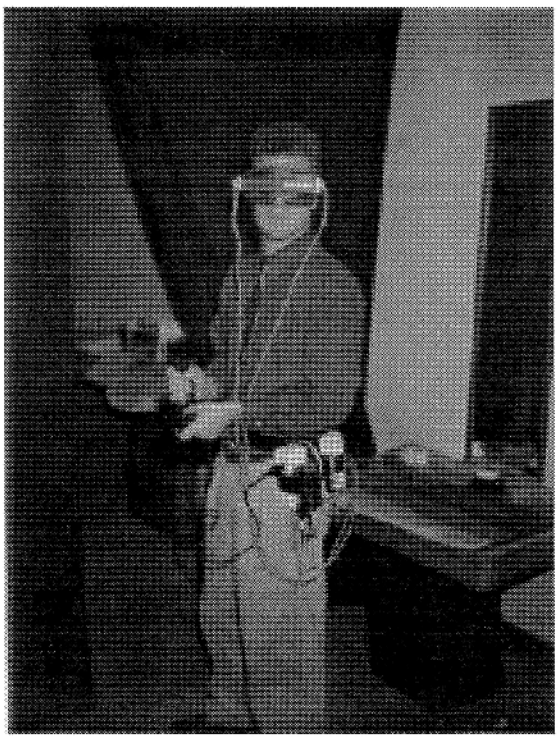

Figure 2-1: InterFACE Generation 3

3.0 Evolution of InterFACE

InterFACE began as an independent research project by Matthew H. Klapman. After two prototypes were developed in 1990, a third prototype was completed. This "Generation 3" unit achieved a workable form factor and provided the basis for ongoing research at Future Vision Technologies, Inc.

3.1 Generation 3

The first public exhibition of InterFACE technology was at the University of Illinois Department of Engineering Open House on March 2, 1991. This system, a third generation prototype, was the first truly portable virtual environment system in existence, although it was displayed in a "nailed-down" configuration. It's internal structure consisted of a control engine, a parallel processing transform engine and a display controller with external interfaces to two PrivateEye displays, a parallel joystick interface, an RS-232 port and a proprietary program slot.

This system, known as the "white box," required 5V power which could be provided from a plug-in transformer or from a notebook computer battery. When publicly displayed in a portable configuration at the San Francisco VRG meeting in March 1993, the white box was strapped to the user's belt with two wires running up to the stereo head-mounted display. When a program cartridge is inserted into the slot and the system is powered up, the user can move the joystick to negotiate the virtual-world using a vehicle model. The unit displays minimal complexity wireframe models with three simple buildings at around 20 frames per second. Direct measurements of exact polygon rates were never measured due to a lack of proper development tools, but it was clear from use that the system needed to be improved to increase rendering performance. In addition, the system lacked a modular design and user position tracking. These problems have been addressed in the successive generations.

3.2 Generation 4

The fourth generation development cycle consisted of multiple operational prototypes and was not intended to produce a complete product. The goal of each of these prototypes was to explore possibilities in increasing rendering performance while reducing power consumption and cost. The final technology that was adopted increased raw rendering performance to 640 Million peak binary pixels/second. (The measurement of binary pixels is relevant due to the nature of the PrivateEye displays.) In addition, sourceless head orientation tracker was developed. This device measures the user's head yaw and pitch relative to the torso. Based on a lightweight mechanical linkage, the tracker provides accurate, real-time orientation data without tying the user down. The tracker is also extremely durable. Although the device was originally developed for use in home video game applications, its rugged design allows it to operate in hostile environments like in a burning building or on the battlefield. The tracker's unique combination of features made it ideal for integration into future InterFACE units.

3.3 Generation 5

The fifth generation prototype is a significant improvement on the initial designs with the focus being on a standardized expansion capability. The system has a modular design based around a core processor with separate rendering engine and peripheral components. The rendering module allows the system to be specifically constructed for various turnkey applications from the most basic 2D monoscopic to full color stereo immersion. The peripheral slots, conforming to PCMCIA 2.0, open InterFACE to existing peripherals like GPS and wireless communication and reduces engineering redundancy. PCMCIA also provides an inexpensive, efficient development option. Applications can be developed on a PC, written to a flash ROM card and tested without a cumbersome console interface. Figure 3-1 displays the basic structure of the InterFACE fifth generation system.

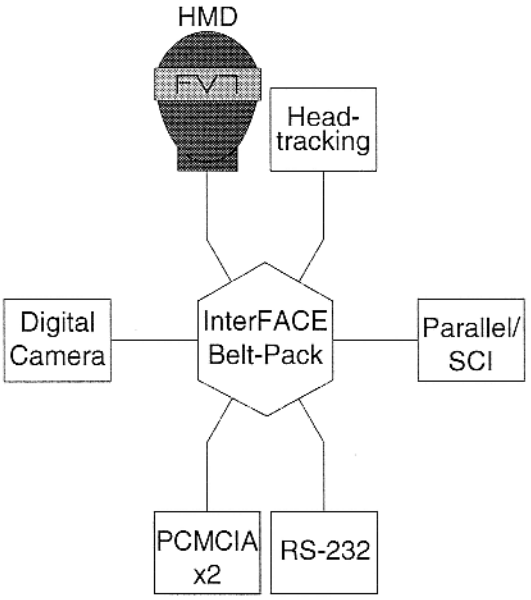

Figure 3-1: InterFACE, Fifth Generation Unit Block Diagram

The hardware in this generation of InterFACE is capable of generating a stereoscopic immersive environment on PrivateEye displays or a monoscopic augmented reality on a color liquid crystal display. Augmented reality is implemented using a digital camera placed on the front of the head-mounted display. The output of this camera is mixed with the InterFACE generated graphics at the pixel level. This unique configuration also allows the user to share what is being viewed through an optional composite video jack on the side of the unit.

