VIRTUAL REALITY FOR EMERGENCY TRAINING

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KEYWORDS: virtual reality, emergency training, surgeon education

ABSTRACT

Virtual reality is a sequence of scenes generated by a computer as a response to our five different senses. These senses are sight, sound, taste, touch, smell. Other senses that can be used in virtual reality include balance, pheromonal, and immunological senses. Many application areasinclude: leisure and entertainment, medicine, architecture, engineering, manufacturing, and training. Virtual reality is especially important when it is used for emergency training and management of natural disasters including earthquakes, floods, tornados and other situations which are hard to emulate. Classical training methods for these extraordinary environments lack the realistic surroundings that virtual reality can provide. In order for virtual reality to be a successful training tool the design needs to include certain aspects; such as how "real" virtual reality should be and how much fixed cost is entailed in setting up the virtual reality trainer. There are also pricing questions regarding the price per training session on virtual reality trainer, and the appropriate training time length(s).

1.0 INTRODUCTION

Virtual reality is an environment that is so realistic it actually emulates the real thing (Holbrook 1991). It has also become a buzz word with "frivolous" connotations (Adam 1993). Virtual reality is a sequence of scenes from a database of images which is determined as a response of our five senses to take us to the depths of an immersive experience. These senses are sight, sound, taste, touch, smell. Others include balance, pheromonal, and immunological senses which look promising with virtual reality. According to David Mitchell, (Mitchell 1992), the systems operator of the Diaspar VR Network BBS: "Virtual reality is the artificial stimulation of human senses and artificial response to human actions." A virtual reality system consists of a display screen, a tracking device for interactivity, a computer image generator, a three--dimensional database, and application software (see Adam 1993). It is defined in (Hayword 1993) as something like reality and almost like reality. How much like reality? 93.742% like reality? How "real" should virtual reality be? Is it a technical question, a strategic question or a marketing problem?

The scope of virtual reality is determined by how many senses are being stimulated. The first five are the ones we learned in elementary school. Balance is defined as a state of equilibrium in weight, value etc. It is felt by the ear and muscle tension. Pheromonal is communicated through scent glands and olfactory lobes. It refers to the chemical messages we transmit. Immunological sensors are lymph nodes, and mucous linings act as the transmitters. The degree to which virtual reality behaves like reality is measured by the scope and intensity of the immersive experience.

Right now balance and sight have been tried in virtual reality skiing but most senses interfaced include sight, sound and touch.

To understand virtual reality imagine you are in a booth covered with TV screens. You see Mohammed Ali. You throw a punch at him, he feels it and drops back a step. He responds with a punch and it is so real you react and go back a step. This is just the beginning. You can make the fight more active according to your choice. If you like excitement and are a risk taker, the system acts differently than if you are risk averse. How can this be done? Virtual reality measures an individual's vital signs through sensors placed on the screen and/or the gloves and adapts to the preferences of individual customers to provide maximum satisfaction.

What can virtual reality do? What are the possible application areas? All possible avenues have not been considered yet. The applications receiving the most publicity for using virtual reality are entertainment and leisure, medicine, architecture, and defense training. The leisure industry may turn out to be the biggest user. For example, a skier can put on a helmet and gloves and start skiing through the trees. If you are not interested in the trees, you can opt for wide open spaces. If you get too tired, you can take a nice and easy, relaxing run. (Thornton 1993), in a recent Fortune magazine article reports that there are

no plans to provide the sensation of broken limbs. However, users can preselect the difficulty which allows a maximum speed of 25 miles per hour, and jumps of up to 33 feet high. Depending on your choice, if your pulse gets too high, the system eases up and flattens moguls or bumps at signs of excessive stress depending on the personal choice.

Other applications of virtual reality include medical students studying to be surgeons. They can put on a helmet and gloves to operate on a virtual patient. Architects can use virtual reality to design a building and walk through it before they actually build it. Engineers can design products and analyze them without going through the expensive steps of manufacturing. Pilots can fly planes without leaving the ground and land at the most difficult airports. Students can learn to drive. It is a very effective learning tool, as per the old Chinese proverb "hear and forget, see and remember, do and understand" as stated in (Theasby 1992).

