MOTION CAPTURE PROCESS, TECHNIQUES AND APPLICATIONS

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Abstract: **In technical terms "Motion capture (Mocap) is sampling and recording motion of humans, animals, and inanimate objects as 3D data", but in simple terms "Recording of motion and playback" OR "One way of acting out an animation" is Motion**

Capture. So in this paper we are going to present technical as well as simple aspects of Motion Capture like from simple history of Mocap to technical process of Mocap, simple applications of mocap to technical aspects of Mocap.

In this paper first thing that would be cleared is that Mocap is not new technology it is used since 1872 when Edward Muybridge performs Flying Horse experiment to know that if a horse ever had all four feet off the ground while trotting? So Muybridge placed cameras to capture movements of running horse and takes multiple pictures of horse and proved that statement true. After that Etienne-Jules Marey became the First person to analyze human and animal motion with video. After all these main-frame motion capture started when in 1915 Rotoscoping which is described in this paper later comes in animation techniques and it changed whole meaning of animation. Then process of basic motion capture and some techniques used i.e. how motion or movements of an actor are captured using various markers, sensors, cameras and mechanical or magnetic suits and then how these recorded data is converted and applied on a virtual actor to perform same movements. Then some applications like films, animation, medical etc. are discussed and at last a brief about some pros and cons of Mocap is stated.so overall in this paper we tried to give basic knowledge on mocap so that a non-technical or normal person can also understand that how mocap is started and how it is useful or popular now days.

Index Terms: **Motion Capture, Rotoscoping, Animation**

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1. INTRODUCTION

Animation gave its first steps in the early 20th century, when in 1911, cartoonist Winsor McCay drew a character in multiple sheets of paper with slight changes between these and then sampled them at a constant rate to create the illusion of motion [5]. Animation processes did not witness considerable innovation until computers started to take place in the process. With the birth of key framing, which reduced the amount of samples needed to create an animation animators saw their work a lot more simplified. This process was time consuming because, at the time, every artist was forced to individually animate each pose/frame [6].

With the introduction of key framing the artist specified the initial and ending frames of the animation and the intermediate frames of the movement where automatically generated. However some animations were still impossible to recreate due to their inherent complexity, for example the human walking animation, which is terrifyingly complex due to our articulations. After this in 1915 Rotoscoping is invented by Max Fleischer, this is considered as start of Motion Capture.

1.1 Rotoscoping

Rotoscoping is an animation technique in which animators trace over footage, frame by frame, for use in live-action and animated films. Originally, recorded live-action film images were projected onto a frosted glass panel and re-drawn by an animator. This projection equipment is called a Rotoscope. [14].

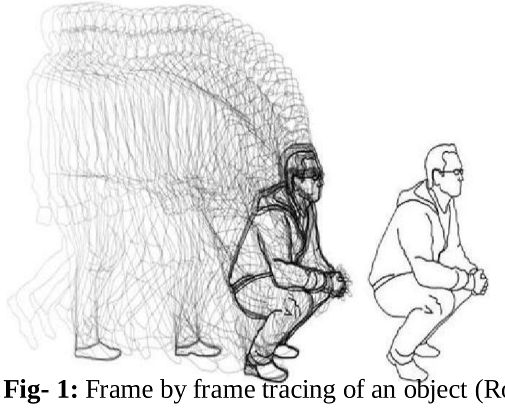


Fig- 1: Frame by frame tracing of an object (Rotoscoping)

To speed up the animation process further, Motion Capture was invented; a means by which we capture the movements of objects in the real world and then insert the data of the captured movement in a tridimensional model of the world in a virtual environment. The process first evolved with mechanical systems that were quite cumbersome and limited the amount of freedom the actor could experience, limiting severely the animation spectrum that could be captured. This happened mainly because these were mechanical systems that resorted to very restrictive suits and large amounts of cable that hindered the actor's movements. Mocap has evolved much since then and today, as a response to these early issues, we have a broader range of options. They include acoustical, mechanical, optical and magnetic systems, further divided in marker and marker less systems [1].

