Sensor Based Affective Learning Information Process System for Intelligent Tutoring System

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Abstract. As smartphones like televisions or cars are used every day and everybody, smartphones are used to access to digital content and various ICT services. Especially, smartphone is equipped with many types of sensors so that various multimedia content can use smartphone sensors. If users’ information through sensors would be analysed, users’ movement, emotion, and states can be inferred. Especially, on e-learning environment, students’ learning states can be decided by students’ information that are collected by smartphone sensors, since more than 90% of students of Korea National Open University have access to learning contents through their smartphones in mobile learning environment. However, previous researches focused on interactions between students and learning contents. And there are few methods, technology, and decision models for students to track their learning activity, learning interests, concentration and emotions. In this paper, we propose a learning reaction analysis state model and Student Activity Analysis System. In this research, sensed learning activity information is collected by sensors of smartphone. Students’ learning activity information can be classified into mandatory and optional information. In Student Activity Analysis System, students’ learning emotional state is decided by learning reaction analysis state model. The students’ learning emotional state could be used for intelligent tutoring system (ITS) that construct personal learning strategy. Since students’ learning activity information is collected and analyzed from the information technology viewpoint, it is possible to measure the concentration and interest of learning contents of students regardless of pedagogical model.

1. Introduction
In the offline classroom, the instructor can evaluate the student’s affective emotional state with the higher reliability based on facial expression, gesture language, and posture. Skilled instructors can assess the student’s affective emotional state by observing the characteristics of a student, including the student’s knowledge level as well as the student’s emotional state. IOT(internet of things) technology has been developed and various ICT services based on it have been provided. In particular, various information and communication services using sensors have provided digital contents that are more user friendly and meet user requirements than existing information and communication services. These technological advances have been focused on the development of the intelligent tutoring system (ITS), and the pursuit of learning contents of student in the field of e-learning and application of learning contents in accordance with the learning condition [1]. ITS has been studied to evaluate students’ emotional state in terms of educational psychology and to develop learning strategies that can improve learning outcomes and learning outcomes using this information. However, the previous method of analyzing the students’ emotional state is mainly following the educational psychological approach.
These learning emotional state analysis methods have not been studied on the basis of sensors, or have limited use of various sensors.

In this paper, sensor based student’s emotional state for learning activity is proposed. The student’s emotional state analysis system is built based on smartphone and his sensors. The proposed student’s emotional state analysis system would decide the value of student’s learning concentrativeness, learning interest, effectiveness. For the value of student’s learning concentrativeness, learning interest, and effectiveness, all of student’s interaction with smartphone are collected and analyzed by the proposed Sensor based Affective Learning Information Process System.

This paper consists of 5 chapters. We reviewed previous student’s emotion state analysis research for e-learning learning and we show that proposed Sensor based Affective Learning Information Process System has several differences with them. The proposed Sensor based Affective Learning Information Process System and affective learning activity information process model are showed in chapter 3. And the Affective Learning Information Process Engine architecture, system messages flows and function modules of Affective Learning Information Process Engine of Sensor based Affective Learning Information Process System are described in chapter 4. We concluded the research paper in chapter 5.

2. Related Works
Previous ITS(intelligent tutoring system) was built based on affective pedagogical model. Thus some of them did not use sensors. And some of them used only 1~3 sensors of external equipment. Cognitive Tutor Algebra [2], CRYSTAL ISLAND [3], Inq-ITS [4], INES [5], MathSpring [6], WaLLis [7] do not use sensors and analyze log files and features of students that are recorded during learning activity and are related to the student’s learning behavior, and learning activity history is also analyzed in the learning process. They analyze student’s affective state basically based on pedagogical model. Prime Climb [8], Easy with Eve[9], FERMAT [10] and PAT2Math [11] used external equipped video camera so that facial feature, posture and eye pattern, eye tracking and gaze pattern are collected and analyzed. Prime Climb [8] used physical sensors so that skin conductivity, heart rate, muscle activity are collected and learning activity log files are analyzed. Most of the previous works are related with affective pedagogical model for learning activity. Thus student’s emotion model is simply used in order to analyze and infer student’s emotion state with only one or only two sensors. This research proposes various sensors with smartphone and collects many kinds of student’s learning activity information through various sensors of smartphones and propose student’s emotional state decision model. Various sensed student’s activity information would be analyzed. With these sensed learning activity information, more detailed analyzed student’s affective state could be decided by ITS.

3. Sensor based Affective Learning Activity Information Process Model
Proposed Sensor based Affective Learning Activity Information Process Model(SALAI model) collects various information about a student who interacts with learning contents trough smartphone. Some student’s personal information are closely related with student’s learning situations on smartphone as learning device. But some student’s personal information is closely related with student’s situations or environment or smartphone situations or environment. With those kind of information, SALAI model decides student’s affective learning emotion state. The proposed SALAI model decision strategy comes from Automated Tutoring Engine that was proposed in [12]. Student’s learning activity patterns, Student’s personal environment state information, student’s learning emotional state information and students’ state decision conditions are defined in [13] and redefined.

