Development and Engineering Design in Support of "Rover Ranch",
A K-12 Outreach Software Project

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ABSTRACT

A continuation of the initial development started in the summer of 1999, the body of work performed in support of "ROVer Ranch" Project during the present fellowship dealt with the concrete concept implementation and resolution of the related issues. The original work performed last summer focused on the initial examination and articulation of the concept treatment strategy, audience and market analysis for the learning technologies software.

The presented work focused on finalizing the set of parts to be made available for building an AERCam Sprint type robot and on defining, testing and implementing process necessary to convert the design engineering files to VRML files. Through reverse engineering, an initial set of mission critical systems was designed for beta testing in schools. The files were created in ProEngineer, exported to VRML 1.0 and converted to VRML 97 (VRML 2.0) for final integration in the software. Attributes for each part were assigned using an in-house developed JAVA based program.

The final set of attributes for each system, their mutual interaction and the identification of the relevant ones to be tracked, still remain to be decided.

INTRODUCTION

Every new wave of media, from filmstrips to video to the many iterations of computer-delivered training, has spawned wild enthusiasm in the past. Each promising a better and more effective learning environment than the last. Despite years of visionary predictions of the inevitable triumph of technology-delivered training, the vast majority of training today is still delivered in the classroom testament to the enduring human preference for face to face, real-time, interactive learning environments.

In order to design a successful new learning tool, it is essential to first identify the elements contributing to the effectiveness of classroom teaching. In physical sciences in general, and in engineering in particular, a course has two interdependent parts: a lecture session, in which the material is usually presented and a laboratory session in which application and experimentation takes place. While it tends to be easier to implement the former in new media – and by new media one refers here to the convergence of many industries such as cable and television broadcasting, film and video, publishing, software, and the IT -, the latter proves more elusive: short of building a physics laboratory in every student's house, how does one allow pupils to practice free thinking through experimentation? Virtual reality (VR) may prove to be the answer.

Virtual Reality is a promising technology for corporate and industrial training applications as well as for the classroom. VR simulations are an effective and inexpensive alternative in situations requiring hands-on training with equipment that is hazardous or expensive; anything from learning how to dock a super tanker or operate a nuclear power plant, to developing microsurgery techniques or teaching procedures for proper wafer handling in semi-conductor manufacturing.

While in the past, large-scale VR simulators required powerful workstations, the advances in computer technology make this type of training attainable in schools. And today, head-mounted displays, or custom control environments prove to be highly effective but they are expensive and can be operated by only one trainee at a time. PC-based simulations can be accessed by many over a corporate intranet and an increasing number of VR training programs are also being developed for delivery over the web.

Creating user-friendly interactive systems is complex and expensive in time and effort. With the increased penetration of 3D solid modeling MCAD (mechanical computer aided design) software in all types of industries, the opportunity exists to use the generated models outside the design loop, and in particular, in the training process. This is especially true for an organization such as NASA, which is globally recognized as a proficient generator of knowledge and a user of advanced CAD tools. However, it can be difficult to train astronauts to operate in environments which are impossible to duplicate on earth.

As the ISS (International Space Station) continues assembly, the opportunity of informing, educating and ultimately involving students in the new challenges, was seized by NASA's JSC Learning Technologies Project by conceiving the "Rover Ranch" software. The NASA Johnson Space Center Learning Technologies Project (http://prime.jsc.nasa.gov) is in charge of developing and implementing new software, methods and methodologies that create learning opportunities with focus on mathematics, science and engineering. Within this context, JSC created a set of Internet tools for K-12 teachers and students. A three-year NASA sponsored project, with the first full operating beta system to be delivered in September 2000, the software's first phase is based on the AERCam Sprint (Autonomous Extravehicular Activity Robotic Camera Sprint – http://tommy.jsc.nasa.gov/projects/Sprint/index.htm) concept (Figure 1). The "Rover Ranch" would represent a departure from today's flight simulation software and their instantaneous input/correction capabilities. Mimicking the engineering design process, the robot would expect the mission to be planned ahead. The planning process involves selecting the various components needed to successfully complete the set tasks after which the simulation would begin thereby allowing students to observe the consequences. Unlike the majority of the learning software on the market today, the "Rover Ranch" would be targeted towards average and above average students. Since the software will emphasize planning and before-fact thinking rather that hand-eye coordination and speed of movement, it should appeal to physically disabled students as well.

