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VOICE-BASED ONLINE EXAMINATION SYSTEM FOR VISUALLY IMPAIRED

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Abstract

Information technology has affected human beings and made their life easier with the support of rapidly growing technologies and applications. The benefit of the new technology should be equally circulated throughout the world. And this benefit should also be gained by physically impaired people as well. Visually impaired people face many difficulties while they are participating in academic activities and they need a real-time solution to overcome these issues. This research will be a malleable solution to overcome the examination-related issues. We have designed a voice-based online examination system that helps the students to take the exams online. Speech Synthesis is used to dictate the questions by the system and Students' answers are converted to text format using Speech Recognition and the text answers are stored in the database for future use and final Scores will be calculated immediately after the submission. This helps to improve the career growth of visually challenged people.

Keywords: *Information Technology, Speech Recognition, Speech Synthesis*

Introduction

With the increase of technological improvement digital divide plays a major role in current education system . Open and Distance Learning(ODL) growth more popular in globally due to the development of advanced features of Information Technology. As per the nature of ODL it means learning regardless of time, distance and location (Azeta, Inam & Daramola, 2018).

The policy states that every child from the age of five to sixteen has the right to free education. But some children's are unable to carry on their studies due to poor economy or physical impairments. There are many applications and technologies introduced for the physically impaired to make their daily routine comfortable and reduce the difficulty in their life. The advantages of these technologies should be equally divided among all the students. Visually impaired cannot see the world using their eyes as normal people. But technology has made them see the world as we do and made them to hear the word, feel the world (Laabidi, Jemni, Ayed, 2014). Blind student's face many struggles while performing their academic activities and participating in examinations. There are existing examination systems for students in schools, universities, and institutes. But features of these systems are inapplicable and non-flexible for visually impaired people. In order to develop the standard of life of visually impaired students, special attention wants to be paid for their education (Lucic, Edlar, Ostrogonac, & Secujski, 2015).

A previous study presents the advantages of using ODL for education and points out the web as the suitable platform for hosting ODL applications. But it is difficult to

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access or use the normal web for visually impaired students as normal people (Azeta, Odukoya, &Ayo 2014). Studies of "Distance Education for People with Visual Impairments" present that the level of usage and distribution of distance learning among visually impaired students does not completely achieve via the method of web-based learning (Evaggelia & Liakou, 2015). Integration of assistive technologies with the ODL applications reduces the difficulty in learning activities for the physically impaired students (Rahanu, Khan, & Alsobhi, 2015). The Study of Liakou et al. (2015) summarized the system with ODL with assistive technologies increases not only the incorporation between visually impaired Education also establishes the incorporation between societal environment (Evaggelia & Liakou, 2015).

In the education sector, learning outcomes are mostly determined by examinations. Sri Lanka has a higher achievement in general education. Public examinations have a major impact on deciding the future of the students and here also Distance learning facilities and e-learning become a common feature of the learning process and become the most demotic and versatile learning method. Therefore, almost all universities in Sri Lanka uses an e-learning system for their academic activities. But it needs changes and development in the way of conducting examinations for visually impaired students.

Within the scope of knowledge, it is very difficult to perform the examination for the visually impaired person like as a normal student, most of the time he needs a human accessor /scriptwriter to write the answers instead of him when they are dictating them or else, he wants to use braille. While using a scriptwriter candidates face a lot of issues. Most of the time scriptwriters do not have much knowledge and their speed and candidate dictating speeds can be varied and they cannot interpret the answer as it is. In the traditional examination system, all the candidates and supervisors need to physically be appeared to the exam. It is difficult for him to do traveling towards the examination hall, as like examination evaluating the answers and providing the results on the time are not easy (Asha, & Chellappan, 2011). This type of exam costs much because it needs many resources such as printing question papers, purchasing papers for writing answers, need to allocate an exam hall for conducting exams, and they want more time to correct essay answers rather than the MCQ/ one-word answers. Most of the time, existing systems need at least a small physical user interaction to deal with them. As a solution to existing system drawbacks, a fully automated voice-based controlled system will be a good solution for them, and it will be very useful when he has a chance to attend the exam from his native place online and evaluate their answers automatically.

