A35 A Biofeedback System for Swing Skill Acquisition in Implement Sports

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Abstract
The acquisition of skills in the use of sporting implements is the quest of sports enthusiasts everywhere. Developmental players wish to gain the skill of the elite sports person, amateurs seek those skills of the professional and the weekend enthusiast just wants to improve. Many sports employ a variety of implements such as clubs in golf, bats in cricket, racquets in tennis and swords in the martial arts and in many cases the swing motion is quite similar.

In this paper a method for measuring swing path of a variety of sporting implements is proposed. This method is a refinement of that previously investigated [1] and uses a combination of inertial sensors to track the path of the swing. From this data a graphical visualization of the motion is presented to the athlete using near real time feedback using a wireless link. The visualization is based on the physical movement but abstracted somewhat. As a form of biofeedback it is overlaid with idealised templates of an optimal swing enabling the athlete to learn the swing skill in a novel manner.

1. Introduction
1-1 Skill Acquisition and Biofeedback
The acquisition of particular skills in sport is an important area for the elite and developmental athlete. Skills are generally acquired through explicit and implicit processes. Each of these learning methods has its advantages and disadvantages. Explicit learning tends to develop more accurate movements, however these movements can be less stable under stress. Implicit learning or learning through doing tends to be less 'perfect' though generates a more robust skill. In practice a combination of implicit and explicit processes are used in the development of a skill.[1]
Skill acquisition or Motor learning is achieved when there is some knowledge of the results of an action. Using this knowledge the athlete makes some changes and hopefully improves their action. Augmented representations of a kinetic or kinematic movements can form this knowledge and form part of the athletes error detection and correction process. It has been observed though that too much feedback can be damaging.[3]

1-2 Inertial Sensors
Inertial sensors measure linear acceleration and rotation at a specified location, typically in one or more axis. Sensor size can be millimeters or smaller in size though conditioning circuits can be much larger. Thus these sensors are ideal for measuring human activity as they can measure inertial changes hundreds of times a second and are small enough that they can be biomechanically neutral to the activity being measured.
Accelerometers measure the time derivative of velocity and velocity is the time derivative of position. Thus accelerometers can measure the dynamics of motion and potentially position as well. It is well understood though that the determination of position from acceleration alone is a difficult and complex task [4] though signature analysis of the movements show unique repeatable characteristics that correlate with traditional performance measures.

1-3 Prior Work
 Implements used in sports have been instrumented [1, 5] showing that key characteristics of swing can be measured and extracted, and that they and correlate well with athlete skill. In both these studies movement patterns such as acceleration, timing of phases of motion and rotation of joints were compared across a range of skill levels in two different sports. That clear differences were found suggests that the measurement method was an ideal candidate for providing feedback to the participants.

2. Implementation
2-1 Hardware
In this study a 6DOF v4 Sparkfun™ off the shelf Inertial Monitoring Unit (IMU) was attached to a wooden practice sword (Bokken). This IMU contained tri-axial accelerometers, gyroscopes and magnetometers with a Bluetooth transceiver. A custom interface client was developed using Visual Basic (VB) to collect near real time sensor data.

Figure 1: Bokken with IMU attached

2-2 Software Client and Operation
The developed VB client initiated secure Bluetooth connection with the Bokken and control of the flow of data. The client consists of 4 modes of operation:

Diagnostic Mode
In this mode direct access to the Bluetooth modem and the 6DOF configuration is made possible through their respective command sets. It is used to configure the sensors and connection.

View Data Mode
In this mode raw data from the 6DOF sensors is displayed in near real time. This allows for practice use and assessment of different sensor placement. It is also useful for determining likely sensor output values for threshold detection.

Get Swing Mode
In this mode the client waits for a user definable threshold on a particular sensor before detecting a valid swing event. Data from n points before the swing to n points after the swing is then...
recorded and displayed in a custom visualization window. n is a user definable quantity. In this custom visualization the magnitude of all the acceleration sensors is plotted against the numerically integrated sword angle, as determined from the gyroscope in the plane of rotation. Using a slide control each data point can be investigated in time series data windows as well as on the visualized representation.

Swing Coach Mode

In this mode the VB client displays a user definable template of a swing in the visualization window. The subject is then free to practice a swing movement. When a valid swing is detected (using the Get Swing routines) the subjects' swing is overlaid on the template. Repeated swings are also overlaid over the template. Only the most recent swing and template are automatically displayed. All swings detected are recorded in a separate directory determined by the user and each swing is stored in a text format for easy import into numerical computation software such as Matlab™ or Excel™ for further analysis.

Figure 2 shows a screen shot of the Swing coach in operation, with a number of swings and the template displayed.

Figure 2: Swing coach in operation

3. Results

Preliminary trials were conducted with a range of subject skill levels.

Protocol

Subjects were given the bokken and instructed to practice their swings from the start position where the Bokken was held above the head and to perform a vertical cut. No instruction on how to hold or strike effectively was given. Subjects were able to view the visualized stroke and template stroke as a form of biofeedback after each stroke.

Subject Feedback

Subjects were interviewed at the end of their session for comments on their learning process and on the concept as a learning tool.

I found changing hand positions had an effect and experimented with that and different balance points

I tried different speeds and found in between fast and slow

gave the best results, here I found a shape that worked and closely matched the template and was easy to reproduce

After awhile I found the sound of the Bokken to be good feedback

I found power wasn't helpful and then concentrated on technique

It would be nice to have a history of more than just one swing to look at my progress.

Expert Assessment

The trials were also observed by an expert practitioner who made the following comments:

The subject progressively relaxed through the experiment and whilst the technique wasn't precise it did improve over the course of the experiment

There were many things I wanted to correct but over the course of the experiment some of them just fixed themselves, it was interesting

4. Conclusions

In this paper a rationale for using biofeedback of kinematic events is presented and a prototype system for assessing the method introduced. Preliminary tests carried out on novice subjects suggest that the method might prove to be a useful tool for further investigation. More substantive analysis of the collected data is envisaged.

A comparative study using a number of subject groups is being considered to show statistical significant for the method, when compared to traditional instruction and no instruction.

5. Acknowledgements

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6. References


