Motion Capture Systems Overview and Accelerometer MoCaps Systems

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Abstract — The Mocap system with accelerometers is quite practical to use and offers great advantages over the other systems. One must know that no system is perfect and every one of these three is good for certain project. MoCap with accelerometers is used for movies and game animation because of the great possibility of real-time animation.

Keywords — Mocap, motion capturing, 3D, 2D, animation, movies, games, industry, technology, accelerometers, systems, recording, dsp;

I. INTRODUCTION

In the last 20 years the popularity of Motion Capturing (MoCap) technique in animation has increased rapidly. MoCap system in animation refers to recording the movements of an actor and then using that information to animate digital character models in 2D or 3D computer animation.MoCap gives some great opportunities to animators such as timesaving, simplifying the process of animation and others.MoCap can be applied in many other fields : sport (analyzing movements), military, robotics, game industry, medicine (orthopedic analysis, surgical manipulation) and others. This report is focused on MoCap in computer animation.

II. MOCAP PARAMETERS AND TYPES

There are many MoCap techniques, but three of them have practical application in animation industry. The next paragraph reveals the most important parameters of the MoCap system and three most used MoCap techniques with short analysis of advantages and disadvantages.The important parameters of Mocap systems are:

- Accuracy: the error of measuring the movements of the actor. This is a basic problem to solve. It's the reason for unrealistic and unpleasing animated characters.
- Animation in real-time: the possibility of the computer model to follow the actor's movements with a very short (negligible) time delay.This is a quite important because the actor can see how the character responds to the movements at the same moment . Then the actor could experiment with different movements without waiting a long time for the system to analyze the data. Only a few systems can work in real-time. Its quite important for the pipeline animation when time is the most important parameter.
- Freedom of movement: how complicated are the movements the actor is able to do. Its very important for the actor to be able to move freely. Freedom gives anopportunity for rich and interesting animation.
- Frames per second: the recording speed. The greater the speed the better the system will capture fast movements like running, jumping, waving etc.
- Possible interruption in recording: recording themovemant with no interuptionin the process of measuring the movements. In some systems an interuprion could accure and the movement of some parts of the body could not be recorded.
- Identification: each part of the body must be identified. In some systems the parts of the body couldn't be identified. The problem is even more complicated when more than one actor are involved in the scene.
- External influence: the independence of the system from external influence. Some systems are sensitive to magnetic fields or light. This leads to errors and requires

more complicated software for analyzing the data and correcting the error.

- Price: the less the better. Some systems require expensive devices to work properly. As one can guess the goal is to make high quality system with affordable price.
- Training: training the actors to work with the system. Some systems require special awareness when acting. The less training is needed the better, because training takes time and efforts that the actor must be paid for.
- Portability: the ability of the system to be moved. Sometimes the scene must be moved and not all the MoCap systems can be moved easily. For example in first scene the actor must crawl on the ground, for the second he must jump down the stairs and in third he must climb up the wall.
- Software complexity: the complexity of the softwaredeveloped for data analyzing and character animating. This parameter is important for time saving in the process of animating and the price of the system.

The three basic MoCap systems are :

- **Mocap with markers**.

Markers are fixed to the face and the body of the actor. Then the actor is shot by cameras. After that asoftware analyzes the pposition of the markers in each frame and calculates the movement of each part of the body. After that the data is sent to the animating software. The markers could be made in different shape and fixed on differentplaces on the body depending on the software and the algorithm for analyzing the movements. For identification of the markers they are made in different colors. For better detection they are made from fluorescentor light reflecting material. An important for practice type of MoCap with markers is LED (light emiting diod) MoCap. Leds are easily detected and could be modulated for identification. The advantages of this system are the accuracy and the freedom of movements. Unlike the two other type of MoCap this one could record the movement of the face quite accurately [6]. The system could even record the movement of the eyelids. The markers don't interfere with the movements of the actorwhich gives him a great freedom of movement. The system gives the position of the body directly unlike some of the other systems that give only the movement vector. The cameras are able to shoot very fast so the system could capture high speed movements. In more advanced systems a real-time animating is possible. Disatvantage is that the system is expensive due to the complicatedsoftware for analysis and the amount of highresolution cameras needed to shot the markers from different angels. Another disadvantage is that the markers could be covered(blocked) from parts of the body, other actors or object on the scene. The analysis become more complicated when more than one actor are shot. The system is vulnerable to lights coming from othersource than the marker.The system is not easy to move. In Table1 are shown the advantages and disadvantages of Mocap with markers.

TABLE I. ADVANTAGES AND DISADVANTAGES OF MOCAP WITH MARKERS

Advantages	**Disadvantages**
High accuracy	High Price
High recording speed	Recording interruption
Actors movement freedom	Complicated software
Real-time	Not portable
Face expressions recording	Great amount of higher cameras
Position indication	
Most popular	
Many applications	

- **Mocap with magnetic field**.

