Grzegorz Koziel[1]

MOTION CAPTURE

In a big number of domains it is necessary to create animations. It can be especially noticed in the entertainment industry which uses a great amount of animations. Creating animations by hand is a very expensive and difficult process. A better solution is to record the movement of the real object and use it as a base to create animation. This technique is called "motion capture". In the article the costs of motion capture are considered.

Keywords: *motion capture, animation.*

Гжегож Козєл

ТЕХНОЛОГІЇ ЗАХОПЛЕННЯ РУХУ

У статті описано технологію захоплення руху в процесі створення анімації. Створення анімації вручну — дуже дорогий і складний процес. Оптимальним рішенням буде запис руху реального об'єкту і використання його як бази для створення анімації. Ця технологія називається "захоплення руху". Приведено розрахунки витрат на захоплення руху.

Ключові слова: *захоплення руху, анімація.*

Гжегож Козел

ТЕХНОЛОГИИ ЗАХВАТА ДВИЖЕНИЯ

В статье описана технология захвата движения в процессе создания анимации. Создание анимации вручную — очень дорогой и сложный процесс. Оптимальным решением будет запись движения реального объекта для использования в качестве базы для создания анимации. Эта технология называется "захват движения". Приведены расчеты расходов на захват движения.

Ключевые слова: *захват движения, анимация.*

1. Introduction. Animation is a widely used technique. It is very popular in entertainment and research. Animations are very often attached to the eLearning courses or used in other systems to make them more attractive or user friendly [2; 3; 4; 7].

It is very difficult to create a realistic animation. It especially concerns human body motion animations because human senses are very sensitive to deformations in such motions. Creating realistic animation in a traditional way (by drawing sequential pictures) is very difficult and expensive. It demands not only specialized software and equipment, but requires a large amount of animator talent in order to make an object move like the real one. Of course, animation has to have certain quality. It means that small inaccuracy is allowed.

Cheaper and easier way to create animation is to use previously recorded motion. It is possible with using motion capture systems. These systems contain a certain number of cameras (not less than 4) and computer used to record video streams gathered from cameras. Specially designed software analyses obtains video sequences and builds 3D models of the recorded objects. These models and their motion can be used to create animations. It is possible to use another texture to cover

[1] PhD, Faculty of Electrical Engineering and Computer Science, Institute of Computer Science, Lublin University of Technology, Poland.

the model. It means that one captured sequence can be used to animate motion of multiply objects having the same shape and various looks.

2. Motion capture cost. Cost of creating animations is often a key factor in the entertainment industry. Almost all modern computer games use animations to present characters in a game or during videos attached to the game. The film industry also uses animations widely. A well-known example is James Cameron's "Avatar". The whole film was created with using motion capture systems to build creatures' models and their motion. Those models were used to animate characters and objects in a film. A lot of films use real video sequence with animated objects or characters included. As we can see the great amount of animations is used. It is very important to create animations at low cost.

Animators have a few possibilities to create animations [10]:

- create animations manually,
- buy short prerecorded motion capture animations to modify them,
- outsource animations to a motion capture studio,
- use own motion capture studio.

The most expensive is the first possibility. Moreover, it results in artificial animation which is poorly received by clients. A bit cheaper and better quality are the two following options. Prerecorded animations average cost ranges from $10 to $150 per animation, but it demands a lot of work to adjust them to animator's requirements. Outsourced animations are created according the animator requirements and do not need modification but their cost is higher — about $10 per one second of animation. Moreover, it is not possible to customize previously bought animation without buying a new one. Additional problem is a long lead time. Usually animation teams can not afford to wait for the animation. The wait time makes the project less effective and more expensive. To avoid these problems it is possible to buy own motion capture studio. The cost of the studio ranges widely. Professional motion capture studios cost over a $100 000. Price depends on the cameras number and their quality. That type studios offers a big number of cameras and high precision. For a big number of animation studios it is not necessary to use equipment having high precision. Very often low cost motion capture systems are enough.

There are a lot of different offers at the market. It is possible to choose appropriate motion capture set in an economical price.

Of course, the core of the system is computer. The computer has to be supplied with specialized software projected to process gathered motion data (video streams). One of possible programs is iPi Desktop Motion Capture. It is a software that can process video streams set recorded in a common way, without using markers. This software is designed especially to track and recognize human body motion. The price of the software depends on the license version and ranges from $350 to $1000 [10].

The iPi system is designed to cooperate with one or two Xbox Kinects or 3 to 6 web-cameras. The devices number influences the global price of the capturing set and its precision and accuracy. Bigger number of devices allows obtaining greater accuracy, but is more expensive. This applies to both equipment price and calculations cost. Bigger cameras number produces more video streams whose have to be calculated. It increases calculation time. Greater calculation time results in higher cost — it is nec-

essary to wait longer or buy more powerful computer to process data to keep time short.

