A Server-Based System Supporting Motor Learning through Real-Time and Reflective Learning Activities

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Abstract. This paper describes a design of training-diary system intended for motor learning regarding daily outdoor activities including sports. As for motor skill, both monitoring and advising based on the key points which are hard to obtain, are significant factors for improving such motor skills. The points comprise the timing of advice and content. Therefore, we propose a system which automatically generates coaching materials based on real-time monitoring data. It aims to become helpful in finding out such points. During training, the server provides learners and the coaches with an annotation on timeline messages of a mobile-device application by adjustable biomechanical/physiological threshold parameters while receiving the data via the mobile device with wireless sensors. After training, s/he can reflect the reconstructed annotations as diary for next training. Thus, the learners can discuss the key points with the coaches through a trial and error process concerning the threshold adjustment.

Keywords: Bio-feedback, remote coaching, wireless sensor, annotation, content management system.

1 Introduction

Physical training in our daily life is recognized as one of requisite human activity in order to promote our health. Some people tend to try to begin the easy training by themselves anytime and everywhere. Those people face dropout problems because of less motivation based on lack of training knowledge through communication with others who take roles like physical educator [1]. To learn the knowledge and acquire the fundamental skill is called as “motor learning” in sense of basic learning in relation to physical activities. Additionally the skill is called as “motor skill” [2]. When a learner is new to a specific task of physical training, s/he needs to acquire appropriate strategies as such knowledge.

On the other hand, in the field of sports athletes require effective methods to improve their performance. Especially it depends on methodologies of monitoring and advising by coaches. The advice from monitoring corresponds to feedback based on

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finding out key points. Motor learning literatures reports that feedback combined with practice is one of significant factors for affecting motor learning [2-3]. Therefore, an appropriate feedback derives remarkable promotion regarding performance and motivation as a result. Thus, in physical training including sports, educational environment which offers such a feedback through coaching, is essential regardless of athlete or non-athlete.

Generally the key points are hard to obtain because of difficulties in the analysis and detection. In many cases, the process frequently takes much time compared with actual training time. Therefore, such complex procedures are conducted after training. However, the key point comprises the appropriate timing of advice in addition to the content. The timing often means a certain point which appears bad habit concerning posture, movement and so on. Thus, real-time feedback is desirable from the viewpoint of practice reflecting the timing. Moreover, after training, reflective learning which promotes comprehension in real-time learning should be considered because learner generally discuss problems with coaches for next training and makes a note in the training diary.

Meanwhile, current bio-feedback technologies which support by computer-based system with sensors can facilitate improvements of the above mentioned requirement. Feedback system assists learners by monitoring their training and providing relevant specific information during training for the purpose of achieving better performance [4-6]. Therefore, in daily training, a feedback system which consistently can support aforementioned real-time and reflective learning activities has potential to promote motor learning more efficiently. In particular, it contributes daily outdoor activities which coaches do not stay on-site because of need from remote coaching.

Thus, this paper describes a design of training-diary system intended for motor learning regarding daily outdoor activities including sports. We propose a server-based system which automatically generates coaching materials based on real-time monitoring data. It aims to become helpful in finding out such points. During training, the server provides a learner and the coach with an annotation on timeline messages of a mobile-device application by adjustable biomechanical/physiological threshold parameters while receiving the data via the mobile device with wireless sensors. After training, s/he can reflect the reconstructed annotations as her/his diary for next training. Thus, the learners can discuss the key points with the coaches through a trial and error process concerning the threshold adjustment.

2 Motor Skill in Dynamic Environment

2.1 Engineering Approach for Motor Learning

Researches on motor skill were conducted with a central focus on scientific field. That is to say, principal results of this domain to the present were based on analytically-based efforts. For instance, potential technics of Olympic gold medalists or other excellent athletes are ideal topics for such projects. In contrast, a process of understanding simple actions on early childhood learning environment is typical target too. When desirable or not desirable performance appears as a result of actions, researchers analyze features by sensors, video, interviews, and so forth to clarify reasons which making a difference in results. Many studies thus far are conducted

quantitatively and qualitatively in different cases. However, as for professional skill in such a technique like passing the ball of soccer game, some reasons in a certain cases would be not effective to recommend a way of improvement for the next training. It is because either environmental or physical conditions of trials would be different from those in the past. In the same way, as for fundamental skill limited to the specified environment without any outside influences like a vertical jump test of kindergarten children, some reasons would be inapplicable to more complex conditions such as jumping rope.

