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System for recognizing lecture quality based on analysis of physical parameters

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A B S T R A C T

In this paper we have presented a smart classroom system that is able to classify students' satisfaction with the lecture quality by examining parameters of the physical environment obtained using different smart devices. The system is based on the Random forest classifier, which showed the best accuracy among all machine learning algorithms available in Weka tool, with dataset collected during 28 lectures and evaluated using 10-fold cross validation. The system is implemented using different set of tools (such as Matlab and Weka) and can extract features from the ambient sound and analyze values obtained from different smart devices deployed in the classroom. Based on the extracted and captured data the system provides in real time information about the students' satisfaction with the lecture quality. For the validation purposes, we recorded 13 more lectures attended by four different student groups where the number of students varied from 5 to 18. The system accuracy was evaluated by comparing system outputs with the students' feedback and ranged from 70.7% to 83.9%.

1. Introduction

The service can be seen as a process that transforms inputs in order to provide customers with the added value (Holbrook, 1994). Services are 'deeds, processes and performances' (Zeithaml and Bitner, 2002) having the following characteristics: intangibility, inseparability of production and consumption and heterogeneity (Zeithaml et al., 1985). A lecturer presents a lecture with the aim to improve students' knowledge that can be seen as an added value. Additionally, presenting a lecture has all the previously mentioned characteristics that are typical for services (Clewes, 2003).

Therefore, giving a lesson represents a service in education. All findings from the services literature can be applied to the context of higher education (Voss and Gruber, 2006). If lecturers know what students need, they may be able to adapt their behavior and presentation to meet students' underlying expectations, which should have a positive impact on their perceived quality and their levels of satisfaction.

Quality in higher education is a complex concept where the single definition cannot capture all its different aspects (Harvey and Green, 1993). As quality of services can be divided into two distinct components: outcome and process quality (Gronroos, 1982) and since everything that states for the service quality can be applied to the lecture quality (Devinder and Datta, 2003), a quality of a lecture delivered to the students consists of the same components. Outcome quality can be seen

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as the extent of skills gained during the lecture, while the process quality can be divided into tangible (classroom condition, illumination, acoustics and quality of presentation) and intangible quality (lecturer ability to deliver the lecture, the willingness to help students, etc.) (Devinder and Datta, 2003).

When we talk about service quality we usually think of the perceived quality, which can be seen as the comparison between customer service expectations and their perceptions of actual performance (Zeithaml et al., 1990). For this reason, the classroom teaching service will be considered as a quality service when the lecturer meets or exceeds student's expectations (Parasuraman et al., 1988).

Service quality cannot be measured objectively (Patterson and Johnson, 1993) and the best way to define and measure service quality does not exist yet (Clewes, 2003). There are many studies that confirm positive correlation (Hasan and Ilias, 2008; Ham and Hayduk, 2003) between perception of service quality and student satisfaction. Satisfaction can be defined as an emotional reaction to a product or service experience (Spreng and Singh, 1993). Satisfaction is a subjective perception (Dabholkar, 1995) of the degree to which customers' requirements have been fulfilled (ISO, 2000). Many studies confirmed that students' perceived service quality is an antecedent to student satisfaction (Browne et al., 1998; Guolla, 1999).

For all these reasons, in order to predict lecture quality we decided to observe students' satisfaction with the lecture quality during lectures. Students' overall satisfaction can be measured using different surveys collected after a lecture, but this piece of information is not useful for differentiating segments of the lecture with which the students were satisfied from the segments with which they were not satisfied. To reveal if the students are satisfied with the lecture quality at a given moment (on a particular segment), we need their real-time feedback instead of the surveys filled in after the lecture ended. For this reason, we gave detailed instruction to the students how to evaluate the ongoing lecture and collected their feedback in real-time to annotate segments of lectures as satisfactory or not satisfactory.

This system is based on the concept that is called Internet of Things (IoT). The International Telecommunication Unit (ITU) views IoT "as a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies" (ITU-T). Things or objects in the IoT refer to a broad range of devices such as RFID tags, sensors, actuators, smartphones, among others. A range of new applications based on this technology is broad and diverse, i.e. e-health, traffic, environmental monitoring, smart homes, smart classrooms, to mention a few. This paper focuses on using IoT in smart classrooms. Smart classrooms can be defined as intelligent environments equipped with an assembly of many different kinds of hardware and software modules such as projectors, cameras, sensors, face recognition module, and many more (Xie et al., 2001). In our case, a smart classroom is equipped with a set of sensors able to monitor parameters of the physical environment (for example CO_2, CO, temperature, humidity, noise), a Bluetooth headset used to capture lecturer's voice, as well as a smartphone with a 3-axis accelerometer sensor used for determining intensity of moving lecturer's hand.

Authors have published few articles where they have investigated some aspects of the learning process and the parameters that influence them (Gligoric et al., 2012, 2015; Uzelac et al., 2015).

The first study (Gligoric et al., 2012) represents the basis for the further researches. The authors have specified the problem of the real-time feedback on the lecture quality using IoT. Among with problem specification, the system requirements were specified and the system experimental design was proposed. The parameters that may have influence on the lecture quality were selected based on the conducted questionnaire. The research lacks implementation part and the thorough analysis of the selected parameters.

The second paper (Uzelac et al., 2015) investigates the parameters of the physical environment and their impact on students' focus. The primary goal of the paper was to identify parameters that significantly affect students' focus during lecture. The parameters that were investigated include humidity, ambient temperature, noise, as well as thorough analysis of the features extracted from the lecturer's voice. Again, this research lacks the implementation part. In contrast with the current research, the study investigates students' focus, not the students' satisfaction with the lecture quality.

In the third research (Gligoric et al., 2015), a smart classroom system that detects students' overall satisfaction level with the given lecture is presented. The aim of the implemented system is to find patterns in students' behavior through the intensity of their motions and by analyzing the sound they produce (without considering any environmental parameters) and use them to determine if the students are satisfied with the lecture at a given moment. This research contains the thorough analysis of the selected parameters as well as the implementation part. As this research does not explore the influence of the environmental parameters (such as humidity, ambient temperature, etc.), and the lecturer' influence on the learning process, further research was needed to shed more light on that part. This led to the different recording setting; new series of recordings were conducted in order to obtain the new dataset. In the new research, instead of analyzing ambient sound, the features from the lecture's voice were extracted and examined. Additionally, different method for parameters selection was used: instead of kappa values, in the new research we are using attributes importance obtained via Weka's toolkit (Hall et al., 2009). Furthermore, we improved the algorithm that calculates the intensity of the lecturer's motions. Additionally, the implementation part was changed: the algorithm used for the classification was switched – instead of Adaboost M1 algorithm, Random forest classifier was implemented; image processing part was thrown, while the new part used for calculating intensity of the lecture's movements was introduced. The cloud platform used for storing values also needed to be altered. All of these changes influenced and changed the overall system architecture.

Due to the previous discussion, the aim of this study is to present a new smart classroom system that is able to classify the students' satisfaction with the lecture quality by examining parameters of the physical environment obtained using different smart devices. The main contributions of this manuscript are: (1) an innovative approach to analyze the impact of different