TRAINING AID SYSTEM FOR HAMMER THROW BASED ON ACCELEROMETRY

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INTRODUCTION

The purpose of this study was to establish method for measuring of hammer movement and biofeedback training system for throwers during their training. We applied the accelerometry to hammer throw training aid integrating small sensors, signal processing, short-range wireless transmission, wearable data-logger and biofeedback training system. In this study we both theoretically and experimentally consider the accelerating mechanism of the hammer and the signal that should be fed back.

METHODS

To study the mechanism theoretically, we use a pendulum model (Figure 1a). In this model, the pendulum moves in an inclined plane at an angle α. The dynamic equation of this system is

$$ml\ddot{q} = -me_q^T(\ddot{p} - g_\alpha), \qquad (1)$$

where m is the mass of the hammer, l is the length of the hammer, q is the angle of the hammer, e is the unit vector of tangential direction of the hammer, p is the position vector of the pendulum joint, and g_α is the gravitational acceleration vector in the inclined plane frame Σxy. This equation indicates that the inverse component of tangential acceleration at handle is required to accelerate the hammer. Since the rotational movement is dominant in the hammer movement, we consider rotational kinetic energy E as

$$E = \frac{1}{2}ml^2\dot{q}^2. \qquad (2)$$

The time derivative of the energy E is given as

$$\dot{E} = F_q v_q$$

where

$$F_q \equiv ml\ddot{q} = -me_q^T(\ddot{p} - g_\alpha), \qquad (3)$$
$$v_q \equiv l\dot{q}. \qquad (4)$$

Since angular acceleration increases gradually during the throwing, we select the angular acceleration as the feedback signal.

Microelectromechanical systems (MEMS) accelerometers were chosen as the sensor platform capable of noninvasive, wearable, and real-time monitoring of hammer movement. In this system, a wireless data-logger was developed as wearable device to replace cables and reduce constraint caused by wearing cables. The transmitted data were given as biofeedback information over a speaker through signal processing and voltage to frequency conversion (Figure 2).

In order to prove the theoretical consideration and the accuracy of the accelerometry, a hammer throw experiment was conducted. In the experiment, five throwers performed and the position data of the hammer during hammer throws were captured with 12 optical cameras of Vicon 624 system (Oxford Metrics, Oxford, UK) at a sampling frequency of 120 Hz. The acceleration data measured by MEMS sensors mounted on hammer wire were recorded at 200 Hz.
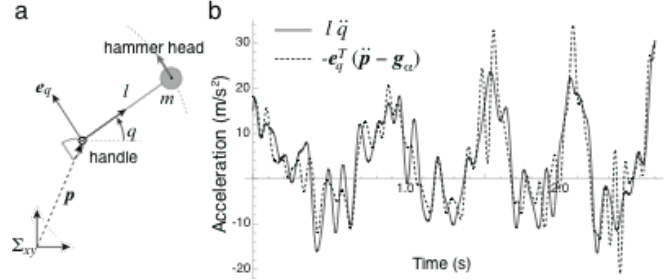

Figure 1: a) Pendulum model of hammer. b) Acceleration of rotational movement of hammer.
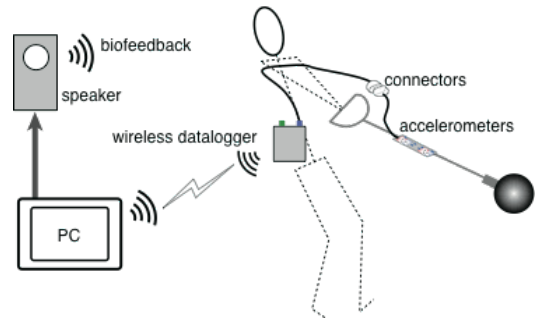

Figure 2: Schematic illustration of biofeedback system.

RESULTS AND DISCUSSION

Figure 1b shows the comparison of rotational acceleration data. In this figure angular acceleration $l\ddot{q}$ was measured by accelerometers and tangential component of handle acceleration $-e_q^T(\ddot{p} - g_\alpha)$ was measured by motion capture system. This result validates the theoretical consideration for hammer acceleration mechanism. We accordingly use this information which measured by accelerometers as a feedback signal.

CONCLUSIONS

During throws the throwers are hard to realize angular acceleration of hammer, which mainly affects the speed of the hammer head, because the centrifugal acceleration composes most of the wire tension. Without the feedback of the information, throwers may exert effort without the effect. To realize efficient sports training, presenting the information, which athletes can't detect by themselves, through virtual sensory organ might be useful for athlete.

REFERENCES

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