ARTSEDU 2012

Recommender system to research students’ study efficiency

Arturas Kaklauskas*, Edmundas Kazimieras Zavadskas, Vaidotas Trinkunas, Laura Tupenaite, Justas Cerkauskas, Paulius Kazokaitis

Vilnius Gediminas Technical University, Sauletekio av. 11, LT–10223 Vilnius, Lithuania

Abstract

The Recommender System to Research Students’ Study Efficiency (Recommender System hereafter) developed by these authors determines a student’s learning productivity based on that same student’s physiological, psychological and behavioral/movement parameters. It then generates thousands of alternative learning productivity recommendations based on the compiled Maslow’s Pyramid Tables and selects out the most rational of these for the student’s specific situation. The Recommender System provides a student with a real-time assessment of his/her own learning productivity and emotional state. This article presents the Recommender System, a case study and a scenario used to test and validate the developed Recommender System and its composite parts to demonstrate its validity, efficiency and usefulness.

Keywords: web-based; recommender system; physiological; psychological and behavioral techniques; emotional state; learning productivity; multiple criteria analysis methods; historical information; recommendations.

1. Introduction

Scientists from all over the world study the interdependence between students’ physiological parameters and their mental stress (arithmetic stress). Fechir et al. (2009) analyzed changing skin humidity parameters caused by changes in the intensity of mental activity. Fechir et al. (2009), Harris et al. (2000), Sloan et al. (1991), Vuksanović & Gal (2007) examined the interdependence between heart rate and mental stress (arithmetic stress). Fechir et al. (2009), Harris et al. (2000) and Sloan et al. (1991) investigated changes in blood pressure caused by changing the intensity of mental activity.

Scientists tried to ascertain to what extent the human brain could work before it approached the limit of “decreasing productivity” – that was how scientists referred to fatigue. The scientists, to their surprise, learned that the brain could work smoothly and efficiently after a workday of as many as eight or even twelve hours. Psychologists claim that fatigue much depends on emotional and psychological states (Carnegie, 2004). Hadfield (1924) argued that the major part of fatigue is attributable to psychological causes.

Emotions may initiate, terminate or disrupt information processing and result in selective information processing, or they may organize recall. Emotions have an effect on learning and achievement, mediated by attention, self-regulation and motivation (Pekrun et al., 2007).
Boredom, spite, discontent, aimless rush and anxiety are emotional factors, which may emaciate people and reduce their productivity. Anxiety, tension and emotional disappointments are three most common causes of fatigue. Namely they make people tired (Carnegie, 2004). Brill (1946) argues that people with sedentary jobs mostly become tired due to psychological and emotional factors.

The results of these studies reveal that changing physiological parameters over time can help to determine the level of a student’s learning efficiency. Increasing skin conductance and rising systolic and diastolic blood pressures, for instance, lead to decreasing learning efficiency in students. The studies of the aforementioned scientists are briefly reviewed below.

The results achieved by the authors herein are compared in this article to those from analogical studies conducted worldwide. This paper is structured as follows: Section 2, following this introduction, analyzes Recommender System to Research Students’ Study Efficiency. Section 3 presents a scenario that was used to test and validate the Recommender System and its composite parts. Finally, some concluding remarks and further research proposals appear in Section 4.

2. Recommender System

The Recommender System to Research Students’ Study Efficiency (i.e., Recommender System) consists of eight subsystems:

1. E-Self-Assessment;
2. Physiological computer mouse;
3. Physiological Finger;
4. Student’s Physiological Database;
5. Maslow’s Pyramid Tables;
6. Model-base Management and Model Base;
7. Student’s Interdependence between Physiological and Self-Assessment Parameters;
8. Graphic Interface.

The subsystems are briefly analyzed below.

A great many researchers, such as Braak (2004), Sung et al. (2009), and others, reached reliable results proving that the reliability of self-assessment is sufficient. Due to the experiences of these authors, including the authors of this article, a decision was made to gain information about student learning productivity, interest in learning and emotional states among other matters by means of self-assessment. The authors herein based their developed Recommender System on the presumption that, by assigning a student self-assessment questions and then searching for the interdependency with that student’s physiological parameters at that time, it is possible to determine this interlink rather accurately. Before starting the work, a student must subjectively assess his/her own learning productivity, interest in learning and emotional states by using the e-Self-Assessment questionnaire. The student conducts the self-analysis by attributing values to each of these parameters on a ten-point scale. The student fills out the questionnaire and clicks on the button labeled “Start working”. The Physiological computer mouse and the Physiological Finger begin selecting the physiological data on the student; these accumulate in the Student’s Physiological Database.