Researchers at British Telecommunications are developing a network design and management tool based on virtual reality. Caterpillar Inc. is using virtual reality to engineer its earth moving equipment. Still other uses include auto design, molecular modeling, animation design. Chrysler and IBM are working on virtual cars. Boeing is developing a virtual airplane. The Pentagon has plans to experiment with wall-to-wall supercomputers powerful enough to grind out more-realistic virtual realities. Miller Brewing Company has used virtual reality in the annual National Restaurant Association Conference in Chicago (1993) to promote its products. Virtual reality even has sex appeal with virtual sex, which as Newstrack (1993) states "should give Madonna enough fodder for a literary sequel."

Virtual reality can do all sorts of things, but at what cost? W Industries based in Leicester, England has machines that allow virtual reality to work, costing up to $120,000. NEC calculated their own machines should sell for $100,000 before they can realize a profit. Michael F. Deering, a senior staff engineer in Sun's virtual reality group, notes "... a virtual reality experience at the right price will sell." The price of virtual reality machines will of course, have a significant input on the price of the virtual reality experience. A key question that we address in the paper is: how should the price of virtual reality training experience be determined? We also ask whether virtual reality trainer should complement or substitute other training systems. This will most likely depend on the individual and the application. Can we distinguish individuals who perceive virtual reality training as a substitute from those who view it as a complement of other training systems? Are the virtual reality training companies likely to merge with other training system companies? Can we expect strategic alliances between virtual reality trainers and other training system providers?

The rest of the paper is organized as follows: Section two describes selected issues in virtual reality design. Section three is the overview of the suggested pricing schemes for virtual reality in the entertainment industry. Section 4.1 considers surgeon interns' education as an illustrative case for the emergency training. It highlights the similarities and differences between the entertainment industry and surgeon education. Section 4.2 looks at the other situations for emergency training with virtual reality. Section 4.3 summarizes the advantages and disadvantages of virtual reality training systems. The final section contains our concluding comments.

2.0 DESIGN OF VIRTUAL REALITY PRODUCTS

The formulation of individual virtual reality product attributestypically assumes a discrete system of a ten point scale, with each point further divided into five sub-categories: excellent, very good, good, fair, poor. For example, a sight including 256 colors may be regarded as excellent by some. Most individuals may regard normal black and white as poor while black and white with 12 shades of gray may be considered as fair. Not every individual has the same value system. Heavy metal rock band Guns and Roses' lead singer Axel Rose may think 100 decibel sound is excellent while comedian George Burns may regard it as poor.

Another attribute could be the camera angles. This is extremely important in sporting events. One may like to watch a football game at the 50 yard line, in the middle of the stands. Someone else might prefer a location with a closer view of the coach. The French Open tennis tournament camera angles cover more flesh -- especially the female players -- while those angles may not be appropriate in the US Open. For a virtual reality trainer some might prefer a camera angle from the point of view of the rescue operator, while others opt for overlooking angle. Sight and sound might be less appealing to some than balance and pheromonal. The foregoing classification does not include interaction between the different senses. Combinations of senses taken out of eight senses have to be considered as different stages.

Consumers are heterogeneous in their preferences. Different people like (dislike) different things. How are virtual reality designers going to determine which frame to show next, under what conditions? How much of an immersive experience is going to be provided in the first, second, third, or the nth trial? What is going to attract the trainee to the virtual reality trainer.

In a movie advertisement, five minutes of scenes are shown to attract the movie goer to come and see the movie. Climactic scenes are shown without the climax itself. Some movies also have sequels. Soap operas continue for years according to the audience response.

Selected issues in the design of virtual reality products include:

- What is the total capability of the system?
- What should the first experience and the subsequent experiences be?
- Is the whole system fixed or ever changing? How does the experience adapt to user response as measured on the eight senses?
- Does virtual reality trainer complement or substitute the other training systems?
- How much fixed cost is entailed in setting up for offering of virtual reality training experience?

The answers to some of the questions might be industry and/or individual dependent. If that is the case, then a dynamic model which changes according to the individual and/or the industry needs to be developed.