Therefore, these describes that the scientific approach has a certain limitation to define reasons. The main concern of this study is not the scientific approach but the engineering for learning with sensor/feedback devices and server-based system.

2.2 Skills in Daily Outdoor Activities

Regarding types of skills, Poulton defined skills displayed by performance in a consistent, typically as stationary environment as closed skills [7]. On the contrary, open skills is in a moving and dynamic environment. Allard and Starkes claimed the difference between open skills and closed skills in two respects [8]. The first difference point is the environment in which the skill is displayed. Most open skills are trained in a dynamic environment. For closed skills, the environment is a stable situation in addition to exercise in predictable conditions.

The second difference between open and closed skills involves the role of a particular motor pattern. Closed skills assume that motor patterns are the skills; it is critical that the learner is able to reproduce consistently/reliably a defined/standard movement pattern. In other words, once a learner developed the skill, s/he can do it again in the same situation. On the other hand, for open skills, it is effectiveness of a motor pattern in producing a particular environmental outcome that constitutes the skill. Concretely speaking, a learner tries something in facing different conditions at every trial time. Since most daily outdoor activities mainly requires open skills.

In respect to physical training, it is a type of gross motor skill that interlocks whole body with coherent movements. Gross motor ability shares connections with other physical functions. In the case of road cycling as an example, repetitive actions itself, combined with pedaling is regarded as closed skills. However, from another viewpoint discussed previously, the outdoor activity is considered as open skills because outdoor cyclist always meets different physical conditions, course conditions, competitor and so forth.

According to a retrospective discussion, regarding training of open skills, it is necessary for learners and the coaches to discuss the key points through a trial and error process because of updated conditions each time. Additionally, remote-coaching environments are required as real-time coaching and reflective learning. Because there are many outdoor activities like road cycling in sports. Therefore, from the viewpoint of engineer approach, we discuss a methodology of real-time and reflective learning for open skills of training in daily outdoor activities which are dynamic environments.

3 Support Scenario of Coaching/Training Environment

Fig. 1 compares a general feedback scenario and our proposal feedback scenario. In the case of the former, basically the coaching is based on the result of analysis regarding the last monitoring data as it was mentioned in Chapter 1 because generally it takes much time for coaches to analyze the data. However, from the viewpoint of open skills, real-time feedback is desirable from the discussion of previous chapter. For this reason, in our proposal, both monitoring and coaching are conducted on parallel under supports from our system. The supports are provided by coaching materials generated automatically through analysis of monitoring data for the purpose of avoiding excessive fatigue of the analysis procedure. During training, the server provides learners and the coaches with an annotation on timeline messages of a mobile-device application by adjustable biomechanical/physiological threshold parameters while receiving the data via the mobile device with wireless sensors.

