Ogata, H. et al. (Eds.) (2015). Proceedings of the 23rd International Conference on Computers in Education. China: Asia-Pacific Society for Computers in Education

Heartbeat Feedback for Learners' Emotional Self Control

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Abstract: The authors propose a heartbeat feedback system for learners. It works on Web browser and utilizes PC equipped Web camera, so is portable on various types of laptop PCs. The proposed system visualizes heartbeat change on a graph in real time manner. Preliminary experiment result shows that the proposed system is effective to recognize learners' emotional status, especially in nervous state. The result also suggests that this effect is effective for self-regulated learning.

Keywords: Learning analytics, heartbeat, biofeedback, emotion, self-regulated learning

1. Introduction

1.1 Learning Analytics

Learning analytics (LA) has become a major area in learning science and learning technology research in the trend on digitization of education. Ferguson (2012) described a definition of Learning Analytics as follows: "Learning analytics is the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs." A trend of digitization of learning, education and training can be divided into three categories. First one is an adoption of digital learning resources, e.g. LMS-based digital material delivery and client PC-based digital textbooks/ references/ dictionaries. Second is an application of digital environment for learning activities, e.g. interactive learning environment, group or peer-to-peer communication environment for discussion or information sharing, and various active learning supporting tools. The first is considered to be an upper stream of learning, whereas the second one is to be a midstream of learning. Compared to them, LA is considered to be a downstream process of learning. It means collection, analysis, and utilization of learning activity log data.

The learning activity log data has been collected and analyzed since hundreds years ago, even in age of paper-based learning environment. In 2000s, LMS (Learning Management System) based learning environments have been spread. During this period, many types of learning activity logs have been collected in these LMSs and analyzed. These data came from instruction-based activities, e.g. class participations, material views, and answers to quizzes. Also they included active learning-based ones, e.g. enrollments, utterances, interim and final products of group activities. In 2010s, usage of laptop or tablet PCs has been common in K-12 education in various countries. In this environment, various fine-grained learner related information have been available for Learning Analytics, e.g. page flip, learners' actions, eye-track, voice and environmental sound, GPS information, and even heartbeat with use of PC-equipped camera. In future, many types of physiological data like blood pressure and sweating will be available with use of wearable devices. This trend is summarized in Figure 1.

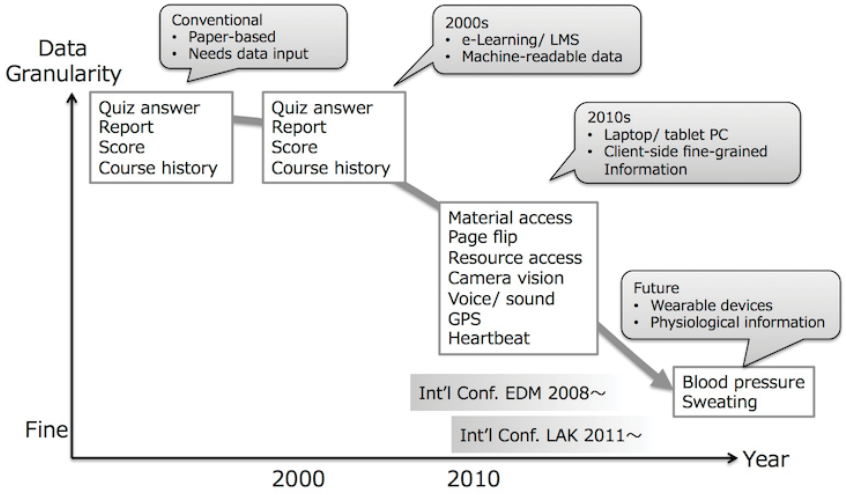

Figure 1. Trend of Learning Activity Data

There are many types of research-based information resources for Learning Analytics. An academic journal called Journal of Learning Analytics is published from SOLAR (Society for Learning Analytics Research) (SOLAR, 2015). Also, two types of International Conferences: Learning Analytics and Knowledge (LAK) and Educational Data Mining (EDM). LAK publishes proceedings from Long et al. (2011) through Baron et al. (2015). Also EDM publishes proceedings since Baker et al. (2008) through Santos et al. (2015). As a general survey, Shum (2012) classifies 5 types of LA activities: (1) analysis dashboard of LMS or VLE, (2) predictive analysis, (3) adaptive learning analytics, (4) social network analysis, and (5) discourse analysis. Especially for active learning and collaborative learning, Shum and Ferguson (2012) shows some LA goal and future issues of these activities. Up to date discussion and information are available on Google Groups on Learning Analytics (2015).