One of the main objectives of this research is to provide a voice-based online examination system for visually impaired students by ODL with voice-based assistive technologies. The proposed system will be able to conduct the examination via a user-friendly Voice Interface. Students can answer via voice and the student’s answer will be evaluated against the correct answer which is stored in the database in real-time also the given answers will be stored in the database for future use. The system will be able to support all kinds of questions and answers including essays, structure, and MCQ. The next objective of the research is to find a suitable algorithm to evaluate the structured type answers.

Literature Survey

A complete review of outgoing research was performed to get sound knowledge in technologies and methodologies and drawbacks in the existing systems and to overcome the issues in the proposed system. Most of the previous studies in the online examination were focusing on the web platforms, such as Giannoulis et al, (2005); Sarma, Borbora, and Choudhury,(2013), using voice technologies with internet technologies(Azeta, Inam, & Daramola, 2018). Visually impaired students face many challenges while accessing the learning and assessments in an ODL environment. In that situation voice-based ODL becomes very paramount for reducing the difficulty in their academic works. (Martyn, 2014).

The studies of a voice-based application named "Examination Portal for Blind Person". It's using Speech Recognition System (SRS) for converting voice-based answers into text format. The system can handle MCQ-type questions only for the examination. The system can only recognize UK English and it needs a noiseless environment to work effectively. But this system has no methods for automatic evaluation of answers (Vats, Tandon, Sinha, 2016).

The study by Ruiz et al. (2012) proposed an interactive software for classrooms that provides cross-platform internet access with the complex e-learning modules and voice modules. This system used VoiceXML to create voice dialogues and Dual Tone Multi-Frequency (DTMF) Signals for input modality.

Naik and Kavitha et al. (2015) was introduced an online examination system. It provides speech-based UI for blinds to deal with the system. Here Teachers can easily update the questions as an excel file. The system can handle MCQ, One Word answer questions only for the examination. The Questions will be dictated to the student through speech synthesis and the Candidate's voice answers will be converted to text form through speech recognition. After submitting the answers software will evaluate the answer and immediately return the results after completion of the exam. This system is not supported by essay, structure-type answers.

Ghosalar and Pandey (2014) were introduced a Voice-based mobile application for examination using speech technology. Implemented only for MCQ-type questions. The system has a timer for set time intervals for the exam and each question has an allocated time interval for answering and System will display the result immediately after the exam is finished. Speech to text, text –to speech converters used for implementing oral communication. Users can also get to know the remaining time as well in the middle of the exam through the speaking clock in the system.

Sundari et al., (2015) developed an examination website, through this users can do the exam at any time from their native place, fingerprint verification is used to log in to the system. Questions can be attempted in a stress-less environment, Questions, and options are given by voice. The answer will be given through the keyboard. The Final Score of the candidate dictates via the system by speech synthesis. Varieties of the questions included in the exam are Yes/No, MCQ/One-word answer or multiple answers, essay questions, matching, numerical. Candidates' answers will be corrected with appropriate answers online. The system uses a timer for set time intervals for the exam. The system can check the time whether it is expired or not and it will automatically finish the exam and save the answer in the database when the time is expired.

Leelaavathi et al. (2015) was implemented a web application called "Novel

Computerized Examination System" for conducting online examinations for normal students. This system has the features of Automatic Result Generation, using a timer for set time intervals for the exam, randomly generating the questions and providing different questions for different candidates, Auto grading, evaluating overall performance, and also this system is very flexible to use. The typical questions handled by the system are MCQ-type Questions.

Srinivas et al. (2019) et al proposed an examination system for blind students. In this, all the instructions and questions are delivered via voice, and candidates will select the answers using laptop keyboards. The main drawback of this system is there is a third person required to monitor and assist the candidates to select the keys.