One of the main purposes of the Recommender System is to determine interdependencies between eleven pieces of data submitted on a student’s own state of being and twelve of that student’s physiological parameters at the time of self-assessment. For example, an analysis of a student’s learning productivity and interest in learning is an effort to determine and then outline the interdependencies between that student’s twelve physiological parameters (see Table 1).

Different researchers, including Shin et al. (2009), Kong et al. (2006) and Pan et al. (2003), are working in the same field as that of the Physiological computer mouse. This Physiological computer mouse is able to measure the temperature and humidity of a student’s hand, skin conductance, touch intensity and heart rate. These physiological parameters provide more information about the student and help to evaluate that student’s learning productivity, interest in learning and emotional state. The Physiological Finger collects data on the following parameters for correlations with a student’s emotional state and work productivity: humidity (humidity sensor), electrogalvanic skin conductance (electrogalvanic skin response sensors), skin temperature (thermistor), heart rate (pulse sensor).
Once a student fills out the e-Self-Assessment questionnaire and clicks on the button labeled “Start working”, the Physiological computer mouse and Physiological Finger begin to gather the physiological data of that student for storage in the Student’s Physiological Database. This way the physiological parameters of different students with different emotional states, temperaments and learning productivity rates are collected in the database. Different physiological parameters have been tested for correlations with student’s learning productivity, interest in learning and emotional states. Each student can view his/her physiological parameters and their interrelationships with the e-Self-Assessment parameters.

Table 1. Interdependency determination in Recommender System

<table>
<thead>
<tr>
<th>Physiological parameters under measurement</th>
<th>Data on a student’s state of being at the time of self-assessment: personal mood, productivity, interest in learning, stress, self-control, happiness, anger, fear, sadness, surprise, anxiety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physiological computer mouse: temperature, humidity, skin conductance, touch intensity, heart rate</td>
<td>Interdependency diagrams determined and outlined</td>
</tr>
<tr>
<td>Physiological Finger: humidity, electrogalvanic skin conductance, skin temperature, heart rate</td>
<td></td>
</tr>
<tr>
<td>Blood pressure and heart rate data: heart rate, systolic blood pressure, diastolic blood pressure</td>
<td></td>
</tr>
</tbody>
</table>

The literature based on the Maslow Theory was used to compile the tables relative to Maslow’s Pyramid. These tables provide information and recommendations about physiological, safety, social/recognition, esteem and self-expression/self-actualization needs. They include the following segments: names and significances of needs and their components, questions given to students, subjective and objective assessments of such questions, recommendations and the source of those recommendations. Maslow’s Pyramid Tables, based both on the developed Maslow’s Pyramid and on the models from the Model Base, provides recommendations on how to improve a student’s learning productivity.

The Model-base consists of the following:
- Model to determine the correlation between a student’s learning productivity, interest in learning, emotional states and the physiological parameters of that student (Dependence Analysis Model);
- Model to automatically evaluate the student’s learning productivity;
- Model to determine initial criteria weights (data and student characteristics and recommendations) using expert evaluation methods;
- Model to determine criteria weights (data from Maslow’s Pyramid Tables and a student’s physiological characteristics);
- Model to design multi-variant recommendations;
- Model to analyze multiple criteria and to prioritize recommendations;
- Model to determine the utility degree of recommendations;
- Model to deliver the recommendations.

The models are briefly reviewed below.

First, the Recommender System collects information about a student’s physiological parameters and accumulates them in the Student’s Physiological Database. Then the Interdependency Analysis Model starts analyzing these data and makes a real-time determination of their correlation with a student’s learning productivity, interest in learning and emotional states. Based on the determined relationships, the Recommender System automatically establishes a student’s learning productivity in digital form.

The main designation of the Module for Dependence Analysis is to search for interdependencies between the physiological and self-assessment parameters of various students and to accumulate these in the Student’s Interdependence between Physiological and Self-Assessment Parameters Subsystem. It must be verified how the different physiological parameters correlate with a student’s learning productivity, interest in learning and emotional
The Student’s Interdependence between Physiological and Self-Assessment Parameters database accumulates a sufficient amount of historical physiological results, which can be analyzed by a student at any time.