Standardization organization of ISO/IEC JTC1/SC36 has started WG8, devoted to Learning Analytics in June 2015. In the WG8 meeting in Rouen France, an overall framework of Learning Analytics was discussed. Figure 2 is based on this discussion, and includes some expansion.

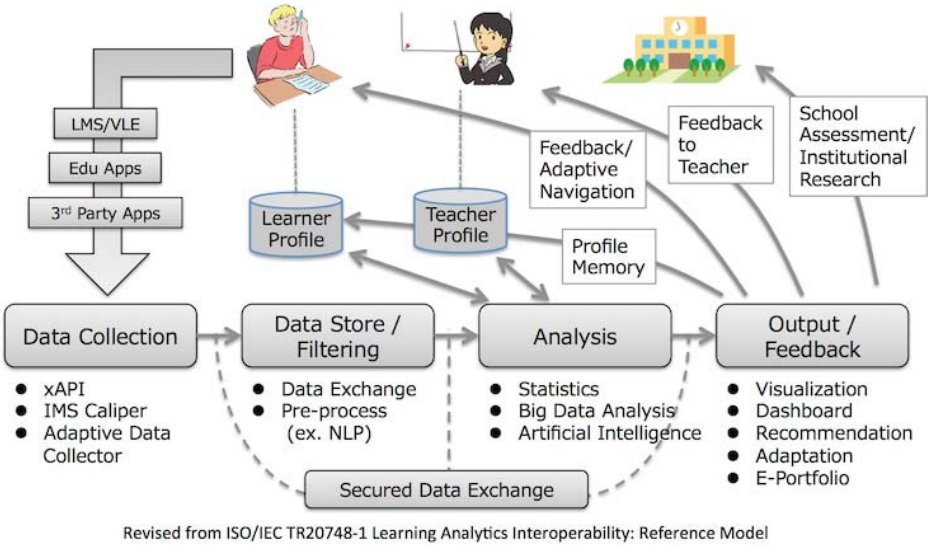

Figure 2. Overall Framework of Learning Analytics

There are major 4 steps: (1) data collection, (2) data store/ filtering, (3) analysis, and (4) output/ feedback. In the first step of data collection, learning activity data is collected with use of LMS, VLE (Virtual Learning Environment), education application or 3rd party application programs that are used by learners.

1.2 Learning Strategy and Biofeedback

Learning strategy is one of core skills to support effective learning activities. Oxford (1994) classified it in six categories below: (1) memorizing, (2) analysis and reasoning, (3) compensation, guess and application, (4) self / situational awareness, (5) emotional control, and (6) cooperation with others. Among them, the authors focus on (5) emotional control. It means that a learner needs to recognize his emotional status objectively, in order to execute his learning activity effectively. If his emotional status is hazardous for learning, he is possible to recognize and improve it by himself or with other's assistance. In this paper, the authors focus on a method to assist self-awareness of a learner's emotional status with use of biofeedback method.

Biofeedback is a method to visualize and feedback one's biological information such as blood pressure, heartbeat, myoelectric, sweating, blood pressure or respiration. The Association for Applied Psychophysiology and Biofeedback defines it as: "Biofeedback is a process that enables an individual to learn how to change physiological activity for the purposes of improving health and performance. Precise instruments measure physiological activity such as brainwaves, heart function, breathing, muscle activity, and skin temperature. These instruments rapidly and accurately "feed back" information to the user. The presentation of this information — often in conjunction with changes in thinking, emotions, and behavior — supports desired physiological changes. Over time, these changes can endure without continued use of an instrument" (AAPB, 2015).