Kaiche et al. (2014) was introduced a descriptive examination and assessment system. This system is used by normal students. Through the online Descriptive Examination System candidate needs to apply for the exam, if his application is accepted an exam card will be sent to him through E-mail and after he attends the exam results will not be displayed immediately and when it must release will be decided by the administrator. Answer evaluations happen manually and System also cross-checks the answers. If a manual paper checker gives wrong marks system will send an alert to him. The system can evaluate the structure type answers by using Pattern Matching Algorithm to increase the trust of the system.

Jadidinejad and Mahmoudi (2014) proposed an unsupervised knowledge-based system to do automatic short answer grading. The system has two phases as Offline phase and the online phase. The offline phase generates an associative network of concepts using Wikipedia. In the online phase, a semantic marker is responsible for comparing a student's answer with the model answer. There is a module called Wikifier in semantic marker, which extracts seed concepts from the input answer. Then semantic marker algorithm sorts of associative network concepts according to their association with seed concepts to create an activation vector, which has a weighted list of associated concepts. Finally, the activation vectors will be compared to grade student answers based on the model answer.

Srinivas et al. (2019) proposed an examination system for blind students. In this, all the instructions and questions are delivered via voice, and candidates will select the answers using laptop keyboards. The main drawback of this system is there is a third person required to monitor and assist the candidates to select the keys.

Research Methodology

This section provides a brief description of our approach to creating the voice-based examination system for visually impaired students. This part includes a description about what is the methodologies we used and how we embrace the technology to overcome the problems in existing systems. Following figure 1 shows the basic architecture of our proposed system.

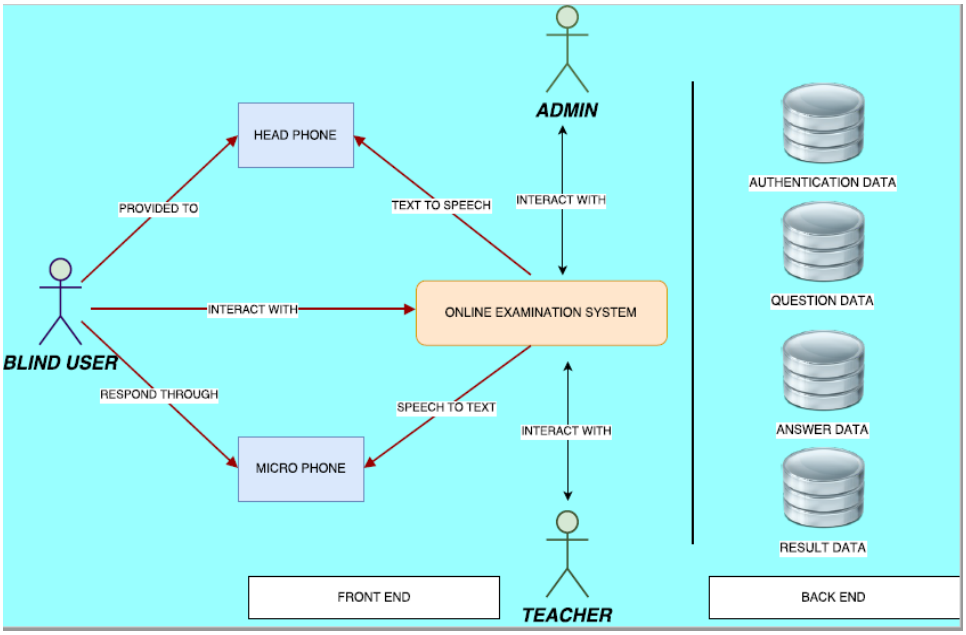

Figure 1: Top Level System Architecture for Voice-Based Online Examination System

