Students Behavioral and Emotional Detection Based Satisfaction Monitoring System for E-Learning

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***Abstract*— E-learning system based on formalized teaching but with the help of electronic resources is known as E-learning. Education has changed dramatically, with the distinctive rise of e-learning, whereby teaching is undertaken remotely and on digital platforms. However, when a student in a physical classroom he can ask questions from the instructor and reduce their stickiness. In addition, the instructor can easily identify if the student understands the lesson or not. But when it comes to the E-learning platforms identifying student satisfaction is challenging. In most E-learning platforms, there are discussion forums to ask questions. However, there is no proper way to identify each student's problems, satisfaction with the lesson as a physical classroom. So this is the main issue here the authors identified in this research. Therefore, to avoid students' stickiness and improve the satisfaction in E-learning platforms here authors suggest a student satisfaction monitoring system for courses or the live sessions. For this here, the authors suggest a Data science approach-based solution. Here in the authors' solution, there are three main components combined to monitor student satisfaction. They are facial expression identifier, Speech analyzer, and the students' browser history analyzing component while in the lecturer. By these three components here, this application is able to analyze whether the student is satisfied with the lecture. The main goal of the author of this research is to increase student satisfaction by notifying each student's satisfaction with the lecturer or the course owner**

***Index Terms*—neural networks, E-Learning, data science, emotional recognition, satisfaction monitoring**

I. Introduction

E-Learning systems are completely new education philosophies via Internet, networks, or standalone computer. E-Learning applications and processes include web-based learning, Computer-based learning, Virtual classroom, and digital collaboration. Online learning has shown significant growth over the last decade as the internet and education combine to provide people to gain new skills. The researches show that the worldwide e-learning market is projected to be worth $325 billion in 2025 [1].

Because of the COVID-19 situation, globally over 1.2 billion students are out of the classroom [2]. Because of this in this COVID-19 period, there is a rapid growth of using E-learning platforms. However, even before the COVID-19, there was a high growth of global education with e-learning platforms. In 2018 there are 30 million students enrolled in different courses in a well-known E-Learning platform Coursera [3]. Fig. 1 clearly shows how the usage of Massive open online courses grows rapidly [4].

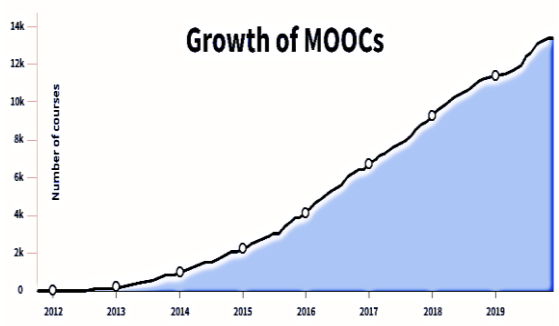

Figure 1. Growth of MOOCs

In the present Covid-19 situation because of the significant demand, many online learning platforms are offering free access to their service. As a result, a well-known online learning platform BYJU's got a 200% increment of sign-up for the courses [1]. Moreover, the usage of distance learning platforms, virtual tutoring, and video conferencing tools are also increased. As an example university of Westminster conduct their lectures via a learning management platform named Blackboard, which has an online classroom feature [5].

When learning on these E-learning platforms there are several ways to remove stickiness and solve problems regarding the lesson. One of the methods used in the present E-learning platform is discussion forums. And some E-learning platforms have chat options and surveys.

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However, when it comes to a normal physical classroom the teacher or the lecturer can identify whether a student has a problem with the lesson by asking questions or by students' expressions. Sometimes students are afraid to tell that they were not satisfied with the lesson. However, a talented well-experienced lecturer is able to identified students satisfaction regarding the lesson by their facial emotions and other behaviors [6]. But when we come to the E-learning platforms identified student satisfaction is a challenge. As mentioned at present there are only above mentioned ways to identify students satisfaction regarding the lesion in E-learning platforms.