Cost of the Xbox Kinect is about $150. Web-camera cost is higher because it is necessary to buy the stands to mount camera. That set costs about $400.

Using the data presented above it is possible to calculate that set with two Xbox Kinects cost about $750. Set with 6 web cameras costs about $2750. Of course, it is a high price but it allows building more complex models and recording the object from six independent positions, what gives a possibility to precisely detect great number of irregularities in the shape body. Two Xbox Kinects allow only for observing object (a black shape in the picture) from two positions. It will make impossible to register irregularities not visible from these positions. That problem is illustrated on Figure 1. Areas that are not visible with any device are dotted.

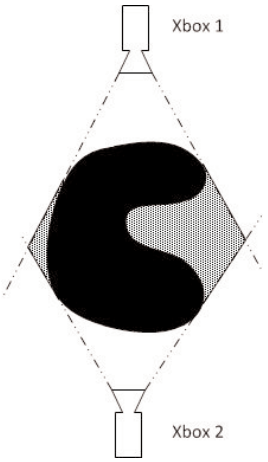

Figure 1. **Invisible areas with 2 Xbox Kinects usage**

It is possible to notice that even while using 6 cameras there can be invisible areas in the scene. Figure 2 shows that even using 6 cameras there is a small invisible area in the dint of the black object [6].

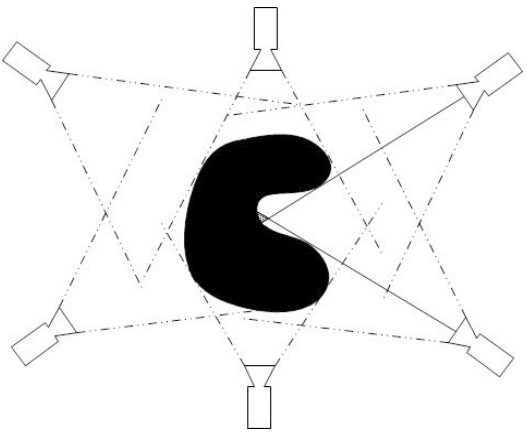

Figure 2. **Invisible areas with 6 cameras usage**

The best solution is very difficult to choose. It is necessary to analyse the demanded system precision and the cameras number. After then the cost analysis can be applied. In the case of producing materials longer than a few minutes it is costly more efficient to buy own motion capture system than to buy animation prepared by other producer [10].

3. Motion capture technologies. In motion capture an object movement is recorded. It is very difficult to locate object and extract its motion directly from the raw video recording. It is especially difficult in the human body motion capture because it changes its shape in a very complicated way.

While using system equipped with cameras we obtain a set of 2-dimensional pictures. It is necessary to calibrate them first to make it possible to transform that set of pictures into three-dimensional model [6].

There are several motion capture technologies [1; 5; 6]:

- electromagnetic sensors,
- optical markers,
- markerless systems,
- electromechanical suites,
- fiber-optic sensors,
- digital armatures.

Each of these technologies can be used to capture the motion. But the biggest popularity gained two first methods. Both of them are based on markers. Optic markers are visible with cameras. Their effect relies on reflecting light in all directions. Usually markers are constructed as reflecting spheres. Electromagnetic sensors are based on detecting electromagnetic field. The result of the detection is calculated into placement in the space. In both of the shortly described solutions it is possible to measure the placement of the marker with good precision. It gives a possibility to cover the recorded object with markers and examine the placement of the markers to determine the object position (shift and rotation).

In the case of human body motion capture the markers are usually placed on bending parts of the body (e.g., knees, elbows). It allows determining the joint places [9].

Systems that use markers have of course some problems. Human skin stretches and shrinks. It causes some changes in the marker placement resulting in inaccuracy. Some markers can be covered up with other parts of the body. In poor illumination optical markers can be poorly visible. Despite these problems passive markers systems have advantage over other systems. Systems with active markers (means optical markers emitting light) are heavier because they demand the energy source and connecting cables that supply markers with energy. Markerless systems have big difficulties with identifying the same point on the pictures taken by different cameras what causes a lot of mistakes. Electromechanical suits limit human movements and make it impossible to record some complicated moves. It introduces some artificial artefacts to the movement too. The advantage of that type suits is a very good precision.

As we can see there is no one ideal motion capture system. We have a lot of available solutions. Each of them has a lot of advantages and disadvantages. Each of them can be suitable in different applications.