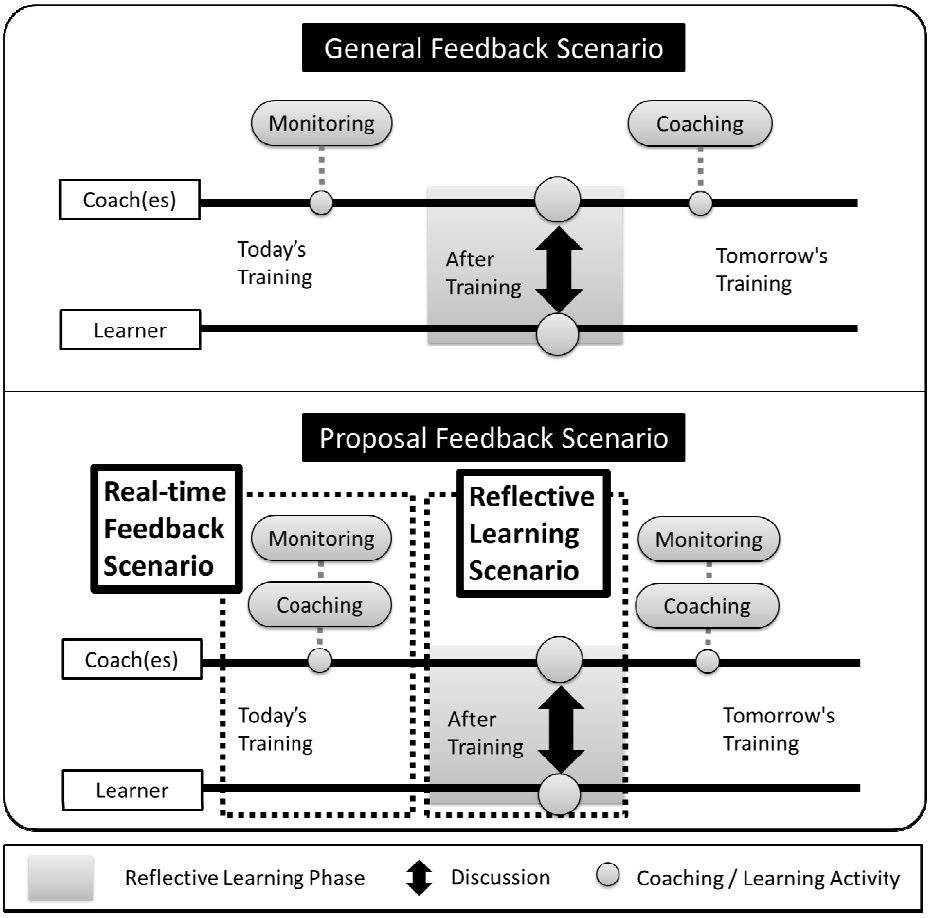

Fig. 1. Comparison with General Feedback Scenario of Physical Training

Furthermore, after training, the other scenario enables deep discussion between coaches and learners. Because after training, s/he can reflect the reconstructed annotations as her/his diary for next training. Following subsections explain to these scenarios.

3.1 Real-Time Feedback Scenario

Fig. 2 shows the real-time feedback scenario during training. We propose a simple decision-making process in order to an achievement of both real-time monitoring and coaching without excessive fatigue. At first step, in monitoring streaming data which includes sensor and video information about training, the system provides an automatic generation of coaching materials. Coaching materials in this real-time scenario mean the information that is help to coaches' judgment in order to provision of an appropriate advice. At second, the system contributes to swift discussion with such coaching materials for feedback. At last simple advice of method to improvement as feedback is provided for learners.