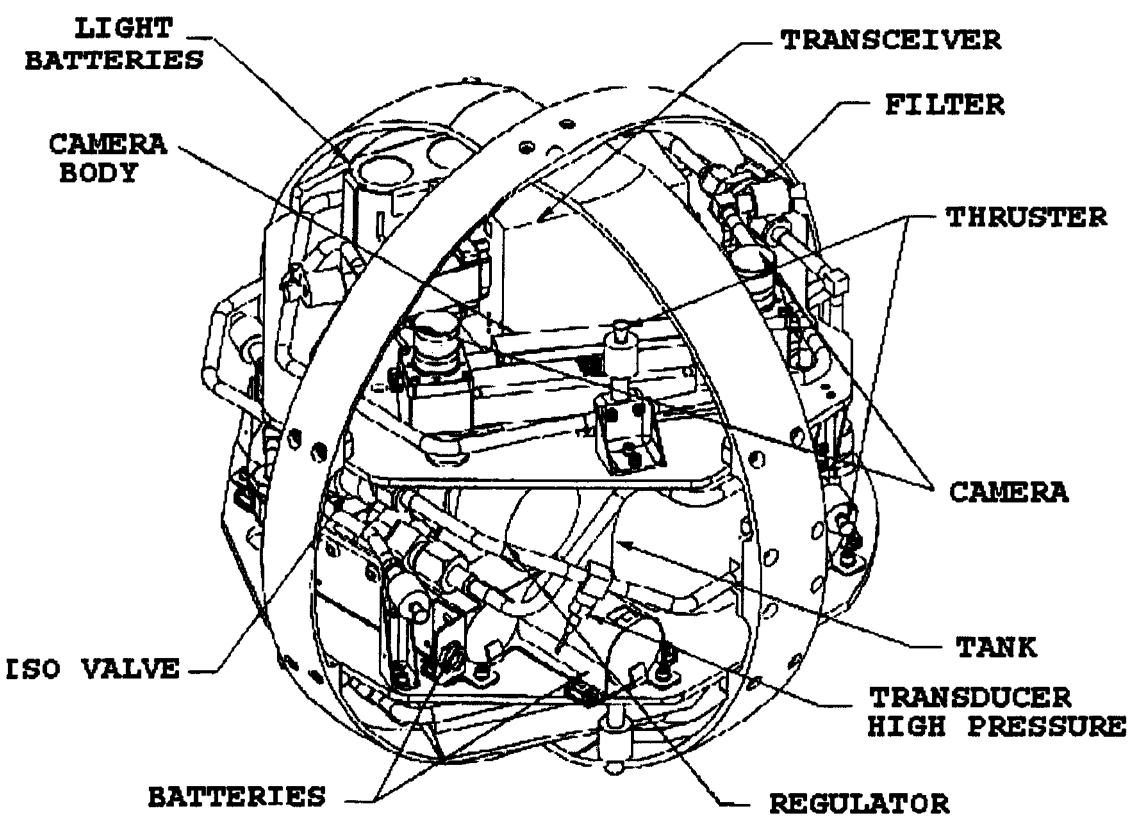

Figure 1: NASA's AERCam Sprint

Since there could be a wide variation in the type of systems used by students, the initial set of requirements for an effective product were that the product be platform independent. Such product must also be visually exciting and easily extendable after the initial phase was completed. These issues were resolved by using JAVA, a platform independent language, capable of creating applets that would run on common browsers. The parts would be displayed in VRML (virtual reality modeling language) which through the use of plug-ins can also be seen in common browsers. As NASA is currently standardizing on Parametric Technologies Corporation (PTC) products (www.ptc.com), ProEngineer was chosen as the software in which the parts would be constructed. This will allow future elimination of preliminary part construction in the initial screening phase, as the parts are created by engineers during the design process.

1. ProEngineer

Pro/ENGINEER is the industry's de facto standard 3D mechanical design suite. It is based on a robust, parametric, feature-based modeler -- so wholesale design changes can be made with ease. While creating the parts in ProE proved more efficient, two issues were encountered.

