Voice Stress Analyser Intelligent System For E-Testing

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Abstract

Three e-learning Master degree studies were introduced at Vilnius Gediminas Technical University in 1999. In order to increase the efficiency and quality of e-learning studies, Voice Stress Analyser Intelligent System for e-Testing (VSA-IST) was also developed. The aim of this paper is to report on the contribution of new integrated technologies (Voice Stress analysis and decision support systems) to e-Testing Systems. The article briefly describes the use of these integrated newest technologies in e-Testing. The authors of the article have developed a voice stress database, which contains students’ answers that are given during an Testing, and a specific algorithm, which is the core of the VSA-IST and which can evaluate a student’s knowledge by giving a precise mark after a psychological test, which is performed prior to the Testing. In order to demonstrate the validity, efficiency and usefulness of the developed VSA-IST, the article also presents a case study.

1. Introduction

Voice Stress Analysis (VSA) technology records psycho-physiological stress responses that are present in the human voice, when a person suffers psychological stress in response to a stimulus such as exam question) [1]. Ruiz et al. 1990, report from their research and suggest that psychological stress may be detected as acoustic modifications in the fundamental frequency of a speaker’s voice and that the fundamental frequency of the vocal signal is slowly modulated (8-14 Hz) during speech in an emotionally neutral situation. In situations demanding increased ‘mental or psychomotor’ activities, the 8-14 Hz modulation then decreases as the striated muscles surrounding the vocal cords contract in response to the arousal, thus limiting the natural trembling.

The tremor varies according to the amount of stress. The more stress, the less tremor [2].

The nonverbal content of speech carries information about the physiological and psychological condition of a speaker. Different voice features from the speech signal to be influenced by stress are: loudness, fundamental frequency, jitter, zero-crossing rate, speech rate and high-energy frequency ratio [3].

Today, Voice-stress analysis is already widely used by the police and insurance companies in professional fraud investigations [4,5] security [6], law enforcement agencies, law firms, journalists, businesspeople, internal affairs investigations, pre-employment examinations [7], real estate [8], the navy [9], ethics committees [10], sexual offenders [11], and in speaker classification, verification and identification.

This paper is structured as follows: Following this introduction, In Section 2 a description of the Voice Stress Analyser Decision Support System for e-Examination is provided. Section 3 presents a Case Study. Finally, some concluding remarks are presented in Section 4.

2. VSA Decision Support System for e-Testing

The Voice Stress Analyser Intelligent System for e-Testing (VSA-IST) consists of five subsystems: Testing Subsystem, Database Management Subsystem, Equipment Subsystem, Model-base Management Subsystem and a Graphic Interface (see Fig. 1). The subsystems are briefly analysed below.

The Testing Subsystem formulates questions of various difficulties, specifies sources for additional studies and helps to select literature and multimedia for further studies and a computer learning system to be used during studies. A student can select the level of difficulty at which the teaching takes place. For example, the chapters of modules with mathematical orientation, i.e. mathematical methods used for the estimation of market or investment values, can be quite difficult for some students. Traditional testing systems evaluate a learner's state by giving them a mark and do not provide the possibility to learn about one’s own knowledge gaps or to improve knowledge. The Testing Subsystem compares the knowledge possessed by a student (test before studies) and knowledge obtained by a student during studies (test after studies), and then it performs a diagnosis based on the differences.
### Databases:
- Historic voice stress data,
- Psychological questions voice stress data base,
- Correlation between the emotional stress and the correct answers data base,
- Historic testing questions data base,
- Historic testing results data base,
- Historic testing results data base of complexity.

### Model-bases:
- a model of developing the alternative variants of Testing,
- a model for determining the initial significances of the criteria (with the use of expert methods),
- a model for the criteria significance establishment,
- a model for determination of the marks of the e-psychological test,
- a model for determination of the marks of the real e-test,
- a model for determination of the regression-correlation trend of the e-psychological test,
- a model for determination of the regression-correlation trend of the real e-test,
- a model for providing recommendations.

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**Fig. 1 Components of Voice Stress Analyser Intelligent System for e-Testing**

By collecting information on the history of a student's responses, the Testing Subsystem provides feedback and helps to determine strengths and weaknesses of the student's knowledge, and his/her new knowledge that was obtained during studies, is summarized and then various recommendations for further education for students are provided. After giving feedback, the system reassesses and updates the student’s skill’s model and the entire cycle is repeated. As the system is assessing what the student knows, it is also considering what the student needs to know and which part of the curriculum is to be taught next.