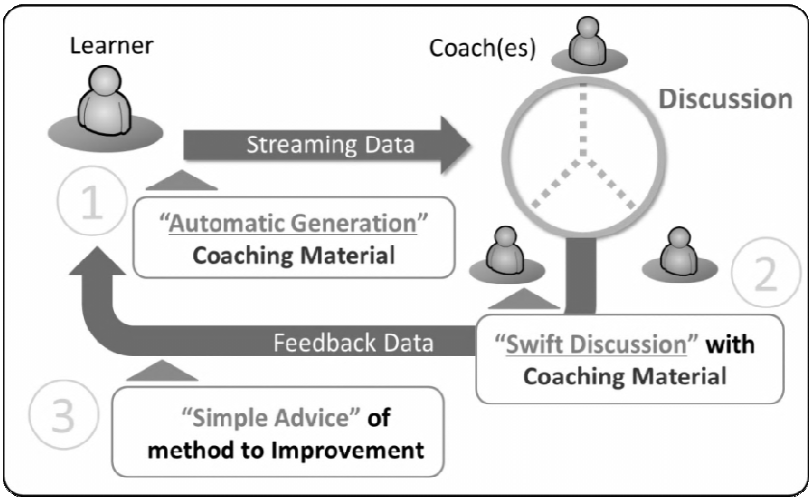

Fig. 2. Real-time Feedback Scenario

Coaching target is to look for and solve the consequent bad habit related to performance, motion posture and so on. Generally, there are several factors of the habit. For examples of factors, exercise intensity, pedaling technique parameter. In the case of professional cycling training as an example of this scenario, coaches who are composed of several field experts focus on these parameters as coaching materials. Each coach preliminary defines the threshold setting of these parameters. This trigger setting is used as the reference information of coaching timing and coaching content.

According to the setting, the system automatically monitors sensor data during training, when the system extract the sensor data which satisfies the condition of parameters, the system automatically triggers the generation of annotation as the tweet message on social service like the left side of Fig. 3.

At the step of swift discussion, while individual coaches monitor video and sensor stream within their area of specialty deeply, coaches share the triggers and the evidence of expertise each other for judgments of simple advice. For example of this discussion in Fig. 3, when the system detects a low rotation of pedaling rate, a coach of biomechanical expert recommends lower gear than current gear. Additionally, another coach of physiological expert indicates the possibility of fatigue because of high intensity compared with training objectives. Consequently the other coach who takes a leading role in coaching integrates with these experts' opinions and instructs learner to "Shift down". Of course, the basic style of coaching is trial by trial. The scenario like this example achieves the improvement of bad habit repeatedly. Regarding concrete real-time feedback, coach pushes the advice buttons among several candidates like the interface of advanced research [4], after that, while the system generates message on twitter timeline, advice is transmitted to learner as the feedback by smartphone application. On the basis of this flow, the real-time feedback is conducted during training.

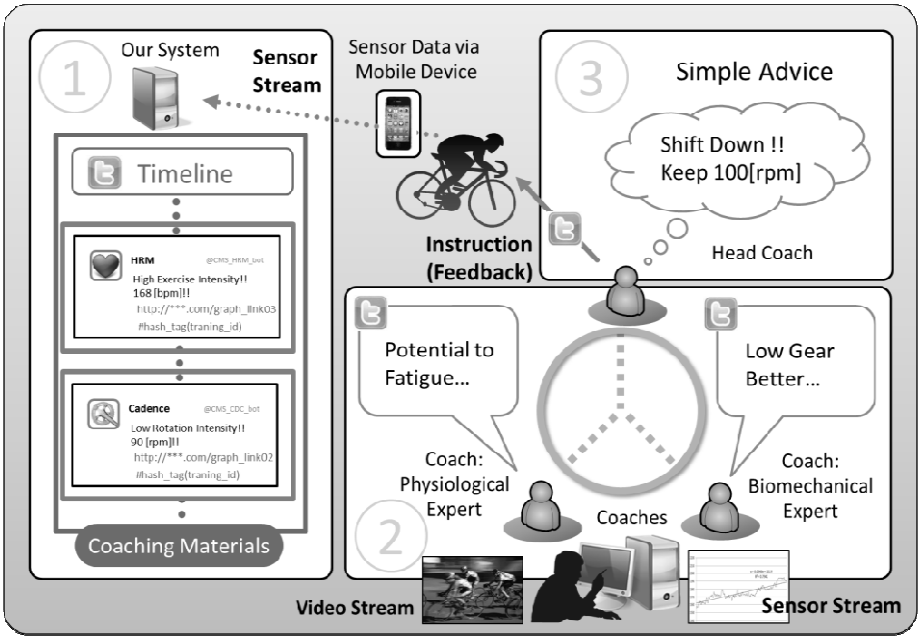

Fig. 3. Real-time feedback based on Timeline message

3.2 Reflective Learning Scenario

On the last stage, reflective learning as an asynchronous task is conducted on the web site of training-diary CMS. Though coaches provide learners with appropriate feedbacks, in fact, learners cannot be always successful in improvement of problems which are revealed in training. The quality and quantity of information which leaner can get and understand them in training are limited because learners have to concentrate on exercise while receiving feedbacks. Much the same is true on coaching of

coaches. Therefore, this stage helps learners and coaches to deepen their consideration of awareness from feedbacks in order to enhancement of upcoming training for both learners and coaches. From the viewpoint of effective feedback and reflect, it is significant for both learner and coaches to improve communication which they understand the intention behind sensor data and feedback. For instance, coach's intention is equivalent to indication contained in feedback. Moreover, learner's intention appears as change action according to feedback.