Optical motion capture has been used to recover the fidelity of the motion of strolling adults, playing children and other lifelike activities. However, though impressive in its ability to replicate movement, the motion capture process is far from perfect. Even with a highly professional system there are many instances where crucial markers are obscured from camera view or when the algorithm confuses the trajectory of one marker with that of another. This requires much work on the part of the animator before the virtual characters are ready for their screen debuts. Paradoxically, the price to pay for getting phenomenally subtle human movement is that it becomes very difficult and very time consuming to alter what has been captured.[4] The issues are only slightly different for game-oriented motion capture. Capturing subtleties is less important because games focus more on big and broad movements. On the other hand, the end user character may considerably differ in shape and proportion from the performer artist. This brings in the additional issue of movement distortion [2].

The recent film "Titanic" has demonstrated the maturity of the virtual actor technology. In the film, the ship was carrying hundreds of digital passengers with a degree of verisimilitude that made them indistinguishable from real actors. Among the many challenges taken over by the production team, the most critical element in the creation of digital humans was the replication of human motion: "no other aspect was as apt to make or break the illusion"[2],[4].

2. PURPOSE OF MOTION CAPTURE

We have discussed the simple methodology above but whole method of simple Motion Capture is divided in four steps which are as follows [2]:

3.1 Overview

Originally used for military tracking purposes.

In sports, motion capture acts as a tool for biomechanics research that is focused on the mechanical functioning of the body, like how the heart and muscles work and move.

The MOCA project is in its first stage but we have already made instrumental decisions about the choice of the human model. MOCA will be future of animation, gaming, sports, medical and many other fields. [3]

3. MOTION CAPTURE PROCESS

In the framework of the MOCA project we propose a motion capture methodology based on an anatomic human model. This model encompasses a precise description of the skeleton mobility associated with an approximated envelope. It has a double objective: by ensuring a high precision mechanical model for the performer, we can predict accurately the 3D location and the visibility of markers, thus reducing significantly the human intervention during the conversion process.

The proposed methodology concentrates on body motion capture; face motion capture requires specific devices and approaches. One issue addressed in another part of the MOCA project is the simultaneous capture of both the body and the face motions with their respective technologies.

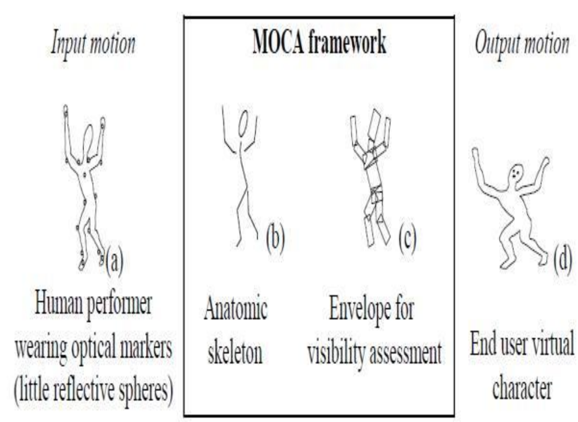


Fig-2: Motion Capture Process

The motion capture process consists of four major stages illustrated below:

- In a typical motion capture session, the performance of standardized "gym" motion is first recorded for the skeleton fitting post-processing.

- Then, according to a work plan, multiple takes of each motion are rehearsed until the artistic director is satisfied with the performance of the artist. It is important to remember that only 2D marker images are captured using dedicated hardware. So the artistic direction aesthetic evaluation can only focus on the real performer's motion and not on the corresponding virtual character's motion [4]. This is the key problem of motion capture.

- The post-processing phase currently occurs after the motion capture session and can last days or weeks depending on the complexity of the recorded material. The first stage is motion tracking, to identify the performer's motion expressed in joint angle trajectories.

- The last stage is the anatomic conversion producing the virtual character's motion while retaining the emotional subtleties conveyed by the real performer's motion. The three post-processing stages benefit from the use of the anatomical skeleton as outlined now.

