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Speak Smart, Teach Smart: Enhancement in Interactive White Board Technology

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***Abstract*— In recent years, interactive boards are known for facilitating effective learning. The success of the interactive board when compared to the traditional blackboard learning in improving the student's academic performance has reached the peak. This paper presents an idea to aid the interactive board with a speech-to-text convertor for better learning. Speech is the natural and most vital form of communication for human being. The conversion of speech to text is based on the information contained in the speech signals. Speech-To-Text system takes a human speech sound as an input and produces a string of words as output. This is a new design of interactive learning board system which can be implemented in schools and colleges. It would be very useful to understand speaker's speech, catch up missed information, and take notes and complete homework.**

Keywords- Interactive White Board Technology (IWBT), Speech to text recