THE DEVELOPMENT OF A REAL-TIME FEEDBACK SYSTEM IN WEIGHTLIFTING

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The purpose of this study was to develop a real-time feedback system (RTFS), which can provide weightlifters some useful information, such as the heights of the bar, video clip and so on, immediately after finishing their attempts under training conditions. A Kinect was used to capture the depth data and RGB video, the methods of the pattern recognition and algorithm were established, and the software was developed to identify the barbell and calculate the 3-D data of barbell COM (Centre of Mass). An experiment was carried out to compare the data from RTFS and that from 3D analysis based on video to check the reliability of RTFS. The results showed that the data of barbell COM obtained by RTFS can describe the movement of barbell sufficiently. This new system can help weightlifters to diagnose their skills and improve their training effectively.

KEY WORDS: weightlifting, real-time, feedback, Kinect.

INTRODUCTION: Different research methods were used to study the movements of weightlifting and to evaluate the abilities of weightlifters, such as three-dimensional analysis based on video or infrared systems (Escamilla et al.,2001), electromyography (Bankoff et al.,2007), dynamometer (Funato et al.,2001) and so on, but all of these methods could not be applied under daily training or competition conditions except for video, so the video analysis is only way to get the information of movements without any negative effects on weightlifters.

Video analysis can be used not only to obtain the kinematic data of weightlifting movements for scientists, but also served as a way of feedback for coachers and weightlifters. However, post-processing is needed to obtain the kinematic data, so it is impossible to provide coachers the video feedback with relevant kinematical data in real-time. Therefore, the purpose of this study was to develop a real-time feedback system (RTFS), which can provide the coachers and weightlifters some useful information, such as the maximal height of the bar, the trajectory of the bar, video clip and so on, immediately after the weightlifters finish their attempts under training conditions.

METHODS: A Kinect-sensor was used as the hardware to capture the depth data and RGB video. The methods of the pattern recognition and algorithm were established, and corresponding software was developed using Kinect SDK v1.5 and C++ programming language to identify the barbell and calculate the data of barbell COM in three dimensions. In order to check the reliability of the data from RTFS, an experiment was carried out to compare the data from RTFS and that from 3D analysis based on video. In training field, two digital cameras were used synchronously to record the video clips of the movement of the barbell lifted by an athlete from the ground to the position over his head, and then dropped to the ground, at same time RTFS captured the depth data and RGB video of the movement of the barbell too.

The video clips were digitized with SIMI Motion system. The raw displacements (x,y,z) of barbell COM were exported respectively by SIMI Motion system and by RTFS under the same reference system, so that these two data groups could be compared and analyzed statistically.

RESULTS: The comparisons of the two systems are shown in Figure 1. The solid and dot lines represent the displacements of barbell COM from SIMI Motion system and RTFS respectively. The curves in Y and Z directions are fitted better than in X direction (X direction is fore- and backward related to athlete, Z direction is vertical). The statistical analysis (T-Test) showed that there were no significant differences between the displacements (x,y,z) of barbell COM obtained by SIMI Motion system and RTFS. Thus the data exported by RTFS in real-time are valid, reliable, and can be used to calculate the other kinematic parameters.