Here the process will be taken through the following steps, first, the user can use headphones to listen to the Instructions and questions and he can use a microphone to answer the question. Next user registration will be done manually by the admin. Username and Passwords will be sent to the users through email. When the user enters the examination site system will welcome the user with a greeting and it will ask for the type of user to log in to the system. Users can use their registration number as the User ID and the password to log in to the system. If user verification is correct, then the user can enter into the system. Otherwise, he will redirect to the login page again. Different type of user has different privileges. (Users can be Students, Admin, and Teachers). Admin users will manage all the information of the users and Information related to examination, and he can set events, can create and delete user accounts. The teacher can use the system to upload question papers, answer scripts, to access students' results. When visually impaired students log in to the system, the system will read out the instruction for starting the exam and after the instruction, it will start the exam. Application has the timer also; it will set to a particular time interval. (Exam Duration). The system will select questions randomly from the SQL database and dictate the questions one by one using Speech synthesis technology. The student will answer the questions one by one after dictating each question, in this time student can answer the question or he /she can skip that question by using the "Skip" voice command. If they skipped the question will be marked as skipped and save into the database. After the candidate answers the question, the "Submit" voice command is used to submit the final answer for evaluation. Voice answers will be converted to text format and used evaluation and stored in the database for future use. When the student says "Next" then only the next question will be read out and when he/she says "Finish" the system should finish the exam. If they do not clearly listen to the question, they can simply repeat the question using the "Repeat" command. If they need to edit the answer or need to answer for the skipped question, they can simply tell the question number and can navigate to that question and can overwrite that answer after saying "Edit". The system has a timer to set the examination duration. If the timer exceeds its limitation answers will be saved in the database automatically and the system will

stop the test. In the evaluation process, for MCQ-type questions system will check the option number with the correct answer number in the database. If both are matching count the marks for that answer. For Structured type questions evaluation process will go through many steps. At the very first it will tokenize both student and standard answers into word by word. Similarity calculation is done by the Hybrid approach for calculating Cosine similarity for measuring the cosine similarity between the 2 answers; here before the comparison Process First we are doing text preprocessing. The main steps including this are,

***Word tokenization*:** Segmentation can be done as Rule-Based. In Rule-Based Segmentation for the given input text string, the system will identify the words which are only available within the dictionary as a word.

***Punctuation Removal*:** By defining the punctuation characters as a list program enables to remove them from the text.

Pos-tagging: Using to identify the word as noun/verb/ adjectives/ adverbs etc. with its correlation with neighboring and interconnected words in a sentence.

lemmatization and Stop words Removal: Lemmatization is a process of converting the words into their base format.

Correcting the Spellings from the student answer: Hereby measuring the Levenstein distance of each word in a sentence to find how much each word deviated from its original format. It is a string metric for measuring the difference between 2 sequences. Here it gives the minimum number of character edits that are required to change one word into the other by insertion of characters or removing the characters or substituting the characters. In here different text has more edit distance rather than similar texts.

After the text preprocessing activities, we are calculating the cosine similarity between the Answers. For this purpose, we are using the hybrid approach for measuring similarity. Figure 2 shows the process of calculating the similarity score.