3.0 PRICING OF VIRTUAL REALITY IN ENTERTAINMENT INDUSTRY

According to (Altinkemer and Kalwani 1994a) the pricing currently used on virtual reality are fixed rate, per unit time and two part pricing. These pricing schemes are suggested to maximize the profits by offering maximum satisfaction making the user come back for subsequent experiences. Differentiation can be used to further increase the profits. This is illustrated in skiing based on the level of skier, snow conditions, difficulty level of slopes, and a combination of above features. Others include seasons and the location of the virtual reality. The winter season may treat virtual reality skiing as a complement. During summers one may charge high prices as they can be considered as substitutes. Location could change whether virtual reality skiing is treated as substitute or complement. In Aspen where you are close to the ski resort treat it as a complement and in New York City where you are not close to a ski resort treat it as a substitute.

Dynamic precision pricing is introduced for virtual reality. Every users' experience is somewhat different than other users'. This aspect of virtual reality allows the implementation of dynamic precision pricing. This price is a function of service quality, attributes of the application, amount of time spent in virtual reality, level the user terminates virtual reality, and system reaction lag. Increasing the system reaction time lag decreases the price. Other considerations increase the price if their level are increased.

(Altinkemer and Kalwani 1994b) suggest in creating a product like virtual reality there are challenges in designing and pricing. It states pricing involves short term and long term pricing. In the long term, the potential interaction in the demand for virtual reality experience with that of the use or consumption of reality is considered. In this case virtual reality is viewed as the precision product that satisfies an individual's tastes. For an optimal pricing strategy, a long term diffusion rate has to be considered. Analysis shows that an integrated monopolist should charge differently than the two independent firms providing virtual reality and reality. It is suggested that whether reality or virtual reality is seen as the contingent product may vary with the individual customer.

4.0 TRAINING

Under this section we look at surgeon education and emergency training. Advantages and disadvantages of virtual reality education are given in section 4.3.

4.1 Surgeon Education

Surgeon education has quite different characteristics of its own compared to the entertainment industry. This is assuming virtual reality where all senses are interfaced. Surgeon interns will be able to get a time slot on the machine and learn interactively at their own pace with the gentle guidance from virtual reality. First, all possible scenarios need to be programmed. In order to put bells, whistles with different twists and angles, many endings and different procedures need to be programmed. Once a complete virtual reality training system is available it will require a learning model to implement virtual reality.

Currently, there is experiential learning. The learning environment enhances participants involvement in some kind of personally meaningful activity. Virtual reality provide interactive fully immersed participation where the participant applies some knowledge of theory and principles which results in accomplishments or failure. Virtual reality will select a path tailored to individual tastes to enhance learning. In order to bring a change in attitudes, behavior and knowledge, often a four state learning model, is referenced in (Keys and Wolfe 1990).

Concrete Experience → Observation and Reflection → Formation of Abstract Concepts and Generalization →

Testing Implications of Concepts in New Situations.

The impact of learning is the greatest when

(i) it is accompanied by an optimal amount of emotional arousal,
(ii) it occurs on safe grounds,
(iii) it allows adequate processing time and a summary pointing and emphasizing the moral of the story.

Others advocate "integrative learning" which emphasizes learning from differences in content, point of view, and learning style with an open ended

approach. Integrative learning is similar to "double loop learning" which is based on informed decisions and internal commitment described in (Keys and Wolfe 1990). The learning grid divides the learning process into content, experience and feedback. All three parts need to be developed for positive, useful, and fully immersed learning exercises.

There does not need to be a superior way or a method. All these methods can be embedded in virtual reality. In fact if a new learning model is developed at a later date one can add to the model, and virtual reality will teach the subject according to the new method.

4.2 Emergency Training

There are natural disasters such as hurricanes, tornados, floods, earthquakes, mud slides, volcanic eruptions, forest fires, avalanches. These are activities where efficient fighting methods are very important, and they have enormous effect on the course of events.

These disasters have been fought by highly skilled people who have been trained with classical methods. One of the limitations of such approaches is that one cannot emulate all possible scenarios. Hence, some of the training is performed during the actual disasters which because of the lack of experience can cause injuries, even loss of lives. Experience can be an expensive teacher. However with virtual reality all of these scenarios can be covered at a smaller cost of physical material and human lives.