Unlike most portable computing platforms, InterFACE has stereo sound integrated into the system design. Not only will this allow bi-directional voice communication, it will also serve to assist multisensory immersion and to increase the bandwidth of the information pathway. Audio icons are an effective way to communicate urgent information to the user while the visual channel is in use. Through the inclusion of sound, InterFACE is viable for a wider range of applications than would otherwise be possible.

The FVT sourceless tracking system developed during generation 4 has also been integrated into the unit. The orientation tracker combined with a flux-gate compass for absolute vector and GPS for ground position gives the portable system sufficient tracking capability required to satisfy many military, police and manufacturing applications.

This version of the InterFACE system, while representing the state of the art in current technology and integration, is not the end of the road. The main limitations of the current state of the art are wireless communication service coverage, short battery life, and poor display cost/performance. These and other problems will be solved as technology progresses. Although the current implementation is suited for many applications (see Section 5.0), Future Vision Technologies will continue to refine and extend InterFACE in order to open new markets.

3.4 Future developments

Near-future modifications to the InterFACE system will concentrate on the display subsystem. The addition of real-time texture mapping and color stereoscopic immersion are the likely next steps in the evolution of the product line. Support for new input peripherals currently under development at FVT will also be added. Most importantly, the open design of the core architecture allows InterFACE to assimilate new proprietary and third party technologies as they become available.

InterFACE is not intended to be a "flash in the pan." The basic premise behind the product will be viable well into the future. InterFACE project long range goals focus on miniaturization, increased functionality and increased fidelity. As technology progresses, the form factor will trend toward a light pair of glasses which have all systems fully integrated. Input will be via natural speech processing and output will be through high-resolution, variable focus image generators. The software user interface will also evolve towards a more intuitive represenation of digital information. Although this type of specification may seem superfluous, long term goals are essential if InterFACE is going to address the needs of today's and tomorrow's markets.

4.0 Market Justifications

The computer marketplace is undergoing rapid changes. The industry has evolved from simple word processor and spreadsheet capabilites to multimedia and communications. There is a growing demand for these capabilities in desktop and portable computing devices. Their inclusion in products has increased the range of communications applications from text to video telephony. The merger of the computer, telephone and television have created new demands to make these increasingly complex devices simple to use. Current user interface technology such as a window-mouse environment has made the computer easier to use but it is still not as intuitive as communicating face-to-face. New user interface methodologies are required to make the next generation of computers more user friendly.

The first products to deviate from the traditional window-mouse user interface are the Personal Digital Assistants (PDA)/Personal Communicators. These devices apply a new user interface that addresses the integration of portability and communications in the form of a pen-tablet metaphor which is an attempt to improve on using pen and paper. This user interface is new to the marketplace and may prove to be a beneficial alternative to the window-mouse interface, but it still has not created the final computer-user interface. There are many drawbacks to the pen-tablet metaphor, an example is not being able to perform physical tasks while interfacing to the device, e.g. prepare dinner while simultaneously purchasing a few thousand shares of MCI stock. Also, PDAs are not adept at manipulating sound or video. In sum, the problems of the pen-tablet PDA's reduce user productivity and limit the environments in which they can be used.

The market is forming for a computer which merges a natural multimedia interface with portable computing. Although current technologies are a great stride forward, they still do not present the user with a computer interface which is as simple as talking with someone face-to-face. InterFACE provides a way to complete a transformation of the computer from an inert tool into a direct extension of the user's senses.

5.0 Applications

The focus of the InterFACE project is to develop real application solutions which can be provided to end users in a simple, complete, easy-to-use package. The InterFACE hardware provides a turnkey platform that can be programmed for a multitude of tasks. A list of applications which take advantage of InterFACE's features is suggested below.

- Search and rescue infostation (firefighter, ski-patrol, park ranger, etc.)
- Police personnel infostation
- Soldier battle infostation
- Computer network management
- Manufacturing and repair infostation
- Transportation personal infostation (truck drivers, train personnel, airport ground personnel)
- Architectural design
- Ultra personal infostation
- Tourist guide infostation

Each of these applications requires that a large amount of information from a wide range of sources be simultaneously displayed to the user. The unique synthetic environment technology in InterFACE solves the problem of displaying dense information on a portable platform making it perfectly suited to these applications. In each of these areas, an introduction to new computing paradigms has already begun through the use of personal data assistants and personal communicators. Once the limitations of these devices become apparent, InterFACE will have a ripe target market.

6.0 Conclusions

After four years of technology refinement, the market is ready for the implementation of portable synthetic environments. The synthetic environment technology in InterFACE provides a step forward in portable computing. It enables a new kind of personal data assistant defined best as a wearable infostation. Instead of interrupting the flow of action to process information, the user is surrounded by an infospace where required information is displayed in a non-obtrusive manner. This infospace changes the relationship between the computer and the user. The user is no longer forced to comply with the computer's interface requirements. The computer and the user are seamlessly interfaced, making the computer an extension of the user's senses. Only by achieving this can a product like InterFACE be accepted in the marketplace. InterFACE provides a level of usability where consumers will be ready to embrace synthetic environments as a useful tool instead of a toy.

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