So this is one of the main problems that the authors identified in the E-learning platforms. If there is a way to remove students' stickiness and improve satisfaction, it will be good for students and improve the usage of the E-learning platforms. And the e-learning platform is able to give an attractive experience as same as a physical classroom. Therefore, to avoid student satisfaction here the authors suggest a novel approach using AI-based solutions. It is a student satisfaction Tracker web-extension using Facial and Audio Emotion identification and browser history analysis. Hereby analyzing students Audio and Facial emotions the system can identify that student is satisfied with the lesson or not. Moreover, it analyzes students search history while in the lecture to capture the points that student is not satisfied related to the lesson.

To implement this solution authors used data science. For the Audio and Facial Emotion analyze it used a deep learning method and to analyze browser history it used natural language processing based (NLP) methods. Authors hope this will be a novel approach to improve the satisfaction of E-learning systems users and a better way to identified users' expectations, update the course materials, and change the teaching way. Finally, this will be an approach to increase the usage of the E-learning system by providing a quality educational experience as same as the user is in a physical classroom. Next, in the paper, the competitive research and how the proposed solution differs from those would be discussed.

II. Literature Review

As mentioned in the above introduction section, monitoring user satisfaction is a major problem in E-Leaning platforms. So this research proposed a novel approach to monitor student satisfaction using a combined approach with an artificial intelligence emotion monitoring system and a browser history analysis system. However, several competitive works can be found related to this approach proposed by the authors in the E-learning industry and other several industries. When it comes to internet-based applications monitoring user satisfaction is necessary in any industry.

Recent research from China shows that there is a good relationship between the tutor and the students' emotions in the ELearning platforms. Moreover, the monitored this is a better way to analyze students satisfaction. They make this analysis using comments from the students and analyze them using natural language processing [7]. So according to this research by identifying students emotions it is easy to predict their satisfaction with the course. So to monitor students' satisfaction through emotions in E-learning platforms here this research proposed a combined approach with Audio and Facial emotions.

There are several applications to monitor students' behaviors in a classroom using CCTV camera systems and image processing. There is a research by several researchers from china and Germany named A Computer-Vision Based Application for Student Behavior Monitoring in the Classroom. As the technologies here, they used Image processing and data analysis. Fig. 2 clearly shows the flow of their system [8].

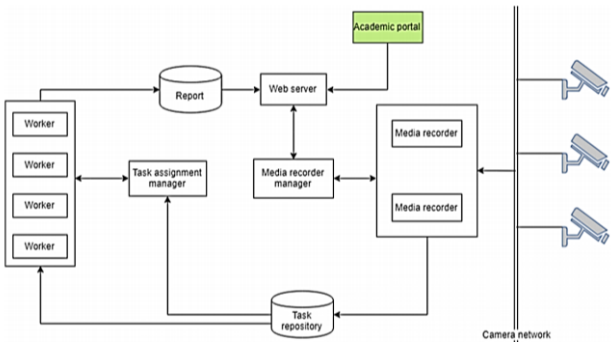

Figure 2. CCTV based students behaviors monitoring system

This system is used to monitor the behaviors of the students and check the students' concentration on the lessons and other academic activities. Here to generate the final report there are several groups of people named workers. Based on this research the proposed research will be implemented to monitor student satisfaction in E-learning systems combining with more advanced features [8]. The main difference between the proposed system and this is the proposed system is for E-Learning systems and it is fully automatic. However, this research is for physical classrooms and this is not fully automatic.

There is another similar research by several Malaysian researchers. This research is named Automated Classroom Monitoring with Connected Visioning System. The proposed solution by them was used to mark the attendance and analyze students' behaviors in a physical classroom. Here they also used an image processing and computer vision-based technology stack. Moreover, their application is fully autonomous [9]. This research differs from the proposed solution is, proposed one is ELearning platforms and it is combined with audio and browser history analysis. Moreover, the proposed solution use three components the accuracy of the proposed solution is high.

In 2017 Janez Zaltelej and Andrej Kosir published a research paper to monitor students' concentration on the lesson by analyzing facial and body features [10]. This system is also fully automated and used image processing and IoT for the development. However, this is also for the physical classrooms. Here they didn't use audio analysis to classify the concentration level. In the proposed solution by the authors used both video and audio analysis to analyze student satisfaction.

