S. L. Wong et al. (Eds.) (2010). Proceedings of the 18th International Conference on Computers in Education. Putrajaya, Malaysia: Asia-Pacific Society for Computers in Education.

Remote Training-Support of Running Form for Runners with Wireless Sensor

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Abstract: This paper describes the environment of the remote training-support for runners with wireless sensor. The system provides the visualization to a remote advisor about their running-form and feedback function to them by using their kinetic feature of arm swing at the real-time. In particular, 3D-acceleration sensor catches repeats of arm swing. Sensors transmit such information to the remote server on the Web. The advisor can observe runners' condition by way of waveform changes as graphic reports. Moreover, runners can receive several advices as alarms from the advisor. We have designed and implemented our proposal.

Keywords: Remote monitoring tool, wireless sensor, arm swing, running form, runner

Introduction

Currently running is regarded as an effective sport in promoting healthy life for those who have few chances of exercise. With respect to this sport, some people tackle to reach their own physical limit through high-intensity training such as interval or build-up one. Others take note of growing the ability about the control of exercise intensity to keep up a pace [1]. The latter training is called pace training. It is defined as the fundamental training in promoting physical performance safely and a preliminary step for the former. In the pace training, the most significant point is that runners keep their own velocity to maintain a stable running-form [2].

In many cases, it is not easy for novice runners to stabilize their velocity with their own running-form in mind. Therefore, a professional advisor or a trainer can give appropriate advice about the improvement of the form instability. However, most of traditional coaching-style about running is tutoring or training session. Individual tutoring is tough to schedule. Moreover, many fun runners including novice might want to be trained in the surrounding field which they can exercise in a daily life and nature against indoor running such as treadmill. A conceivable solution to meet their needs may be the remote support via internet. Gotoda et al. have already started the research project of an SNS (Social Networking Service) based learning-support for such runners. They call this project as "e-running" [3]. In this project, the system provides asynchronous support-functions in order to keep their motivation and promote the development of the physical skill through communications with peers. In contrast, this paper tackles to overcome the environment that an expert as a remote advisor can easily teach novices' runner how to correct running-form at the real-time. The system presents two function with wearable wireless sensor; a waveform visualization of their arm swing to an advisor and feedback from him/her to runners by using alarms.

1. Learning how to run

1.1 Theoretical background

In the field of sports science, human motor skill has long history as one of the studying domain [4]. According to Gentile's well known taxonomy for motor skill, human skill could be divided into two dimensioned space by environmental context axis and functions of action one [5]. Within the environmental context, two factors are considered; the regulatory conditions and the inter-trial variability. Running is one of human skill appeared in such taxonomy. In addition, discussion related to environmental context was tackled in the paper about the difference “Open Skill” and “Closed Skill”. The existence of stationary conditions without variability from response to response represents a closed task, while the presence of motion and inter-trial variability represents an open task. Concretely speaking, closed skill is self-paced in a stable in the unchanging environment. On contrary, open skill is performed in a variable environment and must be repeatedly adapted to the changing demands of that environment.

Regarding illustrative embodiment of running from these viewpoints, indoor running by treadmill exercise for the purpose of correction about posture or motion is regarded as closed skill development because runners can train them freely according to the preset program at a uniform pace without any other expectations. On the other hand, open skill needs for runners in an outdoor-field training in the real world because they have to perform against unstable environments such as facing uphill or downhill, and so forth. The target style of running belongs to open skill development because intended runners from the background of this research train in the surrounding field which they can exercise in a daily life.

1.2 Running training in the remote/field environment

Most of traditional researches in computer-supported education, technology-enhanced learning, computer-supported collaborative learning, and so forth assumed real instructors, teachers to lead learners to correct answer by the computer program. These aspects, in fact, have strong tendency to physical learning and training domains because they are more skill-oriented [6]. When an expert gives a novice some advice, most of such a physical education is face-to-face coaching-style.

However, recent physical education offers different condition to learners. The diversification of lifestyles promotes learning activities into online community. In the case of the SNS for the promotion of exercise, users have far-away relationship each other [7]. They do not have to be aware of each location in the real world. Moreover, they can easily find peers and learn something discovered online. If runners' peers including experts put notes about their daily training, methods, and topics related to advice.

In addition, in the real world, runners may find peers who point their weakness or give advices up. In that case, they can keep the friendship to be highly motivated each other. However, they are likely to have unsatisfactory on schedule coordination such as selecting course or time and so forth. In such a case, the remote monitoring system can help their chances of collaboration about running. The fundamental idea of this study met this motivation.

1.3 Direction for adequate running form

As for running-form, some researchers who are experts of running point out the importance of arm swing. There are some technical points of which runners are unconscious or which are implied indirectly during training. The frequency of arm swing tends to decrease slowly over time. It causes slowdowns in running. Similarly, the direction of repeats tends to be changed from front-back to cross direction. Moreover, the amplitude about the motion of arm swing weakens in connection with the direction change. Therefore, we defined the change of arm swing as the support target of the running-form. However, runners have no meanings to catch the information about their running without any sensing devices or monitoring tool. Hence, we adopt 3D-acceleration sensor and notice equipment with alarms that can be put directly. The system observes the change about the acceleration of arm swing. Additionally, the system makes phenomena noticeable to runners. In this way, an advisor and runners can share timings of awareness through almost the same immediacy as the occurrence of changes.

2. Design and implementation

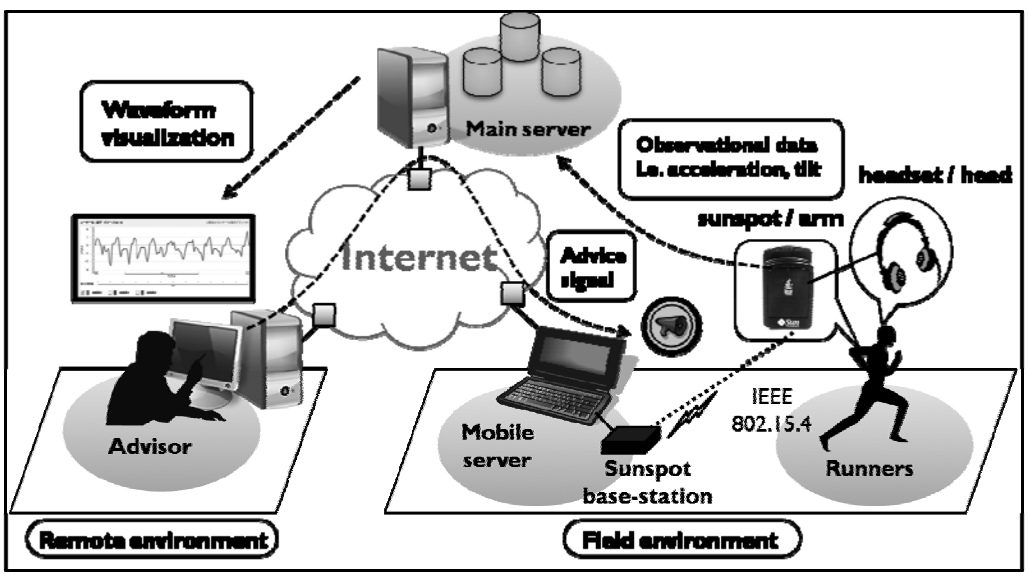

Figure 1 System Configuration

2.1 Sensor and feedback function

Figure 1 illustrates the system configuration of our proposal. The remote environment and the main system are connected in the field via internet. The seamless network by 3G (3rd generation mobile) technology via internet enables a remote adviser to point out improvements of the training at the real-time except for a little communication delay. Since the system works under the 3D-acceleration records, runners have to wear the sensor tool during running. This project adopted the wearable sensor network named “SunSPOT” (Sun Small Programmable Object Technology) by Oracle Corporation. The sampling rate to get the data about the acceleration of their arm swing is 50 milliseconds. All observational data of runners are collected at the mobile server by way of IEE802.15.4 ad-hoc-network. Such data on a mobile server is transferred to the database of the main server during running. A base station connected to the mobile server and relay nodes which also using sunspots are set at the suitable location depending on the course of running. An advisor can refer to such stored information as waveform through a web browser. S/he can decide the type of indication about runners' improvements among several options. That feedback from an adviser sends to the mobile server via the main server. Finally, the extension interface of runner's sunspot connected to a headset plays the sounds based on controls of advice signals.

2.2 System implementation

The main part of the remote environment was developed on the Flash by Action Script because it has a strong advantage in real-time observation with the dynamic graph animation. The flash content is embedded in the web-content generated by Apache built in the main server. The content automatically updates the waveform graph of the observation data on Sun-My-SQL relational database. Furthermore, Observed users are preset by the interface of grouping realized by PHP script. In the field environment, the transmission and the receive functions on the mobile server were developed by the same script. On sunspot, the observation and the sound-conversion functions were implemented by JAVA.

3. Functionality

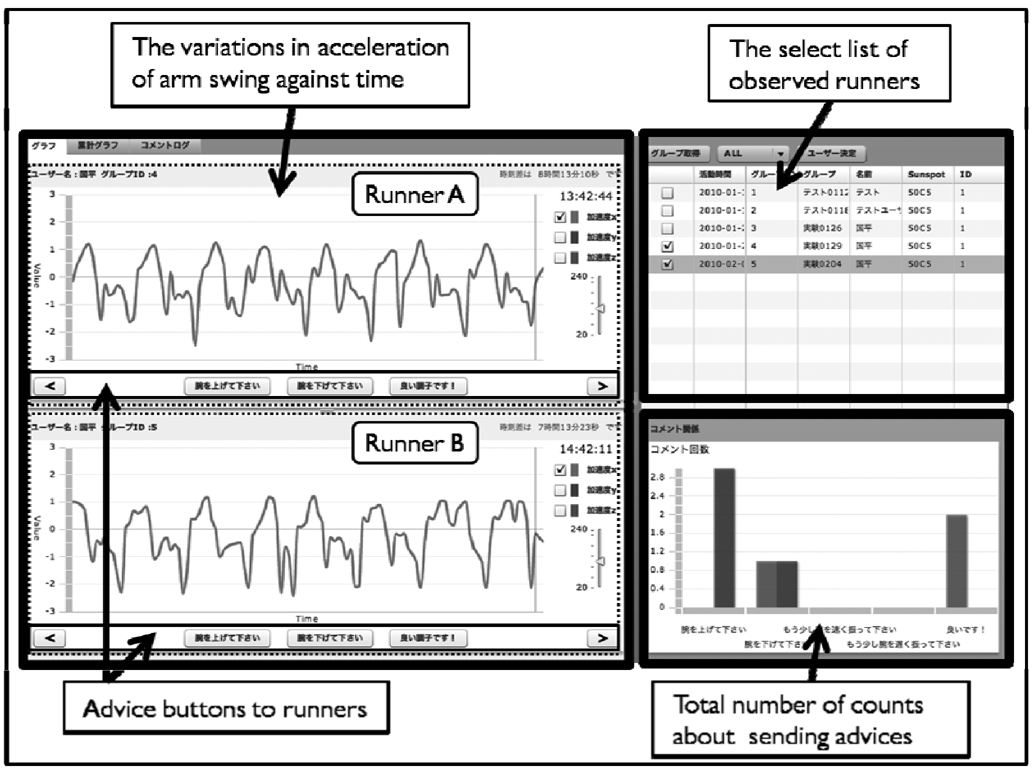

Figure 2 Interface about the waveform visualization and the operation of advice signal

3.1 Waveform visualization of runners' arm swing

Figure 2 shows the interface about the remote monitoring tool. Waveform graphs in the left side of figure 2 provide variations in the amplitude about the acceleration of runners' arm swing against time. An advisor can observe plural runners who are selected on the list shown in the right upper figure simultaneously. S/he can change the time-line scale from the narrow section which s/he can recognize the pattern about a wave of arm swing to the wide one which it is easy for her/him to view the process of comprehensive changes. Also, s/he can switch between display and non-display by way of checkbox of each axis on the interface. Therefore, an advisor can observe the change about the direction of arm-swing through changes about axial components of the acceleration. In addition to real-time play, comparative play with previously-recorded data is supported. S/he can point the improvement of the running form through the comparison with the waveform of a stable condition based on log data.

3.2 Feedback with alarms

If an advisor notices unsteadiness of waveform in a graph, s/he can send the advice signal to runners by the push of advice button in the bottom of individual graph. S/he choice an appropriate button due to the condition of waveform such as changes of a shape, amplitude, frequency, and so on. Several sounds as alarms which play on the sunspot correspond to each signals. Runners know how to be conscious of movement of their arm swing depending on types of sounds in advance. Furthermore, when an advisor can confirm the improvement of waveform or the continuity of stable condition of it, s/he can encourage runners to keep their conditions by playing preset cheer-melody.

4. Conclusion

In this paper, we described the supporting environment of the remote training for runners with wireless sensor network. This sensor network was implemented by tiny devices with ad-hoc radio communication and multi-sensors by Sun Microsystems' sunspot. We applied this architecture to help the stability of their arm swing with alarms from a remote advisor.

Acknowledgements

This work was partially supported by Grant-in-Aid for Young Scientists (B) No.20700641, Scientific Research (A) No.19200055 and JSPS Fellows No.22.10013. In terms of system development, an alumnus of our laboratory, Mr. Shotaro Sakoda, made a profound contribution to this work.

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