Although ProE has capabilities to export to VRML, it does so in ver. 1.0. This represented a concern in terms of interaction with the rest of the software. In addition, learning and keeping track of two sets of commands represents a potential future productivity loss. This issue was resolved by converting files from VRML 1.0 to VRML 2.0. Due to the fact that ProE generates several files for each model, made the selection of the translator challenging.

The second issue, the fact that the VRML files were monochrome, was resolved by changing various settings.

2. Virtual reality

Aristotle enumerated five senses through which humans perceive or interact with the world around them. These were: hearing, smell, touch, taste and sight. Medicine is continuously discovering additional ways through which human body "reads" the environment such as carbon dioxide sensed by the skin.

Virtual reality is a system by which the senses are "tricked" into untrue perception (i.e. different than what they would normally detect). Various tools for virtual reality were created throughout history: artificial flavors for taste and smell, gramophones, radios and later stereo and surround sound for hearing, fabrics, faux fur, etc. for touch and television and cinema for sight. However, computers hold the potential for making the virtual reality meaningful through (a) total immersion and (b) by allowing interactivity with the environment. Hence, educators are in the process of experimenting with virtual reality in a number of teaching applications. As with other computer mediated teaching, virtual reality provides the student with the advantage of learning the subject at their own pace with opportunities to explore a broad band of knowledge relating to a specific subject rather than acquiring such knowledge in a passive manner. One advantage that a threedimensional environment has over a two-dimensional page in this field is the ability to illustrate concepts. Most importantly the immersive element of VR can make the experience more appealing and unique which will, often, attract the interest of a student who might otherwise be hard to motivate. The applications that have been created for education vary. For example historical reconstruction can provide students with the opportunity to re-live any moment in history thereby creating a more in-depth look at that particular point in history. Similarly, the use of simulation can produce a virtual lab that can be used for experimenting with mathematical and physical laws. VR can also be adopted to illustrate principles in a variety of other subjects, for instance the urban impact of an area that is due for development in geography and molecular arrangement in chemistry.

Although VR has not been adopted as a standard tool for teaching basic curriculum, preliminary trials have shown that the quality of learning is comparable to that achieved by using other computer aided learning and in some subjects a superior quality is achieved when using VR. The value of such a learning tool does not lie in replacing, but in complementing and enhancing traditional forms of learning.

3. Concept Definition

It is envisioned that when completed, ROVer Ranch would have three types of robots:

1. Free-flying
2. Mars rover and
3. AUV (autonomous underwater vehicle).

The initial phase would concentrate on a free-flying robot based on AERCam Sprint. The number of systems that can be incorporated was decided to be limited to six. The systems and possible subsystems are enumerated below:

1. Propulsion: cold gas, hot gas, variable specific impulse magnetoplasma rocket (VASIMIR), internal combustion engine, warp drive, electric motor, solar powered.
2. Body: material – steel, stainless steel, aluminum, titanium; shape: spherical, cylindrical, cube, humanoid; color: white, black, glow-in-the-dark, yellow.
3. Power: zinc-carbon, lithium, car battery, rechargeable, fuel cells, fly wheel, ultracapacitors.
4. Control: teleoperated, autonomous
5. Tools: grip only, humanoid arm, continuous deformation, snake.

6. Sensors: visual: digital still camera, digital DV camcorder, SLR camera, VHS Camcorder, light sensors; hearing: commercial microphone, parabolic antenna; smell and taste: spectrometer, nitrogen detector; touch: force sensor.

The Rover Ranch software is meant to be educational and informative about NASA's challenges and current projects, while challenging students' imaginations and encouraging out-of-the-box thinking. Hence, once the systems have been established, the available choices for subsystems varied from common, to high-tech research, to science fiction. It is the aim that in the finalized package that each of the systems as well as subsystems be followed by a short narrative to inform the user of the possible pros and cons as well as the trade offs a one would face during the design process. In addition, web links would be provided, such that individual teacher can elect the depth of the knowledge to be pursued.

CONCLUSION

The final system (Figure 2) will be ready for beta testing in September. Based on the feedback from students and teachers, limited changes are anticipated to the current system. With the proven system defined, design on the Mars Rover will begin in October followed by the AUV parts. As new technologies evolve, it is expected that enhancements to subsystems will have to be added. Due to the modular nature of the software, this should prove relatively easy.

Figure 2: The Developed System in VRML Format