There are a couple of researches for audio emotion analysis based on user satisfaction. An article by Tyler Doll, Matthew Bussing, Kai Nichols, Sidney Johnson proposed a combined model using audio analysis and text analysis to determine customer user satisfaction [10]. Fig. 3 describes how the flow of their proposed application works.

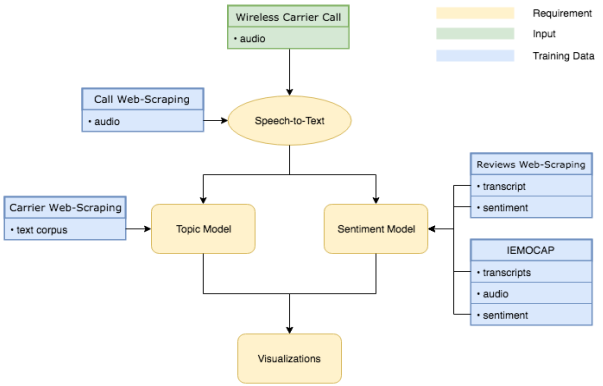

Figure 3. Audio Emotion analysis for customer satisfaction

When it comes to the E-learning platforms text analysis is already used in the surveys. However, in the proposed solution the audio emotion analysis is working as a real-time process and gives a weekly report about whether students are satisfied with the lecture. And it analyze the user's audio while the user is in a lecture automatically.

Here in the proposed solution user satisfaction is identified based on his browser history while in the lecture. For this authors suggest a natural language processing-based similarity checking approach. Research by John Paekrack suggests similar work for this approach. In his research, he developed a customer satisfaction model using clustering. Here he portioned customers into different segments and then he built a linear regression model to predict each customer's satisfaction. A research named Determination of customer satisfaction using Improved K-Means algorithm proposed an unsupervised learning-based approach to predict customers/users satisfaction by their reviews [11].

In the proposed solution for E-Learning, the system is going to build a similar kind of work. But it is combined with the other two data science components and its runs are real-time and generate a weekly report. Moreover, it gets users browser history to make the clustering model. Research by Mamdouh Farouk surveyed how to check the similarity between two sentences using NLP in his research named "Measuring Sentences Similarity: A Survey". Here he analyzes sentence similarity methods like matrix similarity, word-based sentence similarity vector-based sentence similarity, and many other methods [12]. The authors hope that this would be a great support for developing the browser history tracking based student satisfaction component.

So these are the competitive works found for the proposed solution by the authors. Next, it will discuss the development process of the research application briefly.

III. Methods and Materials

Here this research proposes a Data science-based approach to monitor students' satisfaction regarding the lessons in E-Learning platforms. There are three main data science components in the proposed solution they are

1. Facial Emotion Tracking System
2. Audio Emotion Tracking System
3. Natural Language Processing based user browser history analyzing System.

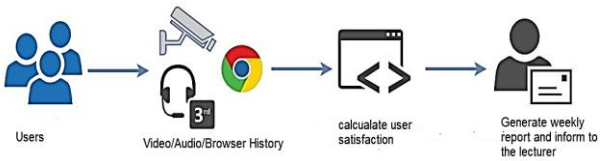

Figure 4. Flow of the proposed solution

Fig. 4 describes the flow of the proposed application by the authors. To develop this flow above-mentioned data science components are used. By using these three data science components the system is monitoring whether the user is satisfied with the lesson or not in real-time. By detecting Facial and Audio emotion, it analyzes whether users are surprised, sad, and sleepy with the lecture. When the system detects these emotions of the user it records all of these emotions throughout a week and end of the week it will inform the summary to the owner of the course or lecturer as a report. In addition, the browser history tracker analyzes when the user in a lecture he/she will search things regarding the lesson. If a user searches for something regarding the lesson, the system detects it and informs the lecture or the owner of the course. So following these pieces of information sent by the proposed system the course owner or the lecture can update the teaching way to make the user is satisfied with the lecture. This is a brief explanation of the proposed system. Next, it will discuss these three main components of the system briefly.

