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Introductory Remarks to Virtual Reality

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1. WHY IS VIRTUAL REALITY AN IMPORTANT ISSUE?

"Just as the alphabet and printing press changed the way people thought, virtual reality will shape our notions of community, self, space and time. The future is arriving; it's happening at computer arcade shopping malls, inside software and hardware companies, and in artists' lofts." (Ken Pimentel & Kevin Teixeira, in "Virtual Reality - Through the new looking glass")

Not everyone may believe that Virtual Reality (VR) will in fact have the impact proposed in the quotation above. But VR certainly is a technology with a diverse and potentially far-reaching set of applications. VR supports engineering design, telerobotics, medical surgery planning, flight simulation, data visualization, education, arts, and - last not least - entertainment (to name only a few).

What is Virtual Reality? As Michael A. Gigante puts it in his book "Virtual Reality Systems": "Virtual Reality (VR) is characterized by the illusion of participation in a synthetic environment rather than external observation of such an environment. VR relies on three-dimensional, stereoscopic, headtracked displays, hand/body tracking and binaural sound. VR is an immersive, multisensory experience."

Present and future applications depend heavily on enabling technologies, primarily real-time 3D computer graphics and sophisticated tracking devices. New techniques clear the way for new applications:

"The promised development of a whole body DataSuit seems likely to prompt the neurologist to seek to restore motor experience to the stroke victim, albeit in an illusory manner. Soon, some psychiatrists and clinical psychologists will wish to explore 'virtual reality' with their patients. Anxiety, phobias and stress control seem possible targets that could be fruitfully explored." (George Mallen, in "Virtual Reality Systems")

This gives some indication of why Virtual Reality is an issue worth our attention. This volume includes contributions covering the following aspects of Virtual Reality:

- Survey and background information, clarification of terminology and concepts

- State-of-the-art of VR technology, technical problems
- VR applications, example systems, future applications
- Social, cultural and philosophical aspects, ethics

In the following I will add a few thoughts on two key ingredients of VR: perception and modelling.

2. VR AND PERCEPTION

VR is a means to exploit the power of human senses and manipulative abilities. By shaping artificial data into a virtual reality, a "user" in the Computer Science sense turns into a "perceiver-and-actor". Instead of analyzing the data by thinking, a perceiver-and-actor can find out important properties of the data by seeing, feeling and manipulating. While thinking can often be laborious and slow, our senses can deliver results almost without conscious effort and fast.

When one considers VR techniques as a tool for problem solving rather than entertainment, it is natural to ask which problems can be visualized in such a way that we can solve it by perceiving and acting. Clearly, if the task is - say - to determine the exact floor area of a newly designed building, visualization of the building will not help much. Adding up numbers is probably more adequate. If the task is, however, to give an aesthetic judgement about the building or to place furniture or to check whether a room can be used in a particular way, VR may provide a problem solving approach which is far superior to other techniques. So which are the tasks amenable to VR?

Perceiving and acting deal with concrete rather than abstract objects. So it is natural to expect that VR can only be a problem solver when the objects of the problem domain are concrete things which can be looked at and felt. Not surprisingly, a large fraction of VR applications is indeed of this nature, for example architectural design, engineering design, flight simulation. The specific tasks carried out in such domains typically involve spatial judgements of various kinds and simple interactive experiments, e.g. moving an object through free-space and checking for collision.

It is important to note that the visual tasks performed in a virtual environment can go far beyond mere stereovision. From the basic 3D visual data, various high-level properties can be derived which may be important for the problem, e.g. the relative size of objects, symmetry, free-space for path-planning, crowdedness, aesthetic qualities, etc. Cognitive Science studies of the human visual system are a rich source of information about the capabilities of vision.

It is also well-known from Cognitive Science that the visual system is not only used for the interpretation of visual data, but is also applied metaphorically. This means that humans can map abstract objects into the visual domain and thus exploit visual interpretation routines. This, of course, is also the idea behind VR applications in data visualization and other more abstract problem domains. Data are transformed into concrete 3D objects and made accessable via VR techniques.