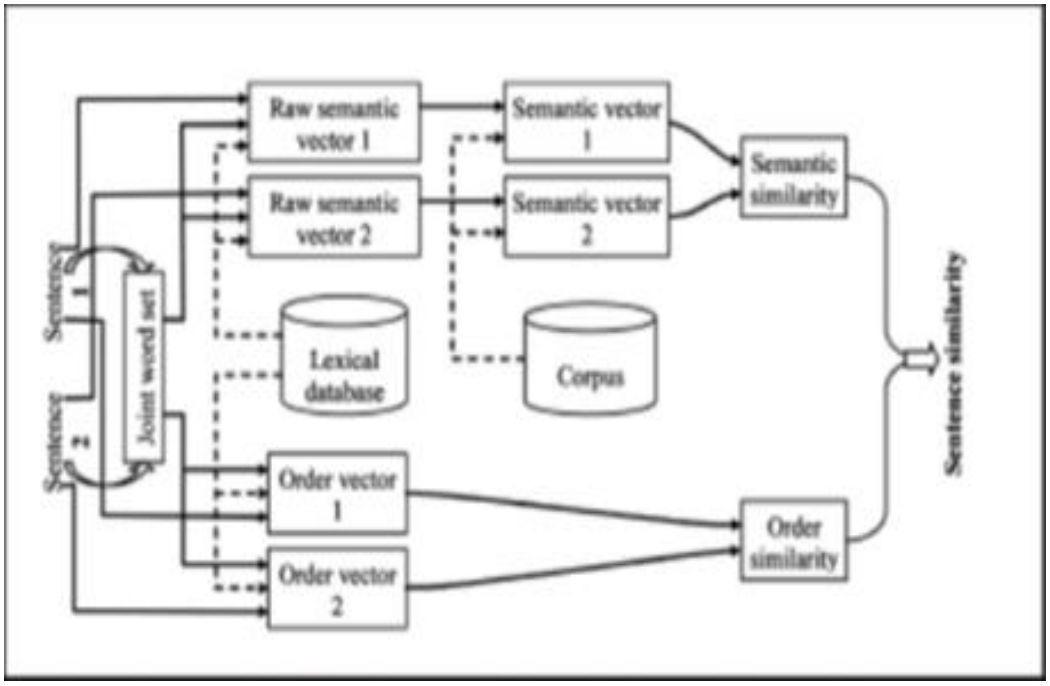

Figure 2: Process of calculating the similarity score

The steps used to calculate the similarity score are given below.

The joint word set creation: Preprocessed word set of both student and scheme answers will be joined as a single word set. The words in the set are unique.

Raw semantic vectors creation: To build the raw semantic vector for given sentences already created joint word set and the WordNet dictionary are used. Each word in the joint word set is compared with each word in both sentences for finding the occurrence of that word in the provided sentence.

Semantic vectors creation: It has been found that a word fall in high frequency has less information than a word occurs with less frequency in a corpus (Khalid, Alturani, Zanoon, 2013). The Information content derived from the Brown corpus is used to measure the Importance of a word in each sentence. Then measure the overall semantic similarity between both answers. The following equation is used to calculate the Information content of a word I(*w*)

$$I(w) = 1 - \log(n+1)\log(N+1)$$

I(*w*) - Information content of a word.
N- Total number of words in the corpus
n - The frequency of the word *w* in the corpus.
For Measuring the Semantic vector following Equation is used,

$$Vi = Si * I(mi) * I(ni)$$

mi - a word in the joint word set
ni - the associated word in answers.
$I\,(mi)\ and\ I\,(ni)$ are the information content of mi and ni, respectively.

At last, the overall semantic similarity between two sentences is calculated as the Cosine Coefficient between these two semantic vectors.

Order vector similarity calculation:

A unique index for each word in the answers was assigned. Then, a word order vector based on the unique word index was created by comparing the Answers with the Joint word set. Word order similarity between the word sets will be calculated through the following equation.

$$S_r = 1 - \frac{|r_1 - r_2|}{|r_1 + r_2|}$$

r_1 - Word order vector of sentence1
r_2- Word order vector of sentence 2

Overall sentence similarity calculation: lexical similarity represents by semantic similarity. When it comes to word order similarity gives the syntactic information between words. For getting the meaning of the sentence both syntactic and semantic information plays a major role (Jadoon et al.,2011). The following equation is used to provide the overall sentence similarity.

$$S = T.val * \frac{v_1 . v_2}{|v_1| . |v_2|} + (1 - T.val) * \frac{|r_1 - r_2|}{|r_1 + r_2|}$$

T is a threshold value that will be given by the user. When students enter into the View Result page it will read out the total student marks with the Grades. After getting the final score user can log out of the system by using the "logout" keyword.

