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AN APPLICATIONS-ORIENTED APPROACH TO THE DEVELOPMENT OF VIRTUAL ENVIRONMENTS

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ABSTRACT

The field of Virtual Reality (VR) is diverse, ranging in scope from research into fundamental enabling technologies to the building of full-scale entertainment facilities. Due to the multi-faceted nature of this field and complicated by excessive media attention and interpretation, the concept of virtual reality means many things to many people. Ideally, a definition of VR should derive from how this technology can provide solutions to existing challenges in building advanced human-computer interfaces. The measure of success for this technology lies in its ability to enhance the assimilation of complex information, whether to aid in difficult decision-making processes, or to recreate real experiences in a compelling way. This philosophy and the virtual environment development process employed by the engineers and artists at GreyStone Technology, Inc. is described using an example from a VR-based advertising project. The common and unique elements of this example are explained, though the fundamental development process is the same for all virtual environments that support information transfer. In short, this development approach is an applications-oriented approach, one that begins by establishing and prioritizing user requirements and seeks to add value to the information transfer process through the appropriate use of VR technology.

INTRODUCTION

This paper describes the development process used by GreyStone in the creation of virtual environments to support complex information transfer. Rather than focus on iterative improvements in display technology or image generators, what is presented here is a discussion of how the initial design of a virtual environment must be geared to the ultimate application of the system and how the various technology components that underlie that system are integrated to provide a working, value-added interface. The emphasis here is on recognizing the unique value of this medium for information transfer and maintaining product focus throughout the development process. This "applications-oriented" process is not specific to certain applications, but is adapted and modified depending on the requirements of the end-user and is driven by factors such as current and emerging capability, affordability, and the accomplishment of specific application objectives. The kinds of applications that have been developed using this process include planning, training, and entertainment experiences.

The Value of Virtual Reality

First, it is useful to put this discussion in the proper context and provide some background. GreyStone is in the business of creating information processing and information transfer products. The company recognizes that information is a critical commodity - the commodity of the future. This focus on information is shaping the nature of business across the globe, and the possibilities for both providers and consumers is enormous. Today, the sheer volume of information available to consumers and businesses is staggering, and this level continues to increase exponentially. But, having access to a large volume of data is of no value unless the information is presented in a usable form. That is where virtual reality comes in: VR technology allows us to build systems that put information into a usable form and make it accessible to the user in an effective way.

It is hard to underestimate the importance of information to human society. In fact, it could be argued that the ability to record and transfer information is the primary ability that distinguishes humans from all other animals [1]. Being able to represent ideas and observations as recorded symbols gave our early ancestors a major competitive advantage. And though other animals can use tools or communicate via language, only our species is able to capture important information in symbolic form to be passed on to future generations. So, the current information revolution is not the first, but one in a series of societal shifts that have influenced our evolution. The current "information age" is about the ability to put information into digital form, to process that data very quickly via computer, and to distribute information at the speed of light to everybody on the planet (and beyond).

Information, then, is a *representation* of something else. In its representational form, it is inert, dependent on somebody or something to *interpret* its meaning and complete the transfer process. With the recent ability to rapidly create and copy information of high volume and complexity came the requirement to complete the information transfer process in more effective ways. The proper employment of VR technology allows this to be accomplished by presenting information at a lower level of abstraction than typically used by traditional computer interfaces. This means that a VR interface presents information in a form that is directly interpreted by the human senses, like images, sounds, and motion. Furthermore, these interfaces allow visible and invisible phenomena to be intermixed, correlated, and displayed. Such an interface may one day allow air traffic controllers, surgeons, and mission planners to better understand their complex, multi-dimensional problem spaces and allow them to make better decisions in less time. If the data representation and transfer process in a VR interface is accurate enough, the participant may get the sense of actually "being there". This fact has led a number of developers to extend the application of VR to the entertainment and advertising markets.