Generally, learning activity with continuous biofeedback training is called "biofeedback training". This training is said to reduce learner's stress and anxiety. Tansey (1984) shows a clinical treatment regime for pathological interhemispheric dysfunction with respect to a population of learning disabled boys. Amon and Campbell (2008) investigated "The Journey to Wild Divine" as a biofeedback management tool teaching breathing and relaxation skills to children with Attention-Deficit/Hyperactivity Disorder (AD/HD).

In psychological view, there are some preceding researches to examine relationship between mindfulness training and cognitive abilities (Chiesa, 2011) (Meiklejohn, 2012). These papers shows that a sort of training effects to improve cognitive abilities of learners. The proposed system does not include some training, but just measurement of heart beat, which implies their mental status.

In this paper, the authors applied the biofeedback to general learners. The learners receive the feedback of their change of heartbeat with use of PC camera based heartbeat monitor system, due to solution of various quizzes. They recognize their emotional situation with use of the proposed system. This feedback also encourages them to self-control their emotional situation.

2. Developed System

The authors developed a system with three functions: (1) to calculate one's heartbeat with use of PC equipped Web camera, (2) to visualize one's change of heartbeat in a graph, and (3) display quizzes. This system is working on Web browser. A screenshot is shown in Figure 3. Pink background section (upper left) shows a quiz. White graph with red dots (upper right) shows change of heartbeat. This graph section utilizes a freeware.

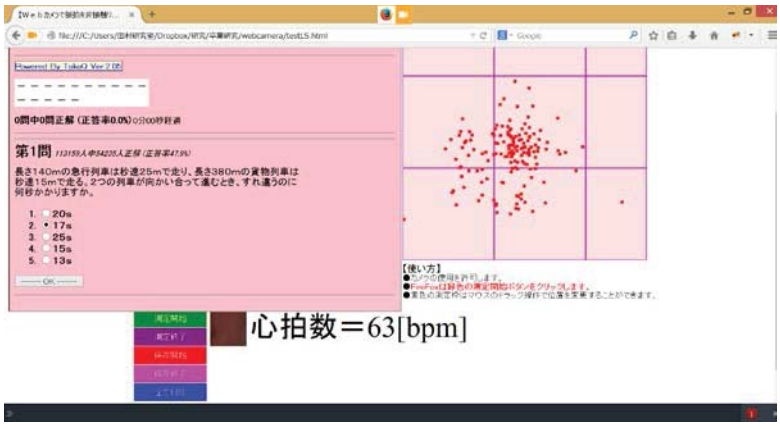

Figure 3. Screenshot of the proposed system

The proposed system has the following features. (1) Since it is written in JavaScript, it works on PC based Web browser. It does not need to install, nor depend on types of operating systems. (2) The system utilizes only a Web camera connected to the client PC to measure heartbeat from user's face. This camera is popular to equipment many laptop PCs. No other special and dedicated equipments are needed. (3) Measured results of heartbeat and quiz answers are stored in the local storage (HTML5 feature) of the Web browser. These results can be transferred to another server automatically.

The graph section in Figure 3 shows heartbeat change by every second, with manner of X-axis (t = n-1) and Y-axis (t = n). According to this drawing, the state and the following changes can be interpreted as a graph in Figure 4.