It is difficult to draw a line between problems which can be made amenable to VR techniques and those which cannot. One might think that the reduction of dimensions to at most three poses a limit. This is true in theory. But for practical problems the reduction of dimensions is very often an acceptable approach.

It is also known from Cognitive Science that humans tend to impose a 2D metric on (not necessarily concrete) objects in the sense that "similar" objects are close to each other in 2D space. Accessing similar objects via association thus becomes possible. As objects may be arbitrary information chunks, various kinds of problem solving may be supported. One example which has attracted much attention in Artificial Intelligence lately, is case-based reasoning. Here the idea is to solve a problem by retrieving a similar case which has been solved in the past and adapting it to the new problem.

In computational models of case-based reasoning, the question of how to find a similar case has remained problematic since adequate similarity functions cannot always defined that easily. Using VR techniques, the power of human senses could be employed to solve this task. Thus similar cases could be identified by inspection.

3. VR AND MODELLING

VR is based on perceiving and manipulating 3D objects in a seemingly concrete world. The power of VR depends to a large degree on the lifelikeness of this artificially created reality. Hence modelling is singled out as a particularly important ingredient of VR.

Good models are important for two reasons. One is to achieve an immersive quality where our senses and natural reactions are turned on. The other is to provide sufficiently rich and precise information in view of the problem solving task. In the following I will concentrate on the latter aspect and point out some connections to related fields.

Modelling in a more general sense is a basic requisit for computer-aided problem solving. A real-world problem is mapped into a computer-based model, a solution is derived within the computer and remapped into the real world. VR techniques are related to this problem-solving cycle mainly if physical properties are important, i.e. physical models are required. A typical problem solving task of this kind is motion-planning for a robot vehicle, e.g. planning the disposal of hazardous waste. A completely computer-based solution of this task will require models of the physical entities of the problem domain quite similar to VR models.

A similar observation can be made with regard to computer-based simulation. Simulating the physical properties of a process often amounts to modelling object shape, location and motion as a function of time. This, of course, is also required for generating views and supporting interactions in a virtual reality. In fact, VR can be considered a particularly flexible user interface to simulation.

As the artificial environments become richer and more complex object behaviors have to be simulated, modelling also pertains to abstract concepts which provide coherence to a scene. For example, in order to create a lifelike traffic scene, trajectories have to be generated in accordance with goals and intentions of individual agents which interact with each other. This is also a well-known problem area in traffic simulation for educational purposes. The point is that modelling for VR is more than rendering lifelike images. VR calls for structured multilevel descriptions of the problem domain in question. Hence VR can draw on modelling techniques developed elsewhere, in particular in Artificial Intelligence and Simulation.

VR modelling requirements have also interesting relations to high-level Computer Vision. In Computer Vision one of the goals is to establish predictions about the contents of a scene, either from the spatial or from the temporal context. Such predictions can be thought of as "imaginations", i.e. as artificially generated images which guide the interpretation task of the real scene. Knowledge for generating such predictions is represented in generic models of objects, object configurations, object motion, episodes, plans and intentions. As an example, consider observing a soccer game. Much of what we see and find noteworthy is a result of top-down guidance by expectations. Because of the central importance of generating predictions, vision has been called "controlled hallucination". The relationship to VR should be obvious now: Generating imaginations in vision is controlled by models very similar to VR models. One of the differences is the need to generate a specific scene in VR as opposed to uncertain predictions in vision.

4. CONCLUSIONS

In the preceding sections I have drawn the attention to the potential and scope of two ingredients of VR: perception and modelling. With regard to the human participant in a virtual environment I have shown that VR techniques have the potential to integrate powerful human problem solving capabilities. Applications are not restricted to problem domains with concrete objects.

On the computer side much depends on modelling techniques. Looking at problem solving in general and at simulation in particular one can see that similar modelling requirements have to be met. More surprisingly, Computer Vision also employs modelling techniques to generate images.

In summary, VR can be seen as a powerful technique for incorporating humans into computer-based problem solving. Modelling requirements are strongly related to similar requirements in other disciplines.