The rest of the Model Base models are intended to formulate possible recommendation variants (how to improve a student’s learning productivity) and then to select the most rational variants for a specific student. One of the main innovative elements of the Recommender System on a global scale is specifically this.

The methods developed by the authors herein provide the bases for the development of these models as follows (Kaklauskas, 1999; Kaklauskas et al., 2005): a method for the complex determination of criteria weights that takes into account their quantitative and qualitative characteristics; a multiple criteria method for a complex and proportional evaluation of alternatives to enable a student to obtain a reduced criterion for determining the complex (overall) efficiency of an alternative; a method to define the utility degree of an alternative; a method for the multiple criteria, multi-variant design of the life cycle of an alternative.

3. Scenario used to test and validate the Recommender System and its composite parts

The initial version of the Recommender System to Research Students’ Study Efficiency was developed in 2006. The testing of the Recommender System has been ongoing since that time. There were 206 distance-learning students testing its composite parts. The preliminary results of the tests on the Recommender System were announced at the 25th International Symposium on Automation and Robotics in Construction in 2008. The Recommender System was improved in light of the continuous testing results.

The Recommender System testing scenario by the authors herein lasted one month. It was conducted in three stages that included eleven steps as follows.

**Stage 1. The interdependencies between a student’s physiological parameters and the data submitted during the self-assessment are diagramed.**

*Step 1.* Students subjectively record the level of their learning productivity, interest in learning and emotional states every 45 minutes using the e-Self-assessment questionnaire.

*Step 2.* The physiological parameters of the students are measured during their learning process. The analysis of this learning process lasts one month.

*Step 3.* Next the Recommender System determines and outlines a diagram of interdependencies between the physiological parameters of a student and the self-assessment data. Dependencies that do not conform to the trends of Best Worldwide Practices are not deliberated any further.

*Step 4.* The reliability of the interdependencies between a student’s physiological parameters and the submitted self-assessment data is determined.

**Stage 2. Reliability of the student’s learning productivity and emotional states is determined.**

*Step 5.* Students assess their learning productivity, interest in learning and emotional states using the e-Self-assessment questionnaire.

*Step 6.* They perform their usual learning process for 45 minutes, while their physiological parameters are measured.

*Step 7.* The system provides each student with an assessment of his/her own learning productivity in real-time. The bases of these assessments are the dependencies determined at Step 3 and the physiological parameters obtained at Step 6 by using the method of the multiple criteria, complex and proportional evaluation of alternatives, which was developed by the authors herein.

*Step 8.* The self-assessment of the student taken during Step 5 is compared with the system’s assessments produced during Step 7.

**Stage 3. The submitted recommendations are validated.**

*Step 9.* The compiled, universal Maslow’s Pyramid Tables are applied for a specific person.

*Step 10.* The system provides the best recommendations to improve the student’s learning efficiency.

*Step 11.* The student either confirms or denies that the recommendations actually contribute to the improvement of his/her learning process.
4. Conclusion

A sufficient number of studies have been performed worldwide, and quite many systems have been developed that apply physiological technologies to establish different human states of being. The global innovativeness of the Recommender System, developed by the authors herein, is primarily that it automatically determines the level of learning productivity, compiles numerous alternative recommendations applicable to a specific student (how to increase learning productivity), performs a multiple criteria analysis of these recommendations and selects out the ten most rational ones for that student. No other system in the world performs these functions to date.

The Recommender System model facilitates an integrated analysis of the alternative recommendations and the selection of the most rational of them, even though the efficiency of alternative recommendations is often evaluated by considering ethical, psychological, economic, aesthetic, technical, technological, comfort, social and other aspects. With the above models serving as the basis, the Recommender System automatically creates alternative variants of recommendations, generates their multiple criteria analysis, determines their utility degree and selects the most efficient variants.

The plans for the next stage of the Recommender System’s development involves integrating this system with other intelligent voice and IRIS analysis systems, which the authors herein have also developed. Such an integration of intelligent and physiological systems would provide even better assessments of the emotional states and learning productivity of students and the submissions of specific recommendations to them.

References


