Mobile sport motion capture system

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Abstract

Power and technique of motion are very important in sport. There are many equipment for power increase, but it's hard to find equipment for real technique improvement. First problem is motion capture of human which takes sport. This paper is dedicated description of device for technique improvement. In the performance of design task main attention is given to mobility and user-accessibility. Second problem is quickness of data processing. For solving this problem we develop mathematical human model which capture human motion using resource minimum.

Index Terms: Sport, Motion capture, Human motion modeling, Mobile measurement system.

I. Introduction

Healthy lifestyle is part of high achiever way. And health is active sport training. Now sport training is prestigious and fashionable. Any high achiever must have fitness club card.

But there is one trouble in this situation. Modern fitness equipment and methods can give amazing effect, but chance to be injured tangibly grow up. Injuries and sprains are most dangerous. It make problem, which can rest for life.

Qualified trainer can solve this annoying problem, but he won't be watching for you during 24 hours. First, it's expensive; second, trainer can't provide you on your work.

But problem solution is an available! Core of problem is deficit of information about human. It means, that need device of data gathering, which correspond following criterion:

- Be accessible to public;
- Be user-friendly;
- Be capable of a human measurement such as motion capture system;
- Be capable of a training managing and pointing at mistakes and its correction.

A. Available device

Specialized sport systems of motion capture solve problem of human measurement, but its application is too expensive and difficult for usage.

Based on mobile, device solutions use GPS and accelerometer such as Nike ipod sport kit. But they are only useful for speed measurement; any other training estimation is inaccessible for them.

Another solution of problem is fitness equipment. It regulates muscle loading due to changing weight or equipment contracting force. And it regulates choice of using muscle group due to constructional decision of equipment.

Let describe this using Newton formulas.

Muscle loading is equal to F = m●a, 'm' is weight of gymnastic apparatus, and 'a' is boost of gymnastic apparatus moving. It means that sport equipment can only change first parameter of force 'F'. Second parameter can be various. In consequence of this value of force can be various too even if weight is known.

Constructional decision of equipment is designed in order for putting human in specified pose at the training time. In this pose superposition of human muscle group forces correctly contracts loading. It means that sportsman can use race track equipment correctly only when he runs forward, but he cans runs backward or sideward. It will be wrong, but he can! And if sportsman changes his run style race track can't detect this.

And now we have following problem:

- Unknown variable 'a' make training estimation not uniquely defined;
- Using sport equipment may be various and it can be wrong;

Sportsman can't change working muscle groups on single equipment during one training cycle.

As result we have that there is no solution measuring up introducing criterion. But there are all wanted technical feature for this:

- There is accessible to public device. This is mobile phone;
- There are various channel of wireless data transfer for user-friendly interface and comfort fitting;
- Available accelerometers and gyroscopes have good ratio of accuracy, price and dimensions for applying in accessible to public device;

But there is no good mathematical model for training estimation..

II. MAIN PART

A. Technical solution

Our group design human motion measurement system. The system under development is a composition of two independent systems which exchanging information (figure 1).

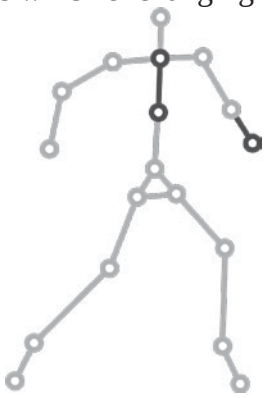

Figure 1. Darker segment - fitting region

The first system is called main and it provides a ground for analytical model of a human. The second system is called secondary and it defines the vector of human statuses. Main system consists of zero number data accelerometer and analysis module for processing. Secondary system is group of devices with accelerometer. These devices are fitting on arm or leg. One of them may be fitted this screen and entry device.

Movement of human is system of balance state and purposeful motion conditions. Balance state condition created by environment around human: lying, sitting, walking, running. This

conditions are estimated by long-continued cycle of measurement. Short-time cycle characterize purposeful motion. Let call summary of this data as status-vector.

Using status-vector and computer modeling we can reconstruct pose of training human.

