Applications of a Motion Capturing System: Music, Modeling and Animation

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ABSTRACT
Recent technological advancements in the field of motion capturing have allowed animators and modelers to apply extremely realistic movement patterns to virtual models and objects. However, it is becoming increasingly common to see the effects of motion-capturing technology applied to a wider variety of fields. Systems using motion capture for music composition and performance, dance instructions, and combinations of animation and sound accompany the traditional uses of animation and modeling. The purpose of this report is to compare various uses of motion-capturing technology, and to assess the usefulness, practicality and future potential of each. Our comparisons show that modern motion-capturing systems have great potential for uses which are uncommon today, and that alternative uses should continue to be explored.

Keywords
Motion capture, gestural input, modeling.

INTRODUCTION
Motion capture, a recently popular tool in the fields of gaming, animation, and virtual reality, extracts data from the motion of a set of sensors. This data can be manipulated and applied to several applications. The most common uses of the motion capture system are to apply lifelike motion to humanlike characters. However, the system's data is usable for other applications, and the number of fields in which it is used is growing.

The Vicon 8 Motion Capturing System (MoCap) is recognized as one of the best options available today for the gathering of information about three-dimensional movement. Currently, the uses of MoCap extend to animation, modeling, biomechanics research, and even manipulation of music, lighting, and digital video. What follows is a comparison of successful and promising applications of MoCap, as well as predictions about how these and other applications will be explored in the future.

HISTORY
In 1980-83, at Simon Fraser University, biomechanics labs were beginning to use computers to analyze human motion. Soon after, MIT started using commercial optical tracking systems such as the Op-Eye and SelSpot systems to be used in computer graphics. In 1988, deGraf/Wahrman developed "Mike the Talking Head" for Silicon Graphics to show off the real-time capabilities of their new 4D machines. All of the heads were able to be controlled by one person. The trend continued until where we are today, with motion capture systems as viable options for computer animation.

DATA FROM THE MOTION CAPTURING SYSTEM
The Vicon 8 motion capture system is a passive system, meaning it uses 8 infrared cameras and tracks "markers" that are placed on the joints of the subject whose movement is desired. These markers are reflective, and the cameras are able to track their position. Vicon records the Cartesian x, y, and z coordinates of each marker. As the markers move, the system will record the motion at an average of 120 fps. A quick processing of the information allows the information to be applied to another set of joints, for example, those placed on a virtual three-dimensional model.

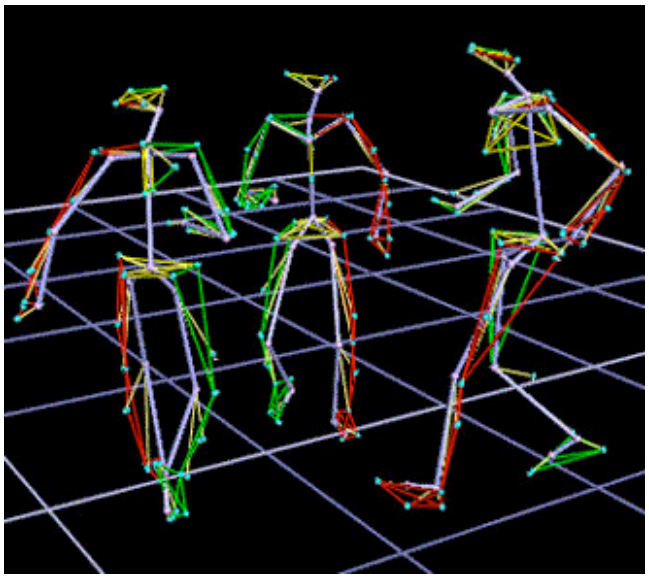


figure 1: A visual representation of MoCap information

The newest system, the Vicon MX13 is a 12-camera system that can record 1280x1024 full frame grayscale pixels at speeds up to 484 frames per second (fps).

MOTION CAPTURING IN ANIMATION

Motion capture for computer animation involves mapping the data collected onto a virtual character. The motion capture system makes a rig to apply this data to. A rig or character is a set of bones that have control points to move the model. When the mapping is direct, as in a human leg motion controlling a character's leg motion, the rig is simply applied to another rig that goes with the model of our choice. So a rig has to be created with the same naming convention of the motion capture system for it to be applied correctly. Just recently software has been developed to use the raw motion capture data directly without having to apply it to a rig. One such software is called MotionBuilder. This software already has many different models and rigs that the motion can be applied to. We can also import our own models but these unfortunately have to already have a rig attached to them before it can be used.

Another related technique is facial motion capture. This is a little more complex since the movements are so minute. This generally performed using multiple cameras arranged in a hemisphere at close range with small markers attached to the face. Though technology is becoming better and therefore a motion capture system is able to capture many markers at a time and can be accurate down in the millimeters. Once again, a rig would still be required to use this data.

Video games use motion capture a lot for the athletes in sports games and for combat moves in those action games. Movies use it for computer-generated effects and for completely computer-generated creatures like Gollum, the Mummy and King Kong. Some virtual reality and augmented reality use motion capture systems but because these require real time input of the user's position, a high-speed, high-resolution system is needed.