Sensors are placed on the body of the actor to measure the low-frequency magnetic field generated by a transmitter source. The sensors report position and rotational information.The system is relatively not expensive and provides data with high accuracy [1]. The software is less complicated than the MoCap with markers.The system gives information for 6 degrees of freedom (6DOF – right/left, up/down, back/forword, pitch, yaw, roll) [2]. The markers are independent form covering that means no recording interruption could accure. A great disadvantage is that the system vulnerable to magnetic fields and metal object. Every single sensor is identified and no aliasing is possible. Since most buildings are made with some metal objects a special place for the scene should be chosen. The recording speed is relativelylow – about 100 frames per second [2]. That means faster movements can't be captured. The actor can move only in the field covered by the transmitter. Theadvantages and disadvantages are shown in table2.

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TABLE II. ADVANTAGES AND DISADVANTAGES OF MAGNETIC FIELD MOCAP

Advantages	**Disadvantages**
High accuracy	Limited movement freedom
Gives orientation and position data	Externalinterfere
Low price	Low recording speed
No complicatedsoftware	Noise
6DOF	
No occlusion	
Sensor Identification	

- **Mocap with accelerometers.**

Accelerometer devices are fixed on the body of the actor. In the recent years this technique became more popular due to the better parameters of accelerometers and lower market price. Great advantages are – high accuracy, movement and orientation data, simple software, portability, no occlusion,6DOF, sensor identification, high recording speed, independence from magnetic field and lights and others.Great disadvantage is that the hardware does not report information about position. In Table 3 are shown the advantages and disadvantages of the system.

TABLE III. ADVANTAGES AND DISADVANTAGES OF MOCAP WITH ACCELEROMETERS

Advantages	**Disadvantages**
High accuracy	No position data
Real time	
Affordable price	
Simple software	
High recording speed	
Sensor identification	
6DOF	
Portability	
No occlusions	
Independence from magnetic fields and light sources	

There are other systems like – acoustic, markless, radio frequency and others. They are not reviewed in this report because they have rare practical use due to great disadvantages.Comparing the systems it is obvious why there is a growing popularity of the MoCap with accelerometers . In the next paragraph willtook a closer look on this system.

III. MOCAP WITH ACCELEROMETERS

There are some new accelerometers at the market. For example ADXL 345. Its high resolution (3.9 mg/LSB) enables measurement of inclination changes less than 1.0° [3]. Lets look at the worst case – one sensor placed at the end of one of the longest part of the body – lower leg (350mm length). ADXL will indicate movement if it is more than 6mm at the end of the leg. Now lets see what will happen for a phalanx of a finger with length 30mm. ADXL 345 will indicatemovementif this part moves with more than 0.5mm at the end. That means even the trembling of a finger will be captured. Thats why the accelerometer system has great accuracy.

The dimensions of ADXL 345 are 3x5x1 mm. The sensor can be placed on small parts of the body like hands and fingers. The system cannot measure the movement of face with high accuracy, but it could measure some basic changes like smiling , lower jaw movements, lips movement and browmovement.

ADXL345 cant measure absolute position [3]. It must be calculated . That leads to errors and a need for correctiens.

ADXL345measures the acceleration in three axes [3]. That gives enough data for easy calculating the movement and the software will be simpler than the marker system where a great amount of calculation for every camera and frame must be made.

ADXL345 measures the orientation to the ground [3] which gives important information for the absolute orientation of the body parts. That makes the calculations for the absolute position more simple.

ADXL345 is based on inertial elements and that's why the systemcant be affected by magnetic fields and light.

ADXL345's consummation is as low as 23 µA in measurement mode and 0.1 µA in standby mode at VS = 2.5 V (typical) [3]. With this consummation all the sensors on the body can be powered by battery and the data can be send wireless. That way the actor will be free to move and the system will be easyly portable.

Like all the other systems this one needs some data analysis for correction. The good thing here is that Mocap with accelerometers provides the most needed data right form the sensors, so there is no need for complicated software. The software will be focused on some errors fix and making the movements more pleasant to watch.

An interesting problem to solve is that the sensors are sliding over the skin [4] - The alignment with the bones can change due to relative movements of muscles and skin. This misalignment can result in large errors of angles. The trackers must be placed close to the bones where there is less muscles and fat. On the other hand, the rotations of the joints must also be limited to stay in the human limitations.

IV. CONCLUSION

As can be seen from this information the Mocap system with accelerometers is quite practical to use and offers great advantages over the other systems. One must know that no system is perfect and every one of these three is good for

certain project. MoCap with accelerometers is used for movies and game animation because of the great possibility of real-time animation.

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