Training-diary CMS gives them a web interface which they can replay streaming video linked feedback triggers during the entire training on a time-series plots in addition to sensor data. By showing such a synchronous video archive with the traces of feedbacks and the chart of sensor data concurrently, the system facilitate the reflective leaning that learner and coach can remember the situation (e.g., biomechanical conditions) when feedback triggered. For this reason, they can check each other's intention surrounded by several conditions. Thus, this stage contributes to the improvement regarding quality and quantity regarding feedback and reflection.

4 System Configuration

One of the requisite factors regarding the sensor system is to avoid excessive fatigue of learners. Generally the complexity of a setup of sensor and application link including transmitting data is comparatively high. Therefore, difficulties regarding the sensor equipment and the application need to be managed in order to minimize interferences for learners during training under realistic conditions like outfield activity.

Meanwhile the continuous progress in up-to-date technologies such as sensors and mobile device contributes to the development of current feedback system. Wireless sensors allow a convenient setup and easier usage during the data acquisition on parallel with training. Therefore, interference which attached to the learner can be reduced dramatically. In addition to the progress, recent sensor technologies have the advantage of low power consumption, allowing their use during long-term training sessions (e.g., Marathon).

Besides modern mobile devices (e.g., smartphone) provide not only the wireless communication tools in relation to the Internet technologies such as a social networking service, but also various wireless sensor protocols (Bluetooth Low Energy, Zigbee/IEEE 802.15.4 etc.). It enables a wide range of mobile training-applications. Therefore, such devices can be used for mobile data relay which realizes the reception of sensor data, storage and transmission to a web server. For example, commercial systems and services (e.g., Nike+) are capable of recording training, thereafter allowing other learners to monitor their training data via social networking services. The mobile system integrated with such wireless sensor could create the potential for the feasible remote coaching environment which prevents excessive fatigue.

Furthermore, live video streaming service (e.g., Ustream) which can now improve the utilization of broadcast because of a simple method and convenient equipment with only a few devices. Moreover, in the case of broadcast regarding training scene, it means that at least one of coaches can monitor learner's training data at individual remote places. Monitoring sensor data synchronized with streaming video of training can enhance coaches' analysis towards feedback.