Another area that can be appropriate to virtual reality is technological disasters. These include urban fires, chemical and nuclear spills, plant accidents, transportation accidents, 911 cases, telecommunication failures, utilities failures, and environmental emergencies. Training for wars, terrorism, and riots are more human response dependent. An action of a rescue worker might decide the success of the whole operation. Again in these situations common sense may not be used because they are not obvious. When fires and violence took place in Los Angeles, on April 29, 1992, it was evident that plans to handle such events were totally inadequate. The Building Emergency Leaders (BEL) SYSTEM mentioned in (Oliver 1993) helps better equipped professionals for emergency situations. (Andrus 1992) mentions an emergency backup system which is also used as an operator training facility. Virtual reality will take it leaps and bounds ahead of these simulators and make such uncommon events a part of everyday life. It will be the perfect trainer for the unexpected.

There is a question of how to price such training sessions. First of all, a twenty-four hour day needs to be divided into reasonable length time slots. For this the optimal length of a training session needs to be determined. Then, the day can be divided from the highest use to lowest use. Trainees can bid on the time slots for training. The bidding needs to be closed a few hours before the actual time slot. The time slots can take bids from stand-by trainees. These measures do not have to be absolute. The system can learn by experimenting and establishing an optimal strategy.

The other unresolved issue is whether a virtual reality trainer substitutes or complements other types of training systems. What would be the functions of a teacher who has been teaching in a conventional training system? Will the teacher be a consultant or a competitor of the virtual reality trainer?

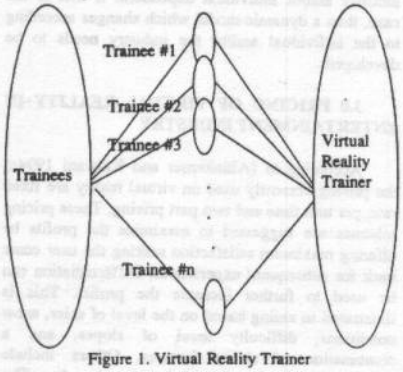

Figure 1. Virtual Reality Trainer

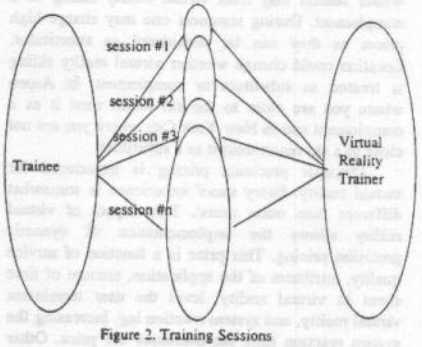

Figure 2. Training Sessions

The virtual reality trainer offers a precision training session for the trainee (see Figure 1). According to their ability and the knowledge, each trainee can have a unique training experience. The trainee can have custom-fit training by choosing the teaching method, camera angles, level of feedback, number of senses involved, and which senses are required. For example, a fire fighter may initially choose an experience without high temperature. This component might be added for later experiences. As

training progresses, sessions get complicated and more comprehensive. Figure 2 depicts this phenomenon.

Virtual reality could be also used as the perfect feedback. It could keep track of the trainee's performance over a training period and it could highlight the perfect finishes, performance under stress, improvement over time. This information can be used to place the trainee for a certain position.

Another possibility is to have different functions of a virtual reality trainer. One of them is the training function, the other is the grading or performance evaluation function. If traditional methods are preferred these functions can be done separately. This would be similar to the conventional teaching methods. Have teaching and exams separately. If you want to have total quality grading, every response during one's learning period is valuable. This continuous grading mechanism could also be achieved with virtual reality trainer. This could be called incremental or total quality learning and performance evaluation.

4.3 Advantages And Disadvantages Of Virtual Reality Training

What are the advantages and disadvantages? About 500 years ago, Leonardo da Vinci sketched the first airplane. The reason people could not materialize the idea was that necessary tools were not yet built - not because it was a wild idea. The Wright Brothers built a plane by being at the right time and the right place. Right now we have the concept and virtual reality where only three senses interfaced (namely sight, sound and touch). We have a long way to go. How far and how fast we approach virtual reality will play an important role with benefits and disadvantages.