Results and Discussions

Experimenting and evaluating our system is not an easy task, because we can't get a suitable benchmark dataset for evaluating the Student Answers. So still this process remains not completed due to the quality of being based on the language and when it comes to the voice-based system still it is a problem because we couldn't get a voice corpus for Sri Lankan English, Because of it we are using US English voice corpus for examination system, Because of this, even if the candidate pronouncing a correct English word, that time also system can recognize it as a different word that will affect the candidate's performance and final score. Since it is a voice-based system it is being more sensitive to environmental noises. So, it needs a noiseless environment for testing and use. Due to that, we couldn't be able to check our examination system with the voice-based approach for the subjective type of questions, we did the experiments for this as a normal user.

Here we were provided 10 similar questions between 20 users. Different ways of representation of the answers were collected as a result of the test. And those test answers were compared against the manually corrected answer. Also, the test carried on against the historical approach for sentence similarity using cosine algorithm and Jaccard similarity approach

While generating the scores to the student's answer against the Manual Human accessors, I used to correct an answer with the 5 different human accessors' answers for the same answer. As per their correction, I got an average value to score the answer. Following Table 1 shows the Score for a 5 marks question in 5 different categories of 5 answers.

Table 1: Golden Standard for Human Scoring Approach

Definition	Similarity Score
Both of the sentences are **fully(100%)** equivalent and mean the same thing.	5
Both sentences are **mostly** equivalent and some unimportant words differ.	4
Both sentences are **roughly** equivalent and some important information changed/missing.	3
Both sentences share some data but are not equivalent.	2
Both sentences are under the same topic but not equivalent.	1
Both sentences are completely different	0

The hybrid similarity calculation approach uses a combination of both corpus and knowledge-based approaches to calculating semantic similarity between two sentences.

A threshold value is set to calculate the final semantic similarity in this approach.

First, the system was tuned with 50 sentence pairs to calculate the Threshold value. The manually annotated score was used to tune up the system, where the threshold was set to 0.85. This means that on average a sentence has a 0.85 weight in semantic information and 0.15 weight in word order information. Then By using the Threshold values the system was evaluated the student answers as shown in the table.

Here we are considering only one question

Question: 01. What is an organization?

Standard Answer (A1): Two or more people who work together in a structured way to achieve a specific goal or set of goals.

Important Keywords considering scoring in Manual approach: People, work together, Structured, Achieve, Goal

In this case, the Expected Similarity Between answers is 0.5.

Total Marks Allocated for this Question: 5

Let's take the Student Answer as A2

Similarity Score through

- Manual Method –M
- Historical Cosine Approach – C1
- Historical Jaccrd Approach – J1
- Hybrid Approach of Cosine without information content desired –HC1
- **Hybrid Approach of Cosine with information content desired-HC2 (**Our Approach)

Table 2: Test result compares with other methods

A2	M	C1	J1	HC1	HC2
Two or more people work together in a structured way to achieve a specific goal or set of goals.	1	1	1	1	1
People work together to achieve a common goal	0.8	0.615	0.416	0.671	0.678
an organized group of people with a specific purpose	0.6	0.246	0.133	0.425	0.442
People work together in a formal way to achieve a specific goal or set of goals.	1	0.768	0.534	0.789	0.791
people working together in a formal way to achieve their goals	1	0.789	0.541	0.790	0.795
people working in a formal and interconnected manner to achieve their specific goals	1	0.631	0.559	0.757	0.816
It is a formal connection between people to achieve a common goal	1	0.578	0.387	0.610	0.660
Two or more people work together to achieve a common goal	0.8	0.589	0.290	0.635	0.675
People working in an informal way	0	0.210	0.113	0.232	0.249
People working hard for their goals	0.2	0.303	0.197	0.313	0.319

According to the test results, our approach (HC2) is giving the similarity near to human accessor.