B. Human motion control level

Level of human motion control divide on three groups: strategical, tactical, dynamic [1](Figure 2). Currently most of motion capture system use dynamic control level – capture position of human model points. But another control level needs another measuring method.

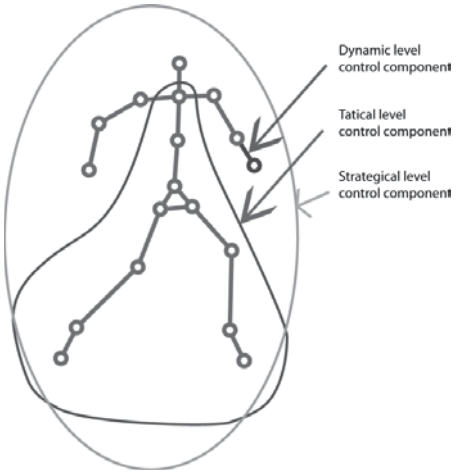

Figure 2. Human control level

Example, goal is pointing out yourself in lecture hall. Strategical control level estimates situation in lecture hall and make a decision to lift up the hand.

Tactical control level simulates behavioral model with following conditions:

- Lift up hand on given height;
- Keep balance;
- Use lowest number of energy;

Dynamic control level get signal from tactical level and move human limb (Figure 3):

- Rotate elbow bone, hold upper arm bone;
- Hold elbow bone, rotate upper arm bone;
- Rotate elbow bone, rotate upper arm bone.

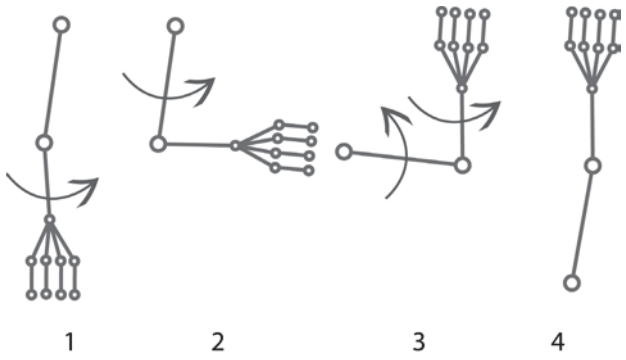

Figure 3. Steps of hand lifting up

Second and third tactical level conditions depend on situation. And only first condition is purposeful motion. So we can only measure active human limb for human pose recognition if we simulate early situation conditions.

That means that tactical level allows us to use much less information for human motion capture than dynamic. Cause this meaning we can estimate human motion and his current activity, measuring only specific human limb.

Mathematical human model:

$$T(t_{i+1})=X(t_i)\cdot V(t_i)+ (X(t_{i+1})- X(t_i))\cdot F(t_i),$$

where $T(t_i)$— skeleton point position at i-th time moment t;
$X(t_i)$— behavior of skeleton point position links;
$V(t_i)$— inertial behavior of skeleton point position;
$F(t_i)$— superposition of human forces.

And use this estimation to provide interaction between mobile device and environment around human. This solution makes possible using mobile phone as sport motion capture system.

C. Browser of augmented reality

Modern measurement methods can't create mobile center of motion capture. But if put to virtual reality copy of human from real life; we can program device responding to changing of human behavior.

For example, increase volume of telephone sound when human takes to the streets, and decrease volume when human lies by.

Application of BAR:

- Usage hand as browser by human;
- Switching mode of phone depending on environment around human;
- Providing sell phone by motion;
- Using sell phone for training in fitness center and during run practice. User can choose individual training plan and sell phone will estimate its realization as coach.

III. Conclusion

Brand new measurement methods make possible to construct devices which solve processing problem using data paucity. This is very important for accessible to public device.

Sport is extreme conditions for data measure and processing. Motion capture sport devises developing demands experiments. For designing system testing optical measurement system is developed. We may estimate mathematical model working comparing measurement results of designing and optical systems.

Motion capture is very interesting feature for sport. High-technology equipment application development is in progress by our group in consort with Saint Petersburg Lesgaft's academy and research center of physical culture. Main scientific activity is investigation of optimal motion capture algorithm.

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