Here to identify E-Learning platform users' satisfaction it analyzes users' emotions. To detect users' emotions here this research proposed a method combined with Audio and Facial emotions. To implement that authors used deep learning. For identifying facial emotions, it used a dataset with facial emotions and trained a convolutional neural network model. When concentrate on this CNN model it was trained using 4 Conv2D layers and 3 MaxPooling2D layers. Moreover, as the activation functions here authors used relu and softmax activation functions.

Then for audio emotion analysis here, the author trained an LSTM recurrent neural network model using the Ravdess human speech dataset from well-known data set providing web page Kaggle[13]. When concentrate on this LSTM model it mainly has Cov2D and LSTM layers. As the activation functions here it used Keras exponential linear unit(ELU) activation. Moreover, to load audio files and extract features to the model here authors used the IPython library and Librosa library [14].

Finally, by combining, these two models the proposed system capture users' emotions like surprise, sad happiness, and drowsiness. Then whether users in sad, surprised, or sleepy the system monitors those throughout a week and informs the owner of the course or the lecturer. Moreover, here the authors proposed to use multimodal fusion methodology to connect these two neural network models. The flowchart in Fig. 5 gives a clear idea about the flow of these two components.

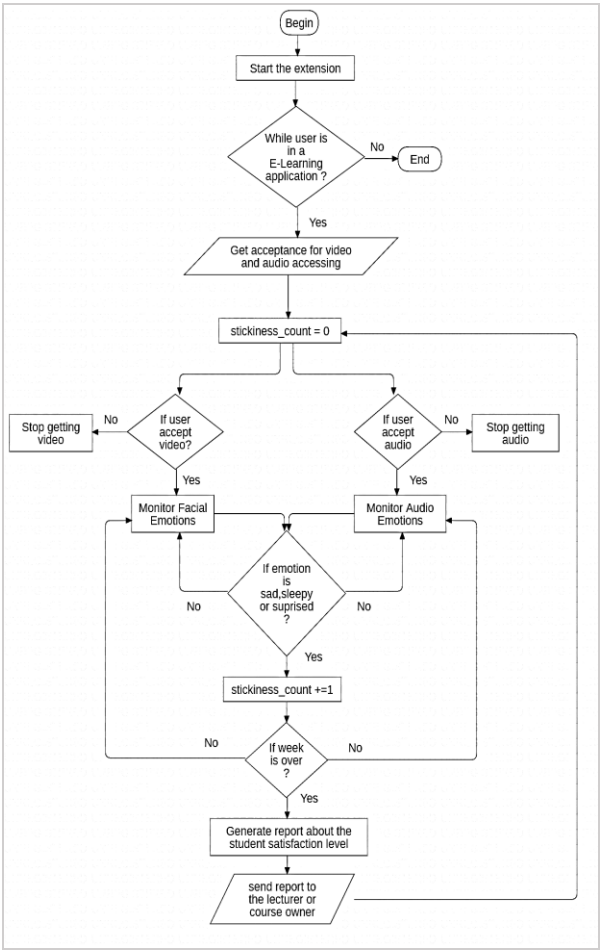

Figure 5. Flow diagram of the proposed solution

Fig. 5, the flow diagram clearly describes how the system used users' emotion analysis to monitor the satisfaction of the lesson. The most important and unique thing about this methodology is this real-time. Here to protect users' privacy before getting the video or the audio of the user it asked for permission from the user. As an example when users do not permit to access video, then the system can monitor the users' satisfaction using only the audio. Here the developers concentrate on the users' privacy when accessing the audio and video. To protect the users' privacy here the user data will not save into a database or cloud of the system owner. Therefore, the user does not need to worry about privacy. This will discuss further under the Discussion part of the paper.

The next methodology used in this research to monitor the E-learning platform users satisfaction is the users' browser history tracker. Here what the system is doing is it tracks users' browser history and check whether the user is searching related things to the lecture or not while he is in an online lecture. When analyzing the browser history of a user there can be possible outcomes.

1. The user is satisfied with the lecture and to gain more knowledge he is searching for things related to the lecturer.

2. The user is bored with the lecture and searching for things not related to the lecturer.

So by using these two possible outcomes here this system groups users' browser history while he is in a lecture to things related to lectures and things not related to the lecture.