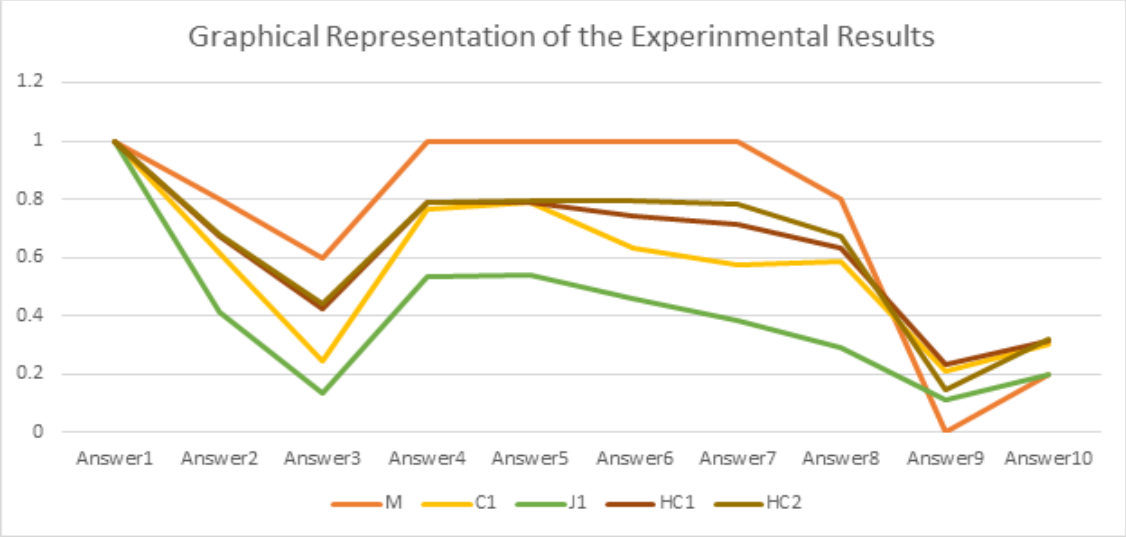

Figure 3: Graphical Representation of the Experimental Results

The Correlation Coefficient (*r*) between the Comparison of M with other methods are shown in the following table 3.

Table 3: Correlation Coefficient (*r*) between the Comparison of M with other methods

	C1	J1	HC1	HC2
R	0.8319	0.7026	0.9051	0.9346

The correlation coefficient comparison between the Manual method and our approach is higher than the other approaches for comparing the essay answers and it is 0.9346 in value. In here Evaluated the accuracy of the system depends on the understanding speech recognizer accuracy and the limitation of recognition no of errors and how those errors affect the student answers and how the system recovers from these errors.

Conclusion

This system is useful for all visually impaired students to prove their talents to the outside world via online exams like normal students. In here they don't want to give any extra dedication to perform the tests. Our system facilitates them to attempt the exam online themselves without any human support. In this project, we are completely avoiding the usage of keyboards while attending exams and it enables the student to attend the exams without the disturbance from surroundings. It is fully controlled by voice commands. Students can easily navigate to previous or next question or save answers, submit answers, repeat the questions, start the exam, check for remaining time through particular voice commands. Also, they can check for the answered and not answered questions. This system can be used for any competitive examination conducted by schools, Universities, Government, etc. This will lead to the percentage of visually impaired students participating in competitive examinations.

Future Research

Those challenging parts were completed by using more techniques, algorithms, and new ways. Because of the noise, the command does not perform well. Therefore, as a future work noise filtering

technique can be added to this system. From those, we will be able to increase the performance of the voice command. Currently, we had developed this for English only, but in the future, we will be making this for other languages as well.

It includes the construction of the system for various types of subjects (E.g., science) by training the speech recognition API for Technical words and an enhancement to the algorithm to reduce the disambiguate in word sense by utilizing the adjacent words to provide the contextual information and now it focuses only the theoretical answers only. But in the future, it will be implemented with Mathematical, Image processing as well. Currently, this system has depended on the traditional login method and need user credentials, it can be improved by implementing fingerprint sensor or using face recognition methods or any other advanced technology to avoid malpractices and to make the system more secure.

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