USING SENSORS FROM A MOTION CAPTURING SYSTEM FOR MORPHOLOGICAL MOVEMENT EXAMINATION AND VISUALIZATION CONTROL

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We report about using sensors from a motion capturing system to control a visualization based on the WorldToolKit; connection of 3D glasses and head mounted displays with the WorldToolKit; setting up of a round projection wall for real size stereo presentations; linking of the motion capturing system sensors to the professional computer animation system Maya and morphological movement examination of jointed figures on the base of the motion capturing system.

Our approach uses the motion capturing system not only for the recording of movements but also to add interactivity to applications, e.g. camera views for real size projections are controlled by motion capturing sensors as well as virtual cameras for other applications using head mounted displays (HMDs), objects in animated 3D worlds are guided by these sensors, too. All these applications are combined with 3D display possibilities.

1. INTRODUCTION

Innovative applications for motion trackers are fighting for center stage. The spotlight sweeps from medicine to biomechanics to entertainment, pausing for new advances in virtual prototyping and simulation.

The DC magnetic approach to motion tracking overcomes two obstacles facing other tracking technologies, which means it is highly adaptable to a broad range of applications. First, the challenge of maintaining a clear line of sight between transmitter and sensor impedes optical tracking. Devices using light or sound energy need a clear path or the data transmission will be broken. With DC field technology, transmitters emit a series of DC fields unaffected by a hand or non-metallic object in the transmission path. Second, DC technology is the only magnetic approach that overcomes many of the metallic distortion problems of older magnetic technologies, such as AC electromagnetic systems. AC trackers continuously induce eddy currents in nearby conductive metals, such as stainless steel and aluminum, which distort accurate measurements. By sampling the magnetic field once it has reached a steady state in which no new eddy currents are being generated in conductive metals, the DC approach overcomes many of the distortion problems that plague earlier magnetic trackers. Furthermore, the DC signal format is significantly less susceptible to distortion errors than AC systems when near ferrous metals such as iron and carbon steel.

The main emphases of the presented research are: controlling and visualizing the motion capturing system sensors by the functions provided from the VR software library, linking of the motion capturing system sensors to the professional computer animation system Maya; morphological movement examination of jointed figures on the base of the motion capturing system.

2. SYSTEM COMPONENTS

2.1. Motion Capturing

The available motion capturing system is Ascensions MotionsStar [5]. This magnetic tracking system is based on a transmitter which produces a hemispherical magnetic field of pulsed direct current with a radius of 3m around the transmitter. The position and orientation can be determined by maximum of 90 sensors (18 per receiver) with a precision of approximate 1cm or 1°. Due to the system principle metal worsens the precision in the area of the monitored volume within this magnetic field. There are two versions of this system available. In the wired version the sensors are connected to the receiver by cables with a maximum length of 11m, in the wireless version the sensors end at the body in a moving bag, the connection to the evaluation station is connected via radio, with a reach of approximate 5m. The wireless version offers in contrary to the cheaper wired version no particular advantage. On the contrary, because every sensor of the wired version is connected to the receiver by cables directly, more independent objects can be pursued, several transmitters/receiver units would be necessary for the wireless version to accomplish this. The advantages of the MotionStar system are in the small sensors, the long range of the base system and the flexible exhibition possibilities.

The main components of the system are shown on figure 1.

2.2. Head Mounted Displays

There are different types of HMDs available. See-through displays offer the possibility to overlay the real environment visible in the display with synthetic images. Non-see-trough displays show only the synthetic images. We work with the Daeyang Cy-visor DH-44003D display. This is a low cost Non-see-trough display. It has a resolution of 800 x 600 pixels in color; the field of view is only 32°. This results in a clearly restricted tunnel look. However, the obtainable stereo impression is definitely comparable with the abilities of high-quality displays.