MOTION CAPTURING IN MODELING

While animation requires mapping motion capture data to a skeletal system or rig for a model to create motion, certainly motion capture data can be used to derive a skeletal structure. The University of Southern California has a system based on volume and a motion capturing system. The system estimates skeletal curves and kinematic posture from volume data. The volume data is collected with a set of cameras around the space the actor moves in. Under the assumption that the human body has immutable segments connected by joints, and these connections create "nonlinearity" in the volume data collected. The volume data is then visualized frame by frame in a reduced dimensional space using an Isomap. This creates "Da Vinci" pose images. The skeletal points can then be estimated and the curves derived. They extrapolate this estimated skeletal system to the original volume data. The system then breaks it up into body parts and determines joint angles.[6]

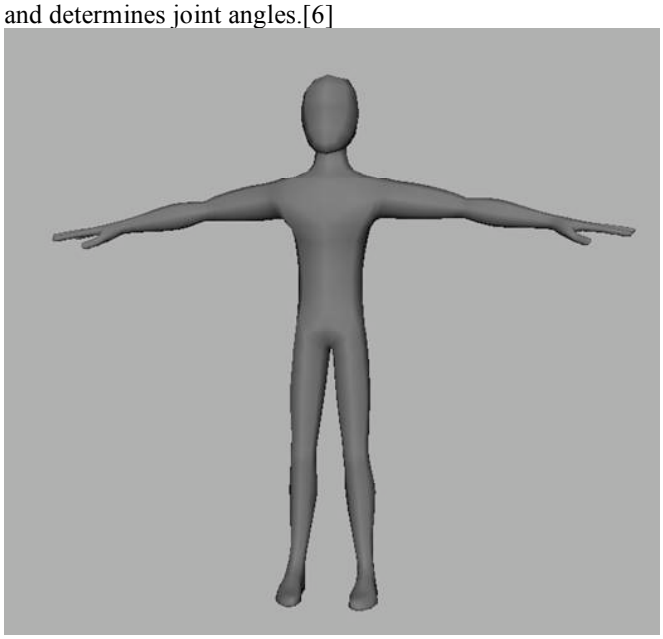


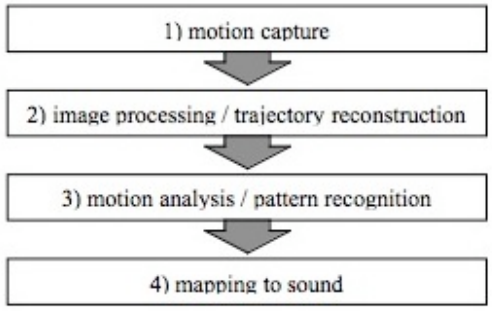
figure 2: Sample 3d model

MOTION CAPTURING IN AUDIO/VISUAL INTERACTION

Production of sound is often associated with a physical motion that creates the sound. For example, a percussive musical instrument is designed such that a motion of striking a surface creates a noise. In a more broad sense, the correlation between audio/visual production and movement lends to the exploration of motion capture as a means of digitally controlling this production. It follows that motion capture may be useful for performing, creating and manipulating sounds, digital videos, music, and even the accompanying light effects. Methods that allow music to be controlled in either a gestural conductor-like form or by the precise movements of a dance have been investigated.

Motion Capture Music

At the University of California, Irvine (UCI), a small group of artists and scientists are working on a system to translate MoCap data into control sequences for musical creation. The working title for this project is Motion Capture Music (MCM). The group mentions that the Vicon 8 system is receiving interest from the music community because of a system known as the "Vicon Real-time Engine." This engine enables real-time transmission and manipulation of captured motion information. The MCM group uses an emulator of the Vicon Real-time Engine known as RTEmulator to output mapped commands to a MIDI creator, which is a type of standard, simple audio output.



Documentation by the MCM team concludes with predictions about how the system might be used in the future. Motion capture, it explains, allows the "playing of a virtual instrument." However, because the instrument is not physically present, a wide variety of improvisations based upon the entire range of human movements is possible. This leaves this virtual instrument far more versatile than any physical instrument could be. Another benefit of MCM-style systems is that when the MoCap system is used for animation, the same data that drives the animation can be used to create the soundtrack. This enables a wide variety of creative audio/visual combinations.

Dance Instruction

Three developers in Japan produced documentation on a system that they have created to teach dance with the help of a motion capturing system. Their stated goal was to focus on beginners for the purpose of teaching the basics of traditional dance. A method where a student wears position-capturable sensors and dances with a robot was compared against a system where the student is simply shown images of the correct form. Feedback (in the form of physical vibration) is given to the student when their motion is found to be inconsistent with the stored information about movement of a professional dancer. As a result, they know when to make changes and what area the change needs to take place.

Documentation by the dance instruction team concludes with results showing that the use of MoCap greatly increases effectiveness of the dance-training program. The authors suggest that future improvements to motion capture technology will make systems like these almost indispensable for the field of dancing and other motion-related instruction.

OBSERVATIONS

Motion capture systems will continue to develop and become more advanced. Eventually, markers on the body won't even be needed and system will be able to create a rig and model just based off the person being filmed. It will also become even more precise and be able to accurately record slight motions like breathing and facial movements.

The MoCap system also shows great potential in the area of audio/visual manipulation. The "Motion Capture Music" system illustrates the prospective use of MoCap as a gestural music generator (in a sense, a virtual musical instrument.) The "Vicon Real-time Engine" is a program that greatly increases the usefulness of the MoCap system in real-time applications, such as the musical performances discussed. The system also opens up creative avenues to change the aesthetics of a musical performance, or to sync animation with a soundtrack that is based on the same control data as the animation itself.

WEAKNESSES

Motion capture is an evolving tool, and there are reasons why it is not in widespread use. Video-based motion capture depends on small sensors, and a bit of error in the placement of these sensors is inevitable. Also, because you are only retrieving information from the "joints" of a subject (where you place the sensors), you are limited as to how much data you receive.

The major problem with motion capturing is the tools necessary are very expensive. The prices of the systems discussed in this paper currently range from $60,000 to $100,000 and above. For purposes such as dance lessons and musical performance, the price tag is not justifiable for use in any situation. Progress and usefulness of the motion-capturing field depends on the future technological developments of the actual motion capturing systems to make them affordable.

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