THE APPLICATIONS-ORIENTED DEVELOPMENT PROCESS

Creating an effective virtual environment requires the coordinated participation of a multi-disciplinary team and the orchestration of that team throughout the many stages of the development process. To ensure that the resulting system achieves its expected aims, it is crucial that an applications-oriented approach be used during the project

definition phase, and that this definition then serves as a functional guide throughout the implementation process. A specific VR development project is used here as an example to illustrate points from the process description. Though any number of examples could have been chosen, this one demonstrates some unique requirements that had to be considered in the design phase. The example is an experience called *Virtual Voyage*™, which was created for product promotion purposes. In this experience, participants navigate a clipper ship from one port to another to deliver a cargo of whisky.

Step 1 - Understand the User's Requirements

Perhaps the most critical step in designing an effective virtual environment is to put oneself at the end of the process and analyze how the system will be employed by the ultimate user. What are the crucial elements of information that must be present? What are the functions that the interface must provide? What is the background of the expected operators? Clear answers to these questions may indicate that a fully immersive environment is not desirable at all, which would have a drastic impact on the system design process. Other user-dependent questions will help frame the development process, like: How important is domain expertise in the creation of an effective interface? What is difficult about accomplishing this interface task using traditional techniques? What is the available budget? What kinds of ergonomic issues exist? By clearly addressing these sorts of questions during the project definition phase, the developed system takes on an applications-oriented purpose, helping to guide its evolution and ensure its usefulness.

In the case of *Virtual Voyage*, the design of the system was driven not only by the general public that would eventually experience the system, but primarily by the customer: the advertising agency paying for the development of the system. Obviously, the advertiser's goal is to feature the product in a relevant and entertaining way. Since the product being advertised is an alcoholic beverage, it was decided to create an experience from the days of prohibition, a recreation of the ferrying of liquor from the Bahamas to Long Island aboard the clipper ship of Captain McCoy. This *theming* of the experience is extremely important for giving the participants a context for involvement, and in this case, helping to achieve the advertiser's goals. At this point, it becomes evident that a certain amount of domain experience will be required to ensure realism of the sailing vessel's behavior and responses. With the purpose of the virtual environment clearly in mind, the entire experience can now be created around the established theme.

Another important factor at this stage is a thorough understanding of the eventual participants who will experience the virtual environment. The users of the system are members of the general public, who happen to see this advertising event as it tours the country. It was desired to leverage the sense of immersion and interactivity with the environment that VR gives the participant, while maintaining the focus on the product being advertised. Since the users would likely experiencing VR for the first time, it was also important to keep the game concept straightforward and the interface simple. Further, the system must achieve its objective within just a few minutes of play. To achieve these aims and promote product identification, the general concept developed was for the participant to sail the virtual

vessel while protecting the cargo from various hazards along the way. These hazards could be in the air, on the water, or on the ship itself, so the visual interface would have to provide the participant with a full field of regard. A hand-held gun with a virtual representation would allow the participant to defend his or her cargo, thereby linking the participant with the scenario and building an identification with the product.

Step 2 - Identify Where and How VR Adds Value

When designing an interface for information transfer, one must be careful that the technologies chosen to support the interface actually enhance the transfer process rather than distract from it. The goal should be to effectively transfer the desired information, not showcase the latest VR product or technique. A big part of virtual environment development has to do with understanding how human beings detect and assimilate sensory information and what tools and techniques are available to reproduce these effects [2]. Of course, a certain amount of cost realism usually enters the equation, but even with compromises, a compelling, immersive environment can be achieved. The key requirements are to provide a high-fidelity visual scene, to correlate that visual scene with an appropriate soundscape, and to provide at least some level of somatic contact with the system (anything from a simple joystick interface to a motion-base), which also allows the participant to interact with the virtual environment. Additionally, this must all be accomplished in a small enough time frame that the user does not notice things like system latency or update rates. Though other sensory modalities can be brought into play, the cost is likely to outweigh the benefits. Again, the analysis should be based upon the requirements defined in step one.

Having settled on the deck of an open sailing vessel as the environment to be recreated in *Virtual Voyage*, the primary requirement is to create a large and realistic visual scene. The fact that events in the environment are occurring all around the participant makes it a good candidate for a head-mounted display (HMD) with a head tracking system. Additionally, the visual resolution requirements in this case are lenient enough to allow an HMD to be used cost-effectively. HMDs are not always the best display medium, and their use certainly does not define the interface system as a virtual environment. Going back to the original guidelines for design, it was determined that a repeat monitor must be included to allow a larger audience to share what the participant sees within the HMD. This allows the information transfer process to reach a much larger audience.