Also, there are options for the selection of the following question in a test, which depends on the correctness of answers to the previous questions.

Correct answers lead to more difficult tasks, incorrect answers to easier tasks. The obtained knowledge is the difference between the possessed knowledge (test before studies) and the final knowledge (test after studies). The Testing Subsystem also explains why one or another answer is correct or incorrect and offers certain additional literature and multimedia related to the incorrectly answered questions.

The Database Management Subsystem consists of six databases: Historic voice stress data, Psychological questions voice stress data base, Correlation between the emotional stress and the correct answers data base, Historic testing questions data base, Historic testing results data base, and Historic testing results data base of complexity.

The Equipment Subsystem consists of Sound record equipment, Data input equipment, Sound recorder software, Testing software, Voice stress analysis software, and Time synchronization module.

The Model-base Management Subsystem consists of seven databases: a model of developing the alternative variants of Testing, a model for determining the initial significances of the criteria (with the use of expert methods), a model for the criteria significance establishment, a model for determination of the marks of the e-psychological test, a model for determination of the marks of the real e-test, a model for determination of the regression-correlation trend of the e-psychological test, a model for determination of the regression-correlation trend of the real e-test, and a model for providing recommendations.

### 3. Case Study

The case study’s aim was to compare data received during an e-testing with the VSA-IST (i.e. information on correct and incorrect answers, time periods for each question, and the number of times a student changed an answer to each question of a test) with similar data received from the Voice Stress Analyser (VSA) Subsystem, so as to make practical conclusions and to plan future research. This research helped to determine changes of students’ psychophysical conditions during an examination. During an e-test, students were asked to select one correct answer from the provided.
alternatives and to say the answer aloud. The sound record of each answer was then saved into a PC memory with an identification code for listening and further analysis. Records were analysed by using the VSA Subsystem and the frequency range of micro-tremors for each specific answer to an e-test question was then determined. Higher frequency of voice vibrations was determined when analysing voice answers to “unknown/difficult” questions. It was found that the emotional stress of a student was higher when answering “unknown/difficult” questions.

The reliability of the results was assessed by making a correlation analysis of emotional stress and of evaluations of correct answers (in percent) to test questions. The analysis showed that a correlation exists between emotional stress and the correctness of an answer. During the experiment, a total of 4,000 voice records in four student groups were examined and analysed. The research helped to determine whether questions can be classified (in respect to students) as “known/simple”, “unknown/difficult” and the remaining questions in-between these two groups.

Higher than average emotional stress was experienced when answering the “unknown/difficult” questions, and zero or minor emotional stress were found in the case of “known/simple” questions. Having analysed the whole set of answers, a direct relationship was noticed between the emotional stress and the correct answers (in percent) to an e-test. During the research, the average micro-tremor was calculated for each question. A part of the results is shown in Figure 2.

![Figure 2](image-url)

**Fig. 2** Correlation between emotional stress and the correct answers (in percent) in the e-test: x-axis indicates numbers of test questions, and y-axis indicates the average micro-tremor frequency (Hz) in student’s voice (on the right) and correct answers (in percent, on the left).

Figure 2 shows the relation between a student’s correct answers and the average micro-tremor frequency of the answers to test questions. The x-axis shows numbers of the test questions for students who were passing/passed/had passed the examination. During the examination, students had to mark and to say the right answers aloud to 20 questions within 10 minutes.

Currently students’ knowledge can be automatically assessed (instead of an examination) by using VSA Subsystem on the basis of student psychological tests, accumulated historic voice stress data, determined regression equation and special developed algorithm. The VSA Subsystem automatically assesses a student’s knowledge before examination according to the student’s spoken/oral answers. For example, when a teacher/lecturer gives a student questions such as “Are you well-prepared for the exam?” “What mark would you give to your knowledge?”, “Have you learnt everything?” etc. before an examination, the student can be assessed precisely by giving him/her a mark by using VSA Subsystem (using a special developed algorithm).

### 4. Conclusions

The authors suggest improvement of validity, efficiency and usefulness of voice stress analysis in several aspects namely: a sufficient sample of people must participate in the VSA research; historic experience of a specific area must be used; intelligent
systems must be used to make a thorough analysis; and intelligent systems must be integrated with contemporary VSA measurement and analysis methods and tools.

The aforementioned aspects to improve validity, efficiency and usefulness of VSA were implemented in practice when developing the Voice Stress Analyser Intelligent System for e-Testing (VSA-IST).

5. References