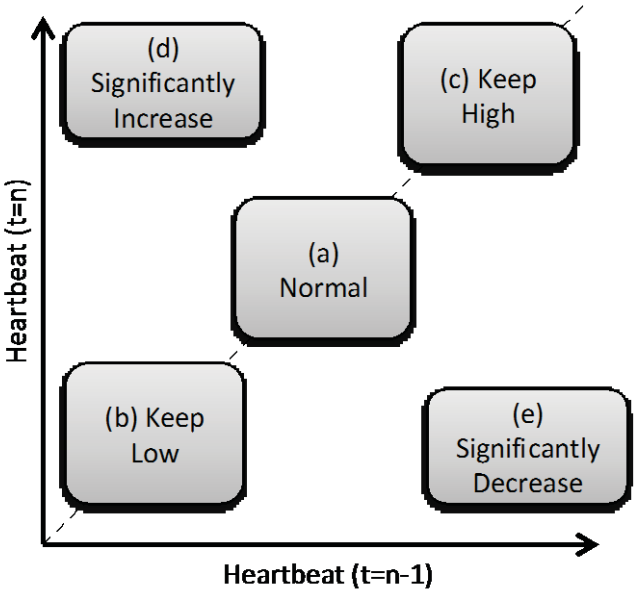

Figure 4. Interpretation of heartbeat change graph

3. Preliminary Experiment

As a preliminary experiment, the authors applied the proposed system to 6 testees. All testees are required to solve 7 problems with various difficulties. Testee A to testee C (target group) are given their heartbeat feedback with use of the proposed system, while testee D to testee F (control group) are shown just problems without heartbeat feedback. A heartbeat monitor result of testee A is shown in Figure 5, where X axis for time (second) and Y axis for heartbeat.

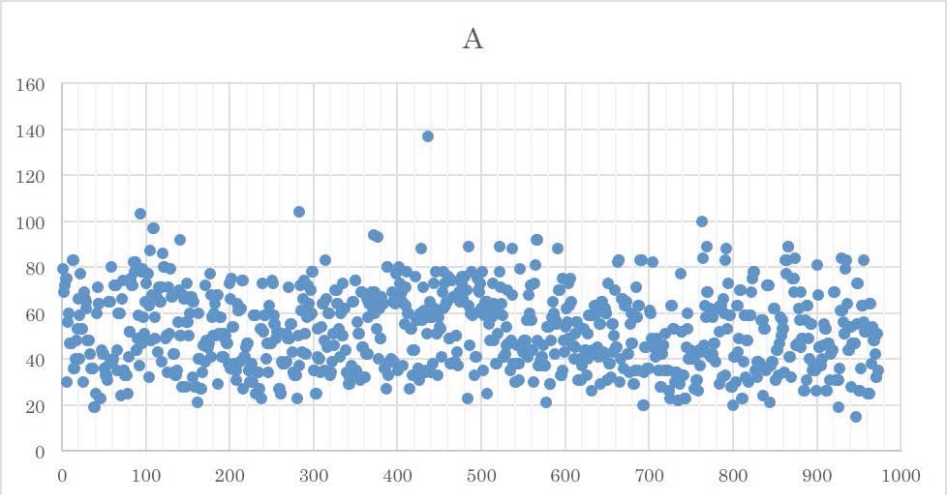

Figure 5. Sample heartbeat result

After the experiment, testees answered questionnaires about their mental status during solving problems. They were asked to feel themselves stressful, nervous, and depressed. Result of answer amount (summation of answers for all quizzes: full score is 21=7x3) is shown in Table 1.

Table 1. Experiment result

	Target group	Control group
Feel stressful	1	2
Feel nervous	3	1
Feel depressed	2	4

Observed from this table, the target group testees recognize themselves to be nervous. On the other hand, the control group testees significantly feel to be depressed, while the target group testees don't feel so. This result shows that the proposed system supports self-recognition of their emotional status. This self-recognition also helps to keep self-motivation of problem solving, without to be depressed. This result means that this biofeedback feature is also effective for self-regulated learning.

This experiment is just a preliminary one. The first reason is that there are too few number of testees. In order to be statistically correct, there need more than 40 testees for both target and control groups. The second is that the authors need to clarify correlation between answer correctness and usage of the proposed system. The third is that interface of the proposed system is not enough familiar. The graph in Figure 3 only shows quantitative change of the heartbeat. Ideally, some qualitative message to the learners (e.g. "You feel stressed" or "You feel nervous") is desirable. These are left to future works.

4. Conclusion

The authors developed a simple heartbeat visualization and feedback system. It visualizes one's change of heartbeat in real time manner. This function is considered to be effective to identify and control learners' mental status, in order to solve problems more efficiently. Preliminary experiment results shows that the proposed system supports testees to identify their nervous state, and prevents from dropping into depressed status. However, it needs further investigation and refinements of the proposed system.

Acknowledgements

This work was supported by JSPS KAKENHI Grant Number 26282059.

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