To cluster each URL here it used a natural language processing-based approach. When the user searched for something while in a lecture the searched URL will get using the JavaScript History API, takes its URI from Regex script, and process the words using Word Lemmatizing technology in NLP. However, in the JavaScript history API authors were able to track the users' history of a single window. Here if there is no lecture description the lecturer needs to add that to the system.

Thereafter by using Cosine Similarity, analyze the users searched URI is related to the lecture description. Finally, after the end of the week, the final report will be generated using this history tracking system and Facial, Audio Emotion monitoring system. Fig. 6 describes the flow of the browser history tracking system.

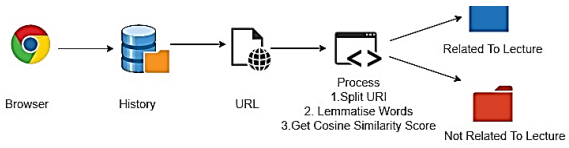

Figure 6. Flow of the history tracking component

In the prototype of the research, there are few limitations in this user's history tracking part. Here it can track the history of a single-window only. All the other limitations will discuss in the conclusion.

So this is the development process of the proposed solution. Here the authors concentrated more on protecting users' privacy and the monitor users' satisfaction levels with high accuracy.

IV. Data and Result

As mentioned earlier here in this research authors used three main data science components for the implementation. When building those models authors got data from various resources. For the facial emotion monitoring in this research, it proposed a convolutional neural network model. To build that model author got an image data set, which contains 3587 facial emotion images. Thea randomly split those two training and testing. Finally using the convolutional neural network model authors are able to achieve more than 80% training accuracy and 65% validation accuracy.

Fig. 7 clearly shows the accuracy of the facial emotion monitoring model. Another model that was used to monitor students' emotions and measure their satisfaction

with the course was the Audio emotion monitoring system. As same as the facial emotion monitoring system this was also developed using data science. To this as the data set authors used the RAVDAAS human speech data set which is nearly 2GB in size. The authors got this data set from the well-known data set providing web site Kaggle. Thereafter as mentioned above the authors developed an LSTM neural network model for this. As a result, here authors get nearly 61% accuracy for this model.

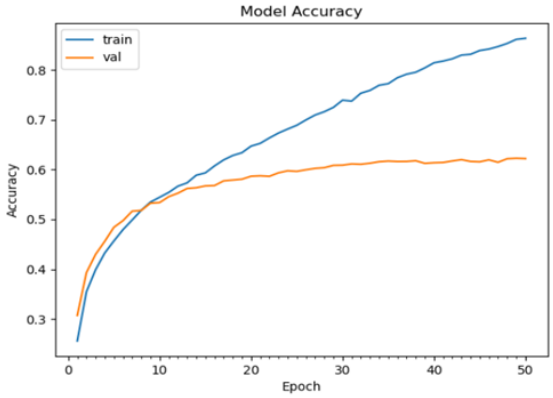

Figure 7. Facial Emotion recognition model accuracy

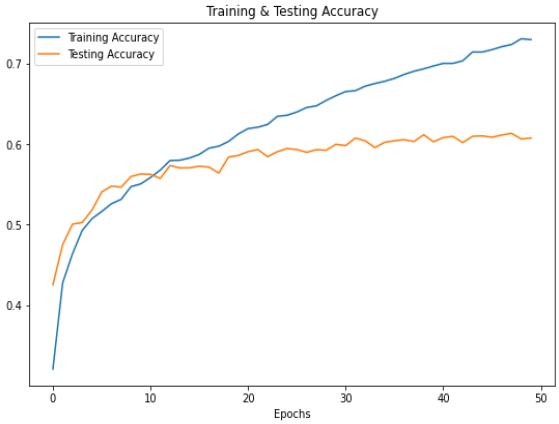

Figure 8. Audio emotion recognition model accuracy

Fig. 8 clearly shows the accuracy of the audio emotion monitoring system.

So the above explanation is clear describe that the students' emotion-based satisfaction monitoring system which was implemented using Facial and Audio emotion is at a significant level. Since these two models have more than a 60% accuracy level and both models are not over fitted or under fitted to the dataset, the user satisfaction identification using the Emotions method which was proposed by the authors is a success.