Somatic contact would be achieved through a physical mockup of the vessel's helm and a plastic pistol. In fact, a portion of the deck and mast was eventually built to provide continuity of the theme between the real and virtual worlds. The design allowed the participant to actually steer the vessel by turning the wheel and observing the change in attitude relative to the prevailing wind in the sails and the motion of the waves. By way of a motion-tracker attached to the hand-held pistol, a virtual gun could be moved about the virtual space. These two modes of physical interaction were intended to get the participant's body involved in the experience, helping to close the sense of presence.

Finally, the auditory channel would have to be supported via a detailed sound profile of

the dynamic environment. The interfaces chosen were headphones to transmit the soundtrack to the participant and loudspeakers to repeat those sound to the audience. To enhance the sense of immersion, a three-dimensional sound system was selected to allow the participant to localize sounds in the surrounding virtual space. Other sensory pathways could have been engaged, like wind blowing from the appropriate direction or a motion-base to simulate the toss of the ocean, but these were not included since the desired effect was achievable at a reasonable cost using the above components.

Step 3 - Develop Concepts of Operation

The last step before implementation can begin is to fully scope the operational employment of the virtual environment. Based on the preliminary definition established thus far, and keeping the user's requirements in mind, the "flow" of system operation must be defined. For entertainment-oriented experiences, this would involve the development of an appropriate storyline, perhaps supported by artistic renderings of probable scenes and scenarios. More serious applications, like a mission planning system, would use sample scenarios to exercise the sequence of interactions during the planning process. Building on the basic goals and components established in steps one and two, the theme must now be "filled out" with details and complete concepts.

In our example process, the operational sequence of *Virtual Voyage* was completed through the development of a few scenarios. An "objective" for the experience was defined: the participant would be scored based on the number of cases of scotch that were successfully delivered to the final port. The primary hazard to delivery would be a stowaway who would attempt to steal cases from the stack of cargo. This virtual thief could be (non-lethally) shot to discourage his troublesome activity. The stowaway would appear throughout each of the voyage scenarios. The scenarios involved navigating the vessel out of the natural harbor in the Bahamas (the initial scenario), and engaging opponents on the open ocean. During a storm scene, good sailing skills would reduce the loss of cargo over the side of the ship. On the way to "Gatsby's Mansion" on Long Island, the participant would encounter a rival gang in speedboats who shoot at the cargo to reduce the player's profits and an attack seaplane with a similar objective. By shooting these opponents, the participant ensures the safety of his or her cargo and thereby achieves a higher score.

The choice of interface devices in step two has implications in the development of an operational concept. A detailed visual representation of the surrounding world meant that a substantial amount of physics would have to underlie the behavior of the graphical objects. This not only applies to the vessel being sailed by the participant, but to the computer-generated adversaries. Of course, attention would have to be given to the polygonal representation of the visual scene, the use of appropriate image textures, and the scene's depth complexity. Additionally, each scenario would have an associate soundtrack so that objects and interactions were represented aurally. This, too, would be of high fidelity, with sound localization included. The kinds of sounds to be sampled and created (ocean waves, seagulls, creaking of the masts and rigging, gunshots, etc.) were identified at this point.

Each of the scenarios or vignettes was defined in this way to serve as a

development template during the implementation phase. The final scenario was defined as the arrival at "Gatsby's Mansion" (to some considerable fanfare, depending on the amount of cargo delivered). Following the initial departure scenario, the vignettes are chosen randomly to provide a sense of novelty for viewers who see the game played a few times. A consistent storyline was put together, and the timing of vignettes and the overall experience were established (30-45 seconds for each vignette and approximately 3 minutes overall).