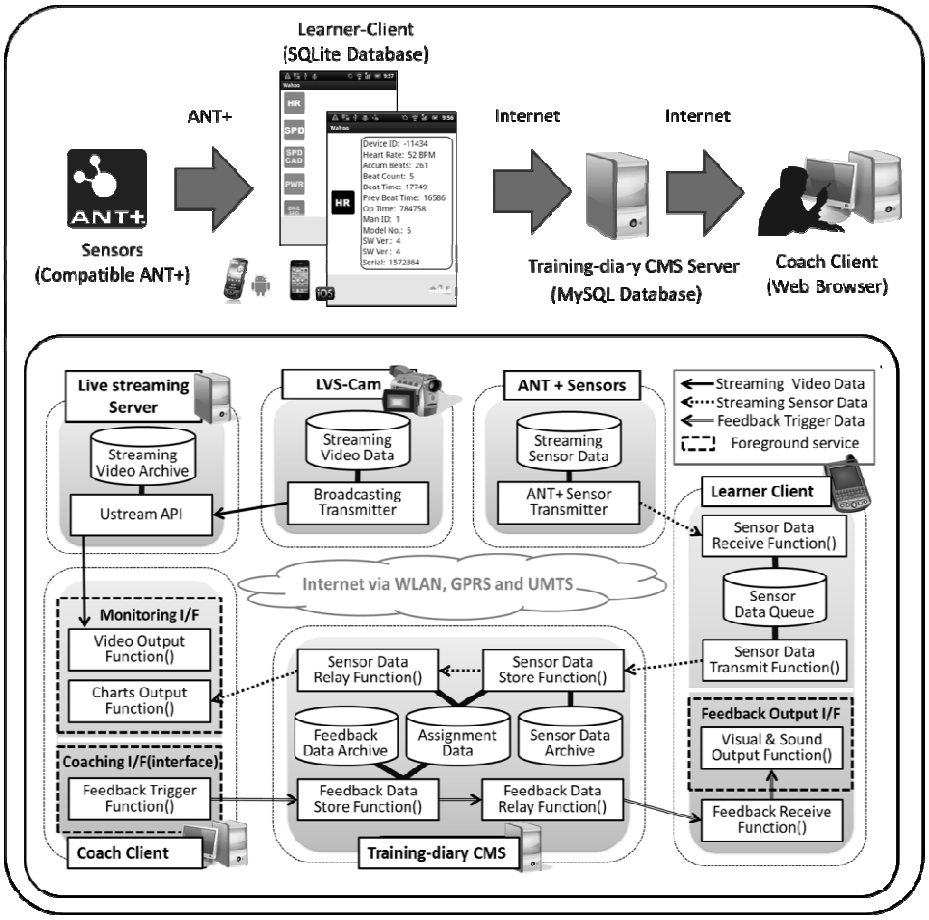

Fig. 4. System Configuration

Fig. 4 shows a system configuration based on the requirements. On the stage of training, bidirectional data flow based on sensor monitoring and feedback is constructed from data transmission between a mobile device and the server via wireless network and the Internet. Coaches can monitor learner's situation by browsing consecutively-updated sensor chart and live video streaming. Feedbacks during training are invoked by judgment of coach. On the stage after training, coaches and learners can reflect their coaching/training through a time-series plots of the web interface.

In this framework, learners are equipped with wireless sensors using ANT+ protocol during training. Our main focus in this paper is set on cycling, running and fitness. Therefore, we chose HRM, speed/distance monitors and cadence sensors as such examples of wireless sensor device. Of course, there are several kinds of sensor function and extension including analog input in this sensor series. Therefore, it is sufficient to cover many activities. Thus, our system has the potential to be capable of supporting a wide range of skill acquisition and so on under educational environment with coaching.

Thus, our objective is to develop training-diary CMS system linking up with a mobile devices (smartphone, tablet PC etc.) which are capable of integrating the aforementioned wireless sensor and live streaming technologies. We tackle to a remote coaching which makes use of a high compatible sensor platform named "ANT+" connectivity solution. The system functionality comprises two services. As a synchronous/real time service, the server provides coaches with analysis and feedback by remote access. They take advantage of data of ANT+ sensors and live video streaming. In this way, coaches are able to analyze the parameters which reflect learners' performance and return the feedback in almost real time. Also for an asynchronous/subsequent service, after training learners and coaches can replay streaming video linked feedback triggers during the entire training on the web interface.

5 Conclusion

This paper describes a design of server-based system of training diary which provides real-time coaching in training and reflective learning after it. On the stage of training, sensor monitoring and feedback is constructed from data transmission between a mobile device and the server via wireless network and the Internet. Coaches can monitor learner's situation by browsing consecutively-updated sensor chart and live video streaming. Feedbacks during training are invoked by judgment of coach. On the stage after training, coaches and learners can reflect their coaching/training through the web interface.

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Our future work concentrates on the implementation and experimentation. For implementation, we have a plan to develop the system, in particular software on mobile device, in several major platforms of mobile devices in order to meet practical demands. Moreover, for experimentation regarding improvement skill, we will obtain knowledge for knowledge-based and expert systems for the automatic generation of feedback [5]. Therefore, we aim to investigate the identification of movement patterns from the viewpoint of coaching by experts [9].

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