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HARDWARE DEVICES USED IN VIRTUAL REALITY TECHNOLOGIES

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Abstract: *Historically, virtual reality has entered into the public awareness as medial toy with equipment „helmet-glove“, which was preferentially determined for wide public and the price of this system had also to correspond to this fact, so price could not be very high. As follows, the producers of virtual reality systems have aimed at developing and providing of the systems for data collecting and analysing and systems supporting economic modelling. It is obvious that, from among areas, where virtual reality systems can be most frequently used are applications based on 3D-space analysing and physical dimension visualisation. Virtual reality with ability to show data 3D and attach sounds and touch information increases extraordinarily data comprehensibility. Along with increasing the number of data are increased the effects from virtual reality too.*
Key words: *virtual reality, virtual reality hardware, virtual reality software*

1. INTRODUCTION

Nowadays computer graphics is used in many domains of our life. At the end of the 20th century it is difficult to imagine an architect, engineer, or interior designer working without a graphics workstation. In the last years the stormy development of microprocessor technology brings faster and faster computers to the market. These machines are equipped with better and faster graphics boards and their prices fall down rapidly. It becomes possible even for an average user, to move into the world of computer graphics. This fascination with a new reality often starts with computer games and lasts forever. It allows to see the surrounding world in other dimension and to experience things that are not accessible in real life or even not yet created. Moreover, the world of three-dimensional graphics has neither borders nor constraints and can be created and manipulated by ourselves as we wish – we can enhance it by a fourth dimension: the dimension of our imagination. But not enough: people always want more. They want to step into this world and interact with it – instead of just watching a picture on the monitor. This technology which becomes overwhelmingly popular and fashionable in current decade is called Virtual Reality (VR). The very first idea of it was presented by Ivan Sutherland in 1965: “make that (virtual) world in the window look real, sound real, feel real, and respond realistically to the viewer’s actions” [1].

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2. BASIC PARTS OF VIRTUAL REALITY

VR requires more resources than standard desktop systems do. Additional input and output hardware devices and special drivers for them are needed for enhanced user interaction. But we have to keep in mind that extra hardware will not create an immersive VR system. Special considerations by making a project of such systems and special software are also required [5].

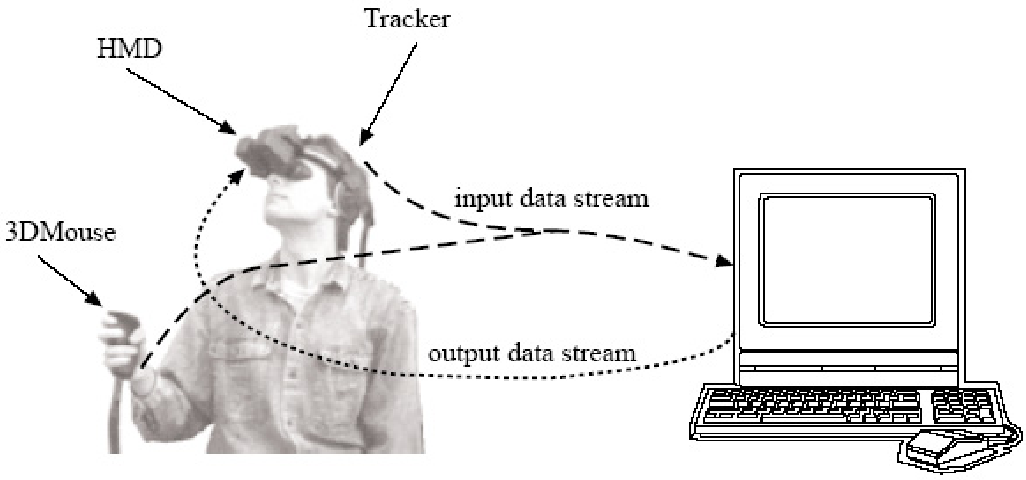

Fig. 1 Basic components of VR

Fig. 1 depicts the most important parts of human-computer-human interaction loop fundamental to every immersive system. The user is equipped with a head mounted display, tracker and optionally a manipulation device (e.g., three-dimensional mouse, data glove etc.). As the human performs actions like walking, head rotating (i.e. changing the point of view), data describing his/her behavior is fed to the computer from the input devices. The computer processes the information in real-time and generates appropriate feedback that is passed back to the user by means of output displays.

In general: input devices are responsible for interaction, output devices for the feeling of immersion and software for a proper control and synchronization of the whole environment.

3. INPUT DEVICES OF VR

Input devices determine the way a user communicates with the computer. Ideally all these devices together, should make user's environment control as intuitive and natural as possible – they should be practically invisible. Unfortunately, the current state of technology is not advanced enough to support this, so naturalness may be reached in some very limited cases. In

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most of cases we still have to introduce some interaction metaphors that may become a difficulty for an unskilled user.

The absolute minimum of information that immersive VR requires, is the position and orientation of the viewer's head, needed for the proper rendering of images. Additionally other parts of body may be tracked e.g., hands – to allow interaction, chest or legs – to allow the graphical user representation etc. Three-dimensional objects have six degrees of freedom (DOF): position coordinates (x, y and z offsets) and orientation (yaw, pitch and roll angles for example). Each tracker must support this data or a subset of it. In general there are two kinds of trackers: those that deliver absolute data (total position/orientation values) and those that deliver relative data (i.e. a change of data from the last state).