Here in the proposed solution, it is also combined with the browser history analyzing method as mentioned above in the paper. To develop this authors used NLP based approach. In the prototype, it analyze the similarity between users' browser search and the description of the lecture it used the cosine similarity approach. To get the similarity score correctly here it also used word-lemmatizing technology. Fig. 9 shows a sample output that gets in this browser history tracking system.

```
Input Lecture Description : Java OOP lesson for beginners
['java', 'oop', 'lesson', 'for', 'beginner']
URL searched by the student : https://www.w3schools.com/java/java_oop.asp
 java java oop asp
['java', 'java', 'oop', 'asp']
similarity:  0.5773502691896258
```

Figure 9. Output of the history tracking component

In the system, it analyzes all of these histories throughout the week and generate report combined with other Facial and Audio Expressions monitoring component.

These are the result, which gets in the development process of the prototype of the proposed solution. By the above explanation, it could be able to understand this prototype has a sufficient accuracy rate and it is a novel approach to monitor students' satisfaction in E-Learning platforms.

V. Discussion

The main aim of this research is to monitor students /users' satisfaction with the lessons in the E-learning system and inform the course owner or the tutor. To that here in this research proposed an Audio and Facial emotion identification based satisfaction monitoring system and users' browser history analyzing and NLP-based satisfaction monitoring system while the user is in a lecture In the E-Learning platform. Here this proposed solution is working in real-time and it is a fully autonomous system. The proposed system will finally launch as a web extension for the testing purpose. However, in the future, the system could be able to launch as a feature of a real E-Learning platform like Udemy.

In the development process of the application, the authors faced several social and privacy issues. When accessing the user's Audio, Video, and browser history it would be a privacy issue for the user. Therefore, before starting the proposed satisfaction monitoring system it will be asked user permission to access those components. If users reject permission for one component, the system can monitor users' satisfaction using the other two components.

Moreover, in the development process authors ensure that the user data is not saved in any cloud or local database in the system. Here all the gathered data will process in a fully secured server in real-time. And those data won't keep for no longer after the process. Therefore, the user is able to fully control this system and they do not need to afraid of privacy issues.

In the development process, most of the issues came at the browser history-tracking component. There is no proper way to track users' browser history yet. Therefore, authors are limited to track the history of a single window of the browser. However, this component also authors ensures the security of the users' privacy by getting acceptance to access history.

However, as mentioned above the authors concentrate on the users' privacy and social issues when using the application and solve those issues. Finally, this research is able to monitor users' satisfaction with the lesson in the

E-learning system in real-time successfully and give improve the quality of the E-learning platform. Next, it will discuss the future enhancement of the application and a summary of the application.

VI. Conclusion

The proposed solution is to monitor students' satisfaction in real-time in E-Learning platforms. As mentioned in the Methods and Materials section of the paper, here authors used three main data science components. All of these three components work as a real-time chain. However, if the user rejects permission for one of these components the system can monitor student satisfaction using the other two. In the development process, there are several limitations to the prototype. They are

1. Porotype was developed as a web extension
2. Application is not able to extract whether the user is an actual student or not
3. Since some E-Learning applications have mobile applications this prototype is not supported for them
4. Browser history tracking component only works for a single window of the browser
5. There can be browser compatibility issues.

So these are the limitations in the prototype of the proposed solution. Next, it will discuss the future enhancement of the prototype

1. Make the prototype as an inbuilt feature of an E-Learning platform.
2. First, identify whether the user is an actual student or not
3. Improve the security of the users' data
4. Improve the accuracy of the models
5. Authors hope to accurate browser history tracking component using the generated tag generation method using Deep-Learning.

Therefore, this is the way that this research was done and its future enhancements. Authors hope this will be a novel approach to monitor students' satisfaction in E-Learning platforms and improve the quality of the E-Learning education.

Conflict of Interest

The authors declare no conflict of interest when doing the research.

Author Contributions

K.T.Y.Mahima is the first author of this paper and Mr.T.N.D.S.Ginige is the co-author of this paper and the supervisor of this research.

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