Step 4 - Implementation and Integration

Finally, the system must be constructed based on the foregoing design. Clearly, this is the bulk of the development process, though, unfortunately beyond the scope of this paper. If the project definition phase has been accomplished successfully, it will serve as a constant guide throughout the implementation process. Having established an applications-oriented goal for the virtual environment system, the following steps can be carried out to achieve project completion:

- Artistic Rendering of Objects and Scenes
- Simulation of Underlying Physics and Object Relationships
- Modeling of Entity Behaviors and Interactions
- Integration of the Human Participant with the Virtual Environment

A photograph of a participant engaged in the completed *Virtual Voyage* experience is shown in Figure 1 and an image of the virtual environment itself is shown in Figure 2.

CONCLUSION

The development of a virtual environment is a complex undertaking requiring skills from many creative and engineering disciplines. To orchestrate these skills and keep the development process focused on the ultimate purpose of the information transfer system, it is important to adopt an applications-oriented methodology. This process consists of understanding the user's breadth of requirements, recognizing the value of VR technology for the current application, applying the technology appropriately, and creating a detailed concept of operation prior to implementation. If such a methodology is followed during the design phase, the implementation task is more focused and directed, and the resulting system is more likely to achieve its objectives.

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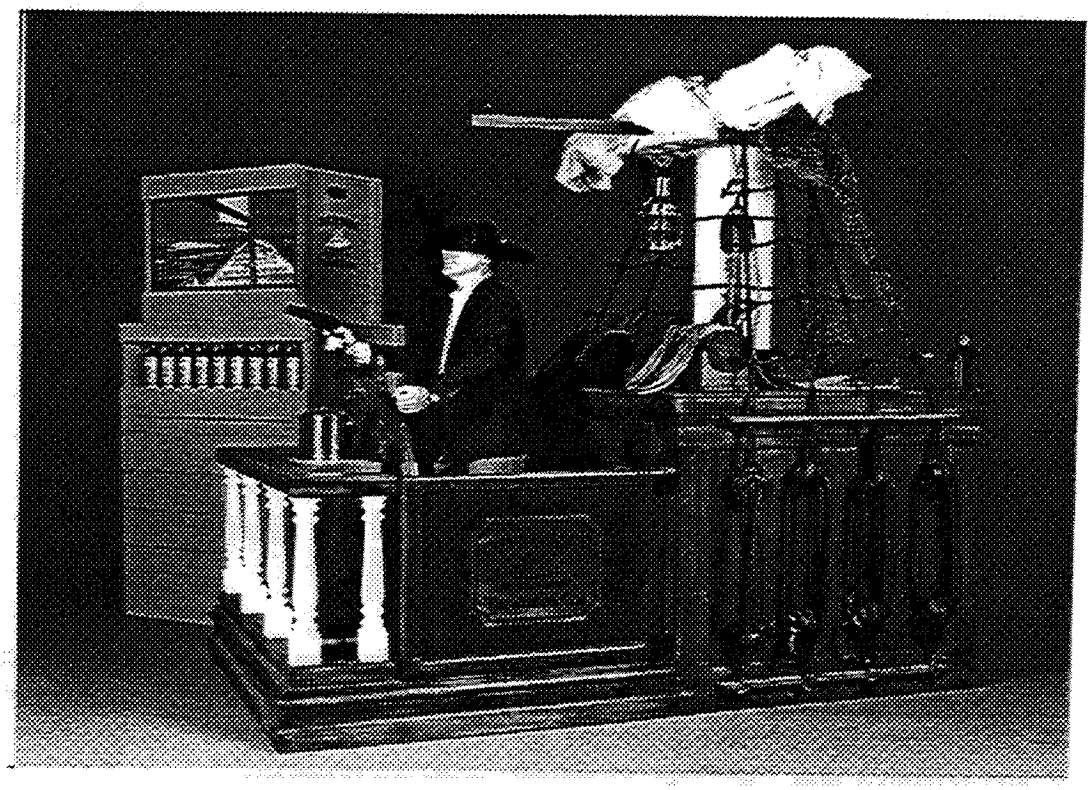

Figure 1. A participant immersed in the *Virtual Voyage* experience.

Figure 2. The stowaway and speedboats harass the participant in *Virtual Voyage*.