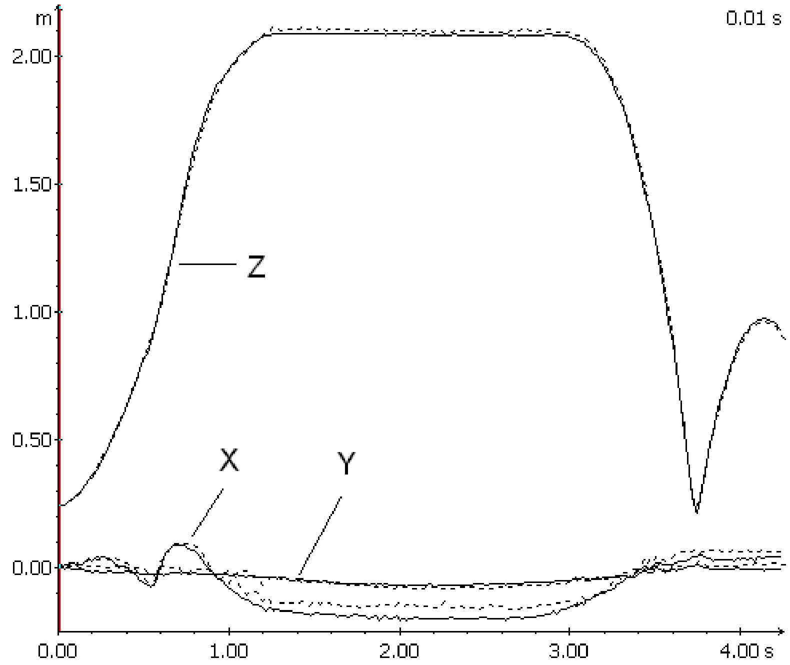

Figure 1: The comparisons of displacements (x,y,z) of barbell COM

The real-time feedback system developed in this study was mainly designed for coachers to diagnose and evaluate the technique of weightlifters in daily training, so this system has following specific features:

1 Without any marker, set up and use the system is very simple.

2 The system starts and stops capturing automatically by means of judging the bar left from the ground and dropped to the ground.

3 After the bar dropped to the ground, the video captured, data and curve, such as the maximal height of the bar, the trajectory of the bar can be shown on LED screen immediately.

4 Pre-defined evaluation protocols for snatch and clean & jerk can be automatically chosen by judging the characteristic of bar movement.

5 Video and kinematic data can be saved directly to database for the further comparison and analysis.

6 The system has two screens, one is touch screen for easy operation, the other one is large screen for showing the feedback of results.

For the researchers, this system can be also used to obtain the kinematical data of barbell with high efficiency, so that the evaluation models for the weightlifting techniques can be set up based on a large number of data captured in training or competitions.

DISCUSSION: Some technical specifications of the Kinect integrated in the system are: the depth images of the objects in the range from 0.8~4.0m can be captured effectively, and the capturing rate is 30 FPS. These specifications meet the needs to carry the measurements and to describe the movements of the barbell COM objectively, because the platform of weightlifing is 4.0 m * 4.0 m, and the maximal velocities of the barbell exceed barely 2.5 m/s when the load lifted by an athlete is over 90% of his 1 RM.

This new system has been used by China National Weightlifting Team in daily training (Figure 2). After each attempt, coachers can give the athletes some advice as correct as possible according to the feedback information provided by the system, so that erroneous feedback can be avoided in the skill acquisition (Ford et al., 2007). Feedback is an essential component of motor skill acquisition and performance. A number of different forms of feedback are used for error detection and correction of the performance. It is apparent that the success of intended actions is dependent upon the information provided by response feedback, it is believed that the feedback in real-time is more effective than before.

Figure 2: The system used for kinematic feedback in training

Another meaningful application of the new system is that it can be used to evaluate or control the performance quantitatively. For example, weightlifters are asked to execute the power snatch or clean as height as possible, but coachers could evaluate the lift only with their subjective experience before, so it could result in erroneous feedback. Now, the height of the barbell is easy to be quantitatified by this new system, and the relationships between the parameters (related to strength and kinematics) in weightlifting can be deeply studied (Stone et al.,2005).

CONCLUSION: The system developed in this study is an integrated system, which has the comprehensive systematic functions including the depth images & video recording, intelligent pattern recognition, data processing and saving, results feedback and exporting. It was designed particularly for coaches in weightlifting to improve the performance executed by lifters. The innovation of this system is to actualize the feedback in real-time, which makes the feedback more and more effective than before. China National Weightlifting Team has been using this system in their daily training, and some improvements will be made to meet the demands for practical applications.

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