2.2. Stereoscopic visualization at the screen

A simple system to view stereoscopic images on a screen is the Crystal Eyes from StereoGraphics. The images for the left and for the right eye are displayed alternatively at the screen. The user is equipped with liquid crystal shutter glasses, which open view to the eye corresponding to the image displayed at the screen. The synchronization between display and shutter glasses is accomplished by a small infrared transmitter connected to the clock pulse output of the graphics card. Using this system in connection with corresponding graphics software, a high-resolution stereoscopic picture can be viewed by several users on an ordinary monitor simultaneously.

2.3. Software

To support newly available and future VR hardware and to develop new VR applications with this hardware, a VR software library enabling interactive virtual worlds was used. This software has an interface for our motion capturing system and therefore allows the combination of the motion capturing system with the available stereoscopic displays.

In the described work we used VR software library and Maya. Alias Maya was the choice for the 3D application where the virtual character shall be set up and animated because of effortless implementation of MotionStar via DOS-driver and MEL-scripts. Additionally the software package features a lot of tools for convenient character animation.

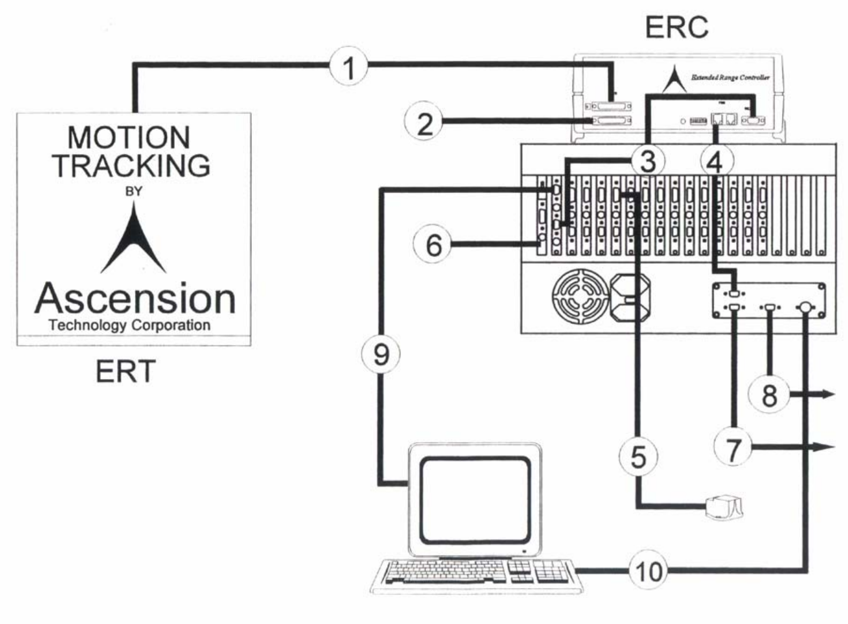

Figure 1. Main components of the system MotionStar:

1-Extended Range Transmitter (ERT) connected to the Controller, 2-ERT Cable Connectors, 3- Connection to COM1, 4-FBB Bus Termination, 5-Sensors, 6- Ethernet Connection, 7-Host Bus Connection, 8-Master to Slave Connection, 9- Monitor, 10-Keyboard Connection.

3. INTEGRATION OF MOTIONSTAR AND MAYA

- **Implementation:** The correct connection between sensors and elements in a virtual scene needs to be achieved and documented.
- **Character Modelling and Rigging:** To test the functionality of the implementation, a human skeleton and character bound to it has to be created in Alias Maya. It is fundamental to design the avatar in a way that also secondary motion like hand, foot and head movement can be controlled by the sensors.
- **Analysis:** After successful recordings of human motion the data shall be cleaned and optimized. Finally the motions are sorted by complexity and compared to the original movements of the actor. Problems with certain grades of complexity or movements have to be analyzed and documented.