Basically, SALAI model considers students’ personal environment state, student’s learning emotional state and student’s learning activity patterns within smartphone that was proposed in [12,[13]. Student’s learning emotional state is defined as student’s emotional state against learning contents and environment that student could feel as like boring, fun, difficult, etc.. Students’ personal environment state is defined as students’ environment information as like noisy environment, walking on the street, alone in a room, etc.. Student’s learning activity patterns are defined as students’ learning activity levels as like active, unconcerned, interested, etc.. According to the SALAI model, student’s affective learning
emotion state is decided by Affective Learning Information Process Engine. Affective Learning Information Process Engine analyzes students’ personal environment state information and student’s environment information and decides student’s affective learning emotion state. Lastly, Affective Learning Information Process Engine sends student’s affective learning emotion state to ITS. According to student’s affective learning emotion state, ITS construct personal learning strategy.

![Figure 1. Architecture of Affective Learning Information Process Engine](image)

Proposed Affective Learning Reaction Analysis Engine that is shown in figure 1, consists of Learning Reaction Analysis Engine, Students’ Emotional State Model, Students’ state database, Bio-Signals DB and Learning Activity database [12, 13].

- student and educational devices : source of students’ learning activities and emotional information with learning agents
- student’s affective learning emotion state : collection of students’ learning emotional state information, and infer and decision of students’ learning contents
- Learning activity : activity level of learning time
- Students’ Learning Emotional State Model: model of learning interests, learning contents reaction and students’ environment
- Bio-signals : student’s bio-signals for learning contents

Learning emotional state means learning interests or learning contents intimacy that mean closeness of learning contents and one student. If learning emotional state level is active, it means that a student is well-matched with learning contents, regardless of difficulty, formats and type of learning contents.

4. System Message Flow of Affective Learning Information Process Engine
We assume that students’ smartphone device has various sensors and seamless communication network that can collect and detect bio-signals. We also assume that there is no middleware to convert and manage noise of bio-signals.
Figure 2. Affective Learning Information Process Engine Message Flow

① A student logs on a smart learning portal server (web server) by his/her learning devices as like a smartphone. At the same time, a student logs on Learning Management Server (LMS) with single-sign-on protocol. In figure 2, a smart learning portal server and LMS are omitted for simple service message flow. And LMS delivers students’ previous learning emotional state history, previous Students’ personal environment state history and Student’s learning activity patterns history.

② Digital textbook Application on smartphone sends App state and student’s user information to ALIPE. ALIPE analyzes student’s user information (smartphone specification information, etc.) and previous learning emotional state history and decides initiative learning emotional state of the student.

③ After delivering learning subject contents, learning personal environment state is sent to ALIPE that infer current emotional state of the student. The emotional state information is periodically sent to ALIPE.

④ Learning activity pattern information is sent to ALIPE that infer current emotional state of the student. Learning activity pattern information is periodically sent to ALIPE.

⑤ Student’s learning emotional state information is sent to ALIPE that infer current emotional state of the student. Student’s learning emotional state information is periodically sent to ALIPE.

⑥ ALIPE analyzes Student’s learning personal environment state information and Learning activity pattern information and saves the results in the support learning emotional state information(e-portfolio). ALIPE analyzes learning emotional state information with the support learning emotional state information, and decides student’s affective learning emotion state.

⑦ and ⑧ ALIPE sends student’s affective learning emotion state to Intelligent Tutoring Engine(System) [13] (ITE). ITE decides and reconstructs personalized learning strategy with student’s affective learning emotion state.
ALIPE sends student’s affective learning emotion state to e-portfolio database.

Figure 3. Students’ affective learning emotion state Decision Algorithm

Learning Reaction Analysis Engine (ALIPE) deals with three kinds of information (students’ personal environment state information, students’ learning activity pattern information, students’ learning emotional information) in figure 3.