The most important properties of 6 DOF trackers, to be considered for choosing the right device for the given application are [3]:

- **update rate** – defines how many measurements per second (measured in Hz) are made. Higher update rate values support smoother tracking of movements, but require more processing.
- **latency** – the amount of time (usually measured in ms) between the user's real (physical) action and the beginning of transmission of the report that represents this action. Lower values contribute to better performance.
- **accuracy** – the measure of error in the reported position and orientation. Defined generally in absolute values (e.g., in mm for position, or in degrees for orientation). Smaller values mean better accuracy.
- **resolution** – smallest change in position and orientation that can be detected by the tracker. Measured like accuracy in absolute values. Smaller values mean better performance.
- **range** – working volume, within which the tracker can measure position and orientation with its specified accuracy and resolution, and the angular coverage of the tracker. Beside these properties, some other aspects cannot be forgotten like the ease of use, size and weight etc. of the device. These characteristics will be further used to determine the quality and usefulness of different kinds of trackers.

4. OUTPUT DEVICES OF VR

Most research focused on presentation of visual information to the user. Beside fast view updates, image quality plays an important role for generation of immersion feeling. Visual

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perception characterization gave an overview of the most important properties of the human visual system that must be taken into consideration for constructing visual displays. The ideal display should have high resolution, high update-rate, wide field of view, high brightness and contrast. On the other hand wearability cannot be forgotten: ease of use, small weight etc. Unfortunately, manufacturing a HMD that fulfills all these needs is beyond today's technology possibilities [6].

Two display technologies are currently available on the market:

- **CRT** – cathode ray tube displays are based on conventional television technology. They offer relatively good image quality: high resolution (up to 1600x1280), sharp view and big contrast. Their disadvantages are high weight and high power consumption. They also generate high-frequency, strong magnetic fields that may be hazardous to the user's eyes and may have negative influence on the quality of measurements of magnetic trackers.
- **LCD** – liquid crystal diode displays are a relatively new technology that is alternative to standard CRT displays. LCD displays are flat, lightweight, have low power consumption and lower emissions than CRTs. The biggest disadvantage is poor image quality: low contrast, brightness and resolution (typically up to 720x480).

The small size of displays used in HMDs brings with it small FOV. To enhance the viewing range special optics may be used such as LEEP or Fresnel lenses. Both of these approaches require a predistortion of the image that will be viewed through the special optics. Wide field optics is used for example by VPL Research for the construction of their HMDs.

Different type of VR systems – from desktop to full immersion – use different output visual displays. They can vary from a standard computer monitor to a sophisticated HMDs. The following section will present an overview of most often used displays in VR.

a) 3D glasses

The simplest VR systems use only a monitor to present the scene to the user. However, the "window onto a world" paradigm can be enhanced by adding a stereo view by use of LCD shutter glasses. LCD shutter glasses support a three-dimensional view using sequential stereo: with high frequency they close and open eye views in turn, when the proper images are presented on the monitor. An alternative solution uses a projection screen instead of a CRT monitor. In this case polarization of light is possible and cheap polarization glasses can be used to extract proper images for each of the eyes. A head movement tracking can be added to support the user with motion parallax depth cue and increase the realism of the presented images.

b) Surround displays

An alternative to standard desktop monitors are large projection screens. They offer not only better image quality but also a wider field of view, which makes them very attractive for VR applications. The total immersion demand may be fulfilled by a CAVE-like displays, where the user is surrounded by multiple flat screens or one domed screen. Ideally it would support full 360° field of view. The disadvantage of such projection systems is that they are big, expensive, fragile and require precise hardware setup.

c) Binocular Omni Oriented Monitors (BOOM)

Developed and commercialized by Fake Space Labs BOOMs are complex devices supporting both mechanical tracking and stereoscopic displaying technology. Two visual displays (for stereo view) are placed in a box mounted to a mechanical arm. The box can be grabbed by the user and the monitors can be watched through two holes. As the mechanical construction supports usually counter-balance, the displays used in the BOOMs need to be neither small nor lightweight. Therefore CRT technology can be used for better resolution and image quality.

d) Head Mounted (Coupled) Displays (HMD)

HMDs are headsets incorporating two small CRT or LCD monitors placed in front of the user's eyes. The images are presented to the user based on his/her current position and orientation measured by a tracker. Since the HMD is mounted to the user's head it must fulfill strict ergonomic requirements: it should be relatively light, comfortable and easy to put on and off. As any visual display it should also have possibly the best quality. These demands force engineers to make hard trade-offs. Consequently, the prices and quality of HMDs vary dramatically: from about 800 dollars for a low-cost, low-quality device to about one million dollars for hi-tech military HMDs.

HMDs can be divided in two principle groups: opaque and see-through. Opaque HMDs totally replace the user's view with images of the virtual world and can be used in applications, that create their own world like architectural walkthroughs, scientific visualization, games etc.

See-through HMDs superimpose computer generated images on real objects, augmenting the real world with additional information. Most of the HMDs currently available on the market support stereo viewing and can be driven either with PAL or NTSC monitor signals.

e) Haptic displays

Haptic sensations perceived by humans can be divided into two main groups [1]:

- kinesthetic (force) feedback – forces sensed by the muscles, joints and tendons.
- tactile feedback – includes feedback through the skin, like sense of touch, temperature, texture or pressure on the skin surface.

These perception issues are extremely important when performing some precise manipulation tasks. Manipulating every object in real world always causes a collision between the hand and this object, which is perceived as haptic feedback. Therefore the many of dexterous manipulators and some data gloves are equipped with devices simulating these sensations. A remote interaction with fragile objects could not be completed accurately without proper haptic cues.

5. CONCLUSION

Virtual reality is a technology that encompasses a broad spectrum of ideas. It defines an umbrella under which many researchers and companies express their work. The phrase was originated by Jaron Lanier the founder of VPL Research one of the original companies selling virtual reality systems. The term was defined as "a computer generated, interactive, three-dimensional environment in which a person is immersed."

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