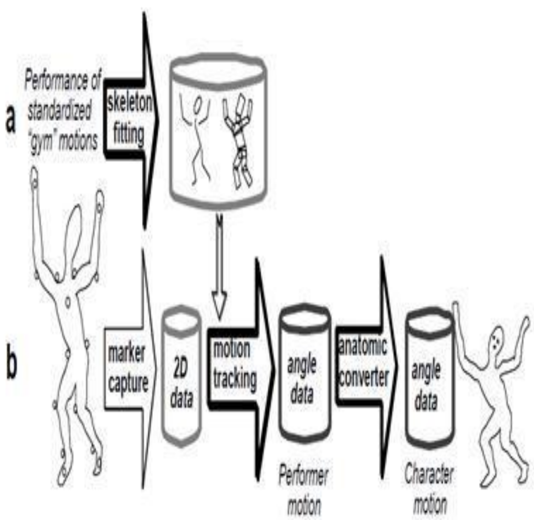
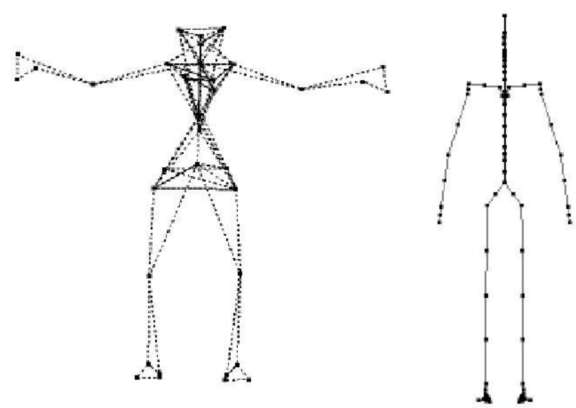


Fig-3: Anatomic Conversion in Mocap

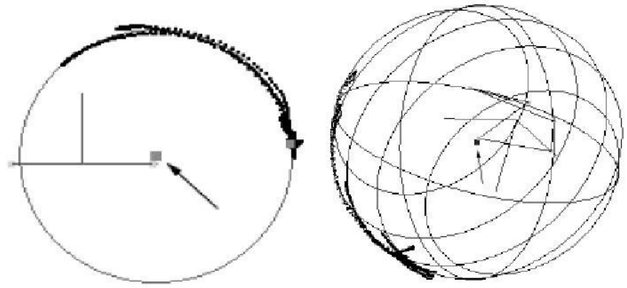
3.2 Skeleton Fitting and Optimal Marker Location

The input to the skeleton fitting procedure is the 3D marker locations computed from simple standardized motions. The difference is clearly visible: the first set forms an exo-skeleton while the one we look for is internal, thus not directly accessible to the measurement technique. The rotation center identification exploits least square fitting techniques as illustrated on Fig. on an elbow-type joint (a) and a shoulder-type joint (b).

The determination of a pertinent cost function is of decisive importance as the skin-level markers always have an unknown relative motion with respect to the underlying bones. Another outcome of this research phase is to identify some simple motions that optimize the skeleton identification. Besides, this knowledge will also provide guidelines for the optimal placement of markers as a function of the end user requirements (e.g. the considered mobility of the virtual character).



(a) (b)



(a) (b)

3.3 3D Marker Tracking and Anatomic Motion Identification

Let us review the three levels of motion tracking to understand the benefit of integrating the information of the 3D anatomical skeleton at that stage. The input is the 2D marker location expressed in the multiple camera image spaces (from two to seven cameras). The motion tracking algorithm proceeds by using as much as possible the low level information (well-known stereo matching from the 2D data, level one) prior to switching to higher level tracking when encountering ambiguities. As motion captured in production is often complex, the 2D tracking is frequently supplemented by a 3D tracking (level two). At that level, the extrapolated 3D trajectory of the markers helps solving ambiguities by predicting future locations of markers in the camera plane. However, in many cases, occlusions bring the tracking algorithm to a halt, forcing costly manual intervention in order to identify lost markers. The major interest of the anatomic skeleton and its associated approximated envelope is to allow matching decisions based on marker visibility (level three).