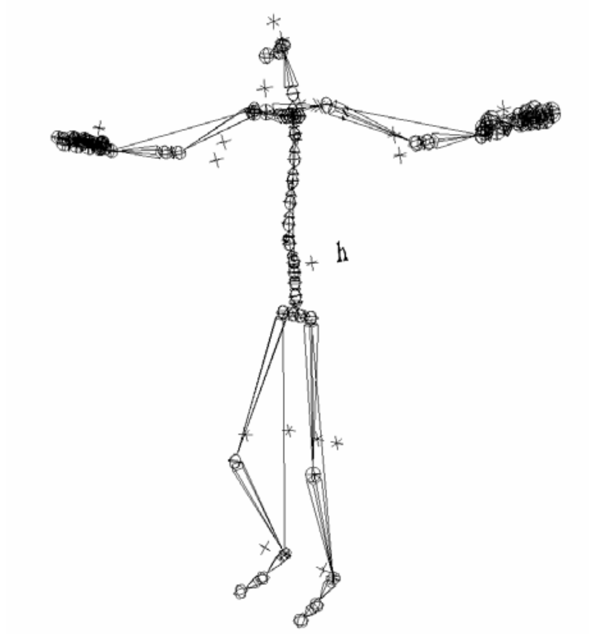

Figure 2. The human skeleton model with 13 sensors

4. EXPERIMENTAL RESULTS

You start with defining which objects and which of their movements you would like to capture. Generally, for a human these are the movements of the joints. A so called specification is built for these objects, consisting of the points you want to track on the video image later. All points are listed to let you pick the desired ones and they can also become connected to each other. This makes it possible to create a hierarchical structure, for example a human skeleton.

First we use forward kinematics [6] assigning the absolute rotation values of the sensors to the joints. The first sensor is mounted on the upper arm, assigned to the rotation of the shoulder joint. The second sensor is put on the actor's lower arm allocating the rotation values to the elbow joint. The animated model is based on the skeleton model from [4].

Problems occur when the arm is not stretched out. Obviously the first joint inherits its values to the second one and so on. That means: When the arm is stretched out to the front, both sensors send rotation values of 90 degrees in one axis. So the virtual upper arm points to the front as it should but the lower arm points to the side, because it changes the rotation relative to the upper arm.

Expressions seem to be the final solution. With the expressions came the locators - the sensors had to be assigned to them and not directly to the joints. Otherwise the expressions didn't work correctly. So locators are added to our scene and expressions like the following are used:

```
elbow.rotateX=locator.rotateX-shoulder.rotateX;
```

These equations work for most of the movements of the arm but not for all. Some weird twitches occur when the actor's arm was completely stretched out to the front. So we decided to go one step back and try it with position values instead of rotation values. Therefore sensors are attached to the actor's shoulder, elbow and wrist and these sensors are assigned to the position of the virtual joints. Using this principle the problem remains: not only the rotation of joints are relative to their parent joints but also the position. Exactly this relationship between the joints was the problem in our very first try. The solution lies in the following expressions:

```
elbow.translateX=locator_elbow.translateX-locator_shoulder.translateX;
```

With a new setup of joints without auto-orientation, locators driven by the sensors and joints assigned to the according locators using expressions it is possible to record nearly realistic arm movements. For this experiment we use the motion capturing system in a room with less interfering materials and monitors, which leads to quite smooth and error free results.

We made some tries with a new skeleton and with 13 sensors fitted on an actor (fig.2). We could transfer several motions into Maya: movements with arms and legs both seemed to be no problem.

Problems get obvious after attaching a skin to the character. To avoid twisted skins it is necessary to stick to usual Inverse Kinematics [1] for the limbs. To also include all the secondary motion a combination with Forward Kinematics using constraints results in convenient Motion Capture data.

5. CONCLUSIONS

Magnetic motion tracking is building a broad repertoire of applications. Portable motion capture stages bring performance animation to just about any venue. Automobile manufacturers rely on virtual reality technology to evaluate new car designs in real time. Multiple motion capture performers put on boxing matches for game developers. Surgeons practice suturing tiny simulated blood vessels. And on the immediate horizon—new ways to evaluate the environment so the applications for magnetic motion tracking using DC field technology can become even quicker, even easier.

We showed that the motion capturing system can be successfully used for interactive VR applications as well. Especially interface problems and difficulties, particularly between the Motion Capturing System and World Tool Kit and Maya have to be investigated by the future works.

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