At the first, ALIPE receives students’ personal environment state information and students’ learning activity pattern information. Each of students’ personal environment state information and students’ learning activity pattern information has mandatory information so that ALIPE checks the mandatory information of students’ personal environment state information and students’ learning activity pattern information. If all mandatory information satisfies conditions of students’ personal environment state information and students’ learning activity pattern information, a student does active learning activity. In this case, ALIPE need not receive optional information of students’ personal environment state information and students’ learning activity pattern information. And if all mandatory information of students’ personal environment state information and students’ learning activity pattern information does not satisfy conditions of each information, a student could have two kinds of learning state, one is not-learning state and the other is passive learning state. If a student’s learning state is passive learning state, intelligent tutoring engine (ATE) sends alert or pop-up quiz to the student. If a student’s learning state is in not-learning state, intelligent tutoring engine (ATE) sends this situation to a learning instructor or lecturer. Lastly, ALIPE receives students’ learning emotional state information. ALIPE checks the mandatory information of students’ learning emotional state information. If all mandatory information of students’ learning emotional state information satisfies conditions of students’ learning emotional state information, a student does active learning activity and ALIPE need not receive optional information of students’ learning emotional state information. But, if all mandatory information of students’ learning emotional state information does not satisfy conditions of students’ learning emotional state information, ALIPE receives optional information of students’ learning emotional state information and combines mandatory information of students’ learning emotional state information, optional information of students’ learning emotional state information and mandatory information of students’ personal environment state information and students’ learning activity pattern information. If the combined information analysis results show negative, it means the student is in ‘not-learning’ state. If the combined information analysis results show positive, it means the student actively do learning activity and is in ‘active-learning’ state. If the combined information analysis results show ‘not-decided’ state, it means the student’s learning emotional state is determinant state. If a student’s affective learning emotion state is ‘not-learning’ state or ‘passive’ state, ITS sends alert or pop-up quiz to the student and send a student’s affective learning emotion state to a learning instructor or lecturer. The learning instructor personally contacts with the student and warns the student.
5. Conclusion
As smartphone get popular to students, most students become to use smartphone and smartphone becomes the most important learning devices. In this research, students’ emotion state information is collected and analysed from sensors equipped with smartphone. We defined Sensor based Affective Learning Activity Information Process Model and Affective Learning Information Process Engine. And we used the decision conditions of three kinds of information, as like student’s learning emotional state information, Students’ personal environment state information student’s learning activity patterns information that were proposed in [13]. In Sensor based Affective Learning Activity Information Process Model, various student related information comes from smartphone sensors. The student related information is classified into the three kinds of student’s information and Affective Learning Information Process Engine decides student’s affective learning emotion state. Proposed Affective Learning Information Process Engine closely relates with ITE(Intelligent Tutoring Engine) that was proposed in [13]. Lastly we propose student’s affective learning emotion state decision algorithm that would be used to decide student learning state. Student’s affective learning emotion state could be used to construct personal learning environment by ITE. The future research have plan to combine pedagogical model with Sensor based Affective Learning Activity Information Process Model and Affective Learning Information Process Engine so that we could have more detail and more accurate learns’ learning state.

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References
[1] Sintija Petrovica, Alla Anohina-Naumeca, Hazim Kemal Ekenel, Recognition in Affective Tutoring Systems: Collection of Ground-truth Data, Procedia Computer Science, Volume 104 Issue C, March 2017, Pages 437-444
[2] Baker RSJ et al. Towards Sensor-free Affect Detection in Cognitive Tutor Algebra. In: Proc of the EDM’2012. p. 126-133.
[3] Sabourin JL et al. Considering Alternate Futures to Classify Off-Task Behavior as Emotion Self-Regulation: A Supervised Learning Approach. J Educ Data Mining. 5 (9); 2013. p. 9-38.
[4] Paquette L et al. Sensor-Free Affect Detection for a Simulation-Based Science Inquiry Learning Environment. In: Trauscan-Matu S, Boyer KE, Crosby M, Panourgia K. (eds.). Proc of the ITS’2014. Switzerland: Springer International Publishing; 2014. p. 1-10.
[5] Heylen D, Nijholt A, Akker HJ. Affect in Tutoring Dialogues. J Appl AI. 19 (3-4); 2005. p. 287-310.
[6] Wixon M et al. The Opportunities and Limitations of Scaling Up Sensor-Free Affect Detection. In: Proc of the EDM’2014. p.145-152.
[7] Porayska-Pomsta K et al. Diagnosing and Acting on Student Affect. User Model User-Adap. 18 (1-2); 2008. p. 125-173.
[8] Amershi S et al. Using Feature Selection and Unsupervised Clustering to Identify Affective Expressions in Educational Games. In: Ikeda M, Ashlay KD, Chan TW. (eds.). Proceedings of the ITS’2006. Springer-Verlag; 2006. p. 21-28.
[9] Sarrafi zadeh A et al. How Do You Know that I Don’t Understand? Comput Hum Behav. 24; 2008. p. 1342-1363.
[10] Zatarain-Cabada R et al. Affective Tutoring System for Android Mobiles. In: Proceedings of the ICIC’2014; 2014. p. 1-10.
[11] Jaque PA et al. Rule-Based Expert Systems to Support Step-by-Step Guidance in Algebraic Problem Solving: The Case of the Tutor PAT2Math. Expert Syst with Appl. 40 (14); 2013. p. 5456-5465.
[12] Kwang Sik Chung, Learning Reaction Analysis Engine for Interactive Digital Textbook Platform FutureTech 2017: Advanced Multimedia and Ubiquitous Engineering pp 459-465, 2017
[13] Kwang Sik Chung, Sungho Chin, Affective Learning Reaction Model based on Smartphone and Sensors, Journal of Physics: Conference Series, Volume 1060