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Information Visualisation of Optimised Underhand Throw for Cybernetic Training

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Abstract

We have previously proposed a training system that helps inexperienced athletes acquire skills through a repeated comparison of their electromyography (EMG) signals measured in real time to signals produced by an optimisation calculation using a musculoskeletal model. We refer to this training system as Cybernetic Training, which references a feedback-based signal produced artificially by optimisation of the model calculations. However, when considering many muscles, it is difficult to compare EMG signals and optimised signals because of the significant amount of information. The aim of this study was to develop a method to integrate significant amounts of human motion information to facilitate convenient perception during the Cybernetic Training. In the proposed method, a self-organising map (SOM) is employed to visualise the integrated motion data. Examples of visualisations include the motion data of an optimised underhand throw and that of human subjects wearing inertial and EMG sensors. We compared the optimised motion data and measured motion data using the obtained SOM.

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Keywords: Visualisation; Self-Organising Map; Musculoskeletal Model; Optimisation; Cybernetic Training

1. Introduction

Sports training systems are widely used to improve the motor skills of athletes. A well-developed motor skill involves the precise movement of muscles with the intent to perform a specific action, which can be learned by

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applying empirical knowledge and technological advances during practical training. In general, inexperienced subjects acquire new skills by imitating the body motion of skilled athletes with visual control. Subjects learn from the posture, body part positions, joint trajectories and motion timing of skilled athletes. However, such observable information is restricted to kinematic information. Kinematic information does not contain dynamic information, such as muscle contraction, which drives body movements. To improve a motor skill that involves the activation of various muscles, a learner must develop an internal model, i.e. a correlation map between body motion and motor command, by trial and error.

We have previously proposed a training system that helps inexperienced athletes acquire skills through repeated comparison of their electromyography (EMG) signals measured in real time to that of the signals produced by an optimisation calculation using a musculoskeletal model that considers the physical characteristics of each subject [1][2]. We call this training system Cybernetic Training, which references a feedback-based signal produced artificially by optimisation of the model calculations. However, when considering many muscles, it is difficult to compare EMG signals and optimised signals because of the significant amount of information involved. Furthermore, to facilitate efficient learning when constructing a correlation map between body motion and motor command, the subject must receive feedback about both muscle activation signals and kinematic information such as joint angle, angular velocity and angular acceleration. We propose a method to integrate significant amounts of information relative to human motion to facilitate convenient visual perception during the Cybernetic Training. In the proposed method, a self-organising map (SOM) is employed to visualise the integrated motion data. We visualised the optimised underhand throwing data that represented optimal solutions regarding the speed of a pitched ball and the stress of muscles. Next, we projected the data of human subjects wearing inertial and EMG sensors onto the obtained map to compare optimised motor skills.

2. Proposed Visual Feedback Method

We propose a visual feedback method for the Cybernetic Training that helps subjects acquire developed motor skills by referencing integrated information of optimised motion data using two-dimensional space, as shown in Fig. 1. It is expected that subjects can perceive optimised motor skills involving the activation of various muscles easily by comparing the trajectories of integrated data of optimised motion and that of human subjects wearing inertial and EMG sensors. Here integrated information is comprised of muscle activation signals, joint angle, joint angular velocity and joint angular acceleration, and was visualised with a SOM as the two-dimensional map.

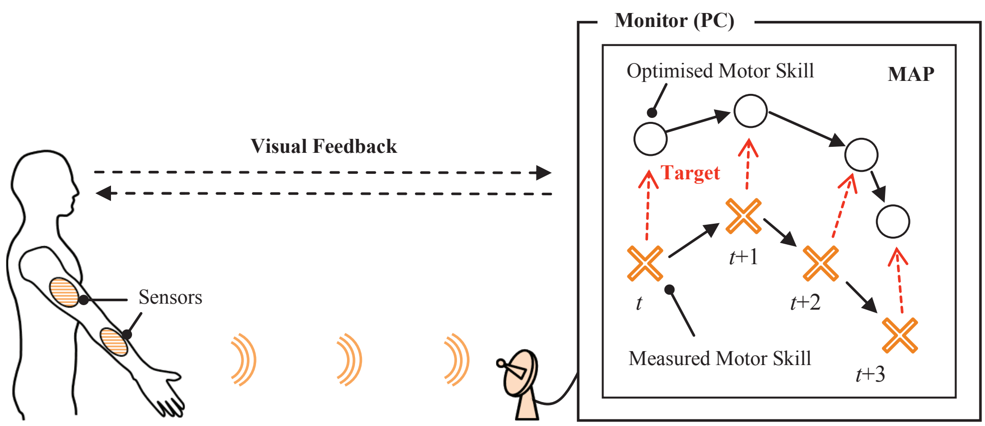

Fig. 1. Proposed visual feedback system with two-dimensional map.

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