Let's assume perfect virtual reality where all senses are interfaced. One of the benefits of virtual reality is reliability. Virtual reality does not become tired, bored or sick. It does not go on a strike, and it does not argue with the boss. Most importantly, it will notice the slightest errors and perfect finishes. This will help it furnish the perfect feedback.

We can draw an analogy to Expert Systems (ES). ES can function better than the expert which the system is built upon because of factors such as not having a headache. ES may operate better because expertise might be collected from more than one expert. Because of the synergy of knowledge they might out perform the human expert. These may be some of the benefits of virtual reality as well.

Other benefits include a point system which would help surgeons or emergency trainees find their true market value. This point system could be a benefit because a computerized system virtual reality could match the performance to a score system which gives a generalized score (like GRE, GMAT). Another benefit could be that surgeons would be on a more equal playing field - it would not matter whether you received the training from University of Nebraska Medical School or John Hopkins Medical School. The precision and teaching ability might not be dependent on the prestige of the school.

The disadvantages may come from the technology. If certain aspects are not realized it will not be able to emulate reality. We assume given time, virtual reality will be perfected. Another factor is that an intern using virtual reality may subconsciously know that it is not real and can feel more relaxed and perform better surgery. Under real conditions the pressure of reality might cause more mistakes and degrade the performance. This is a possible disadvantage, but by using the point system mentioned above, real-life pressure could be emulated. If interns perform unsatisfactory operations they receive fewer points, which in turn will affect their market value.

In terms of a grading scheme, a surgeon intern with perfect finishes since the first virtual reality experience maybe clearly superior to others. However, one who improved to be a perfect finisher in x trials versus y trials does not imply dominance relationship even $x<y$. A grading scheme like GRE, GMAT national tests on different areas such as quantitative, verbal, analytical or specific subjects like biology, could be used. This system will allow surgeon interns to specialize on certain aspects and certain surgeries. If one is not precise, one should not choose to be a surgeon using lasers for prostate surgery.

There are other issues, such as the long-term capacity planning problem and the short-term resource allocation problem. The two problems are tied to each other. In order to decide on the long-term problem, one might look at the number of full time equivalent teacher hours that will be available. Another component is the productivity and efficiency gain or loss due to a virtual reality switch. A surgeon educator might end up doing more surgery or research or clinical care and the educator might do better or worse in those tasks depending on their background and combination of tasks. This also holds true for the emergency training.

The short-term problem is equivalent to assigning time slots to surgeon students or emergency trainees. Alvin Roth has studied in a series of papers the two-sided matching problem which he concluded in a book by (Roth and Sotomayer 1990). The problem deals with how men and women are matched to each other when they reveal their preferences about the other sex. The problem has been applied to sorority rush, assigning interns to hospitals, and the college admission problem.

We need a mechanism which leads to revelation of true preferences on time slots. Certain time slots will be in more demand than others. Students might bid on time slots and the system might place students

on the time slots based on their preferences and system optimum.

There are different problems and challenges from the entertainment industry to surgeon interns' education and emergency training. At least one issue remains the same: Is virtual reality training a substitute or a complement of the real thing? The answer to this question may make the difference in pricing the activity and may help engineer the design of virtual reality.

6.0 CONCLUSION

Virtual reality has many application areas such as leisure and entertainment, medicine, architecture, engineering, manufacturing, and training. Since it is a totally new product with attributes unlike any other existing products, its design and pricing are challenging problems.

Surgeon educator or emergency trainer virtual reality, on the other hand, is totally different than use within the entertainment industry. First of all, it has to be based on a learning model. Students can choose from many available models. Benefits of virtual reality in this area are similar to the benefits of expert systems. Virtual reality educators do not sleep, get sick, have a down day etc. implying better performance with zero variability for every experience. New benefits include the effect of virtual reality on the school's name, and a point system which may help establish a surgeon's or emergency trainee's true market value.

The common issue is whether virtual reality trainers and conventional training systems are complements or substitutes. The composition of the clientele, whether naive or sophisticated may govern who will be trained in which system. Being a complement or a substitute may affect the pricing strategy and the design method.

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BIOGRAPHY

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