3.3 D. Conversion from Anatomic Motion to Character Motion

Once the performer's motion has been identified, the goal is to convert it into a motion for the virtual character. The more different the virtual character is in scale and proportion from the real performer, the more artefacts the conversion introduces. For example, self-collisions occur between limbs or significant Cartesian constraints are lost. We address these problems in two stages, first by working only in joint space. In this space, the end-user can establish the transfer functions between the performer and the character models. Two aspects are considered here: the mobility simplification and the joint motion deformation. Whenever this is not sufficient to recover the desired motion, the second stage is to express Cartesian constraints that the character has to enforce all along the motion. The problem that we foresee with this second level is an additional loss in the artistic quality of the motion [2].

4. MOTION CAPTURE METHODOLOGY

There are primarily two methods in motion capture, they are

4.1 Marker-based Motion Capture

In Marker-based motion capture various types of markers or sensors are placed or fitted on Actor and then movements and activities of actor are recorded. Some popular methods of marker-based MOCA are:

4.1.1 Acoustical System

In this type of system a set of sound transmitters are placed on

the actor’s main articulations, while three receptors are positioned in the capture site. The emitters are then sequentially activated, producing a characteristic set of frequencies that the receptors pick up and use to calculate the emitters positions in three-dimensional space. The computation of the position of each transmitter is as follows: Using as data the time interval between the emitting of the noise by the transmitter, the reception of this one by the receptor and the travelling speed of sound in the environment, one can calculate the distance travelled by the noise. To determine the 3D position of each transmitter, a triangulation of the distances between the emitter and each of the receptors is computed [7].

Some problems in this technique are like the difficulty in obtaining a correct description of the data in a certain instant, the restrictions to the freedom of movement the cables induce on the actor.

4.1.2 Mechanical System

These systems are made out of potentiometers and sliders that are put in the desired articulations and enable the display of their position. Despite being underdeveloped, mechanical motion capture systems have some advantages that make them quite attractive. One advantage of these systems is that they possess an interface that is similar to stop-motion systems that are very popular and used in the film industry, thus permitting an easy transition between the two technologies. A final advantage is that they’re not affected by magnetic fields or unwanted reflections, not needing a long recalibration process, which makes their use easy and productive.

Fig- 4: Mechanical Mocap System

4.1.3 Magnetic System

Using a set of receptors that are placed in the actor's articulations it's possible to measure the positioning and orientation of the articulations relative to an antenna. Magnetic systems aren't very expensive, in comparison with other systems for motion capture. The workstation used for data acquisition and processing is cheap as well and the precision of data is quite high. With a typical sampling rate of ~100 frames per second, magnetic systems are perfect for simple movement capture.

The disadvantages of these systems include the huge number of cables that connect to the antenna, reducing the freedom degrees of the actor [8].

Fig-5: Magnetic Mocap System

4.1.4 Optical System

With this kind of system the actor wears an especially designed suit, covered with reflectors that are placed in their main articulations. Then, high-resolution cameras are strategically positioned to track those reflectors during the actor's movement. Each camera generates the 2D coordinates for each reflector, obtained via a segmentation step. Proprietary software is then used to analyse the data captured by all of the cameras to compute the 3D coordinates of the reflectors. These systems are the most expensive ones in the market due to their cutting-end technological nature, such as the high-resolution cameras and sophisticated proprietary software.

The advantages of using these systems are mainly the very high sampling rate, which enables the capture of fast movements such as martial arts, acrobatics and gymnastics, among others. Another advantage is the freedom offered by these systems, since, unlike the other systems, there are no cables or limited workspace and the reflectors pose no restrain

or cumbersome effect on the actor [9].