3. Three-dimensional position reconstruction. In systems that use a set of cameras we obtain a set of 2-dimensional pictures. It is impossible to determine point placement on the basis of one picture. We can only determine the line on which the point is located. The line goes through 2 known points. First of them is the center of the camera. The second is the point on the picture taken by this camera. The line that goes through these points goes by the point P. If we know the camera placement (it has to be defined first) and we have found the coordinates of the point l_1 on the picture, we are able to identify the desired line in 3-dimensional space. The way of locating point is presented on Figure 3.

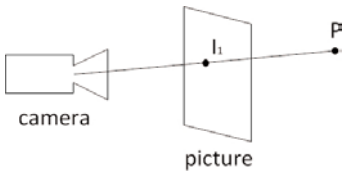

Figure 3. **Identifying the line on which the point P is located**

To identify the placement of the point P in the space we need at least one more camera. In the ideal situation the point will lay in the place of intersection of 2 lines that identify placement of the point according to various cameras. In the real situation we do not obtain intersecting lines because of the narrow cameras resolution and rounding during measurement and calculations. In this case we assume that the requested point is located in the middle of the shortest section connecting these two lines. That situation is illustrated on Figure 4.

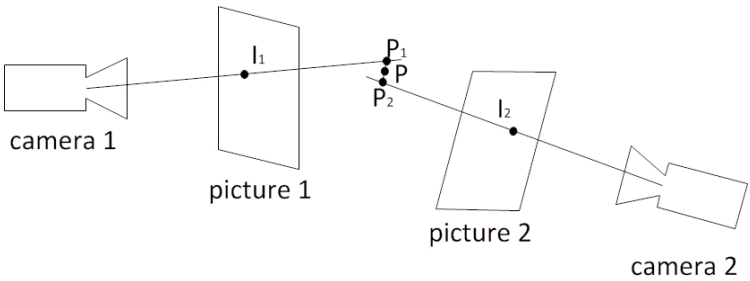

Figure 4. **Calculating location of the point P in 3-dimensional space**

To compute the coordinates of the point P it is necessary to resolve the equations (1) and (2):

$$C_1+k_1(l_1-C_1)=P, \quad (1)$$

$$C_2+k_2(l_2-C_2)=P, \quad (2)$$

where: C_1 — coordinates of camera 1, C_2 — coordinates of camera 2, k_1, k_2 — unknown.

By setting these equations equal to each other we obtain equation (3):

$$C_1+k_1(l_1-C_1)= C_2+k_2(l_2-C_2). \quad (3)$$

Because of noise, limited camera resolution and calculations inaccuracy in the real world we do not obtain the same point P form each calculation. We have to find shortest perpendicular line connecting lines from cameras 1 and 2. It means that line must meet equations (4) and (5):

$$(P_2 - P_1)*(I_1-C_1)=0, \quad (1)$$

$$(P_2 - P_1)*(I_2-C_2)=0. \quad (2)$$

On the basis of the obtained points in the space we can build the movement paths. For this operation the interpolation methods are necessary [8].

4. Summary. Motion capture is a very important technique in a great number of enterprises. Especially in entertainment productions it is impossible to deal without this technique. Creating animation by hand does not meet high demands and is extremely expensive. Motion capture allows for big costs reduction, boosts the creating animation speed and increases animations precision and reality. It is possible to buy prepared animations from different sources but the most costly effective solution is to use an own motion capture studio. It allows having studio accessible all the time what positively influences the animation creating tempo.

Bibliography:

Gleicher M., Ferrier N. (2002). Evaluating Video-Based Motion Capture, Proceedings of Computer Animation.

Lukasik, E., Skublewska-Paszkowska, M. (2012). E-learning as a modern tool in corporation training, Actual Problems of Economics, (in press), #10, pp. 496-501.

Milosz, M., Milosz, E. (2012). Efficiency analysis of the electronic channels use to communicate between enterprises and the administration. Actual Problems of Economics (in press), #6, pp.407-421.

Milosz, M. (2011). Global collaborative knowledge systems in the mind of entrepreneurs, Actual Problems of Economics, No. 7, pp. 372-376.

Moelsund, T. B., Granum, E. (2011). A Survey of Computer Vision-Based Human Motion Capture, Computer Vision and Image Understanding, pp. 231-268.

Parent, R. (2011). Animacja komputerowa, PWN.

Plechawska-Wojcik, M. (2011). Application of expectation-maximization algorithm and maximum likelihood rule to estimation of mixture models parameters, Actual Problems of Economics,#6, pp.346-353.

Skublewska-Paszkowska, M., Lukasik, E., Smolka, J. (2012). Analysis of motion interpolation methods, Actual Problems of Economy (in press), #11, pp. 448-255.

http://explow.com/motion_capture (accessed 15.07.2012)

http://skyreignsoftware.com/resourcepage/low-cost-motion-capture-technology (accessed 15.07.2012)

Стаття надійшла до редакції 23.08.2012.