Fig-6: Optical Mocap System

4.2 Marker-less Motion Capture

The ever-growing research in computer vision fields is quickly enabling the development of marker less optical motion capture techniques. These systems do not require special equipment for tracking of the actors' movement. The actors' movement is recorded in multiple video streams and computer vision algorithms analyse these streams to identify human forms, decomposing these into single, isolated parts used for tracking. The motion capture process is, thus, completely done via software, removing all the physical limitations while introducing computational constrains.

A perfect example of such a system is Microsoft's **KINECT**, which has successfully introduced a solution for low-cost motion capture to the masses [1],[10], [11], [12], [13].

Fig-7: Marker Less Mocap

5. APPLICATIONS

Motion capture started as an analysis tool in biomechanics research, but has grown increasingly important as a source of motion data for computer animation as well as education, training and sports and recently for both cinema and video games. Motion capture is widely used technique in Film making. Now day's motion capture is used in films to record the actors and proprietary software to animate the creatures and battle scenes. These animations created via software were constantly subjected to synchronization with the mocap actor's movements (and also between the digital creatures), in order to create a believable battle or dialog scene. Mocap is used in making of films like King-Kong, The Lord of the Ring, Avatar, The Incredible Hulk and Matrix etc. but in film Real Steel mocap is shown on screen, where a robot is shadowing (capturing) movements of an actor.

Video games uses motion capture for football, baseball and basketball players or the combat moves of a martial artist. Tools like Kinect, Play station, Move, Wii provides platform for mocap to users.

Motion capture can be used in the field of Medicine for gait analysis, sports medicine, and in prosthetic design. It can be used in sports to improve athletic performance. Normal motion capture is a form of visualization and can aid in other areas of science such as psychology. Motion capture can be used to produce a reconstructive video of events in criminal law. For example, it was used to recreate events of the murder of Nicole Simpson and Ronald Goldman. The video wasn't used as actual evidence in that trial. For a reconstructive video to be admissible as evidence in a trial, the animation must be plain and supported by accompanying testimony from animation creators during trial or deposition.

Real-Time Immersive Simulator Technology used by the U.S. Army (STRICOM) for Virtual Soldier Distributed Simulation/War Games since 1995.

In Sports mocap is used in increase in performance of players, by better understanding of motion of opponent, better visualization, digitation plays major role in every game. In cricket, for verifying the action of bowlers mocap is used.

In Health & Medicine mocap is used in performing various tests on user. For better visualization and movements of body parts mocap is widely used in hospitals and test centres.

6. CONCLUSION

Mocap systems, as shown throughout the paper, have evolved from simple, highly restricting, user un-friendly systems (software wise), to very mobile and specialized ones. We have discussed whole process of mocap and all methods used for mocap, so we can say that a lot of work has been done on this topic and a lot is remaining. Mocap has some advantages like it can take far fewer man-hours of work to animate a character, it can capture secondary animation that traditional animators might not have had the skill, vision, or time to create, it can accurately capture difficult-to-model physical movement and most important mocap can provide Virtual Reality and Augmented Reality.

On the negative side, mocap data requires special programs and time to manipulate once captured and processed, and if the data is wrong, it is often easier to throw it away and reshoot the scene rather than trying to manipulate the data. Newer, lower cost active marker optical systems allow real time viewing of the data to decide if the take needs to be redone. Another important point is that while it is common and comparatively easy to mocap a human actor in order to animate a biped model, applying motion capture to animals like horses can be difficult. Motion capture equipment costs tens of thousands of dollars for the digital video cameras, lights, software, and staff to run a mocap studio, and this technology investment can become obsolete every few years as better software and techniques are invented.

So after discussing all aspects of mocap it can be stated that mocap systems are very useful tools and provide a solution to a very important problem as well as enable truly amazing effects, as shown in the article. We have introduced the basic methods behind the various mocap systems and explored their advantages and disadvantages, concluding that every system has its best use in a specific scenario (and budget). The reader was also introduced to some of this technology's uses in real life and research topics, which we hope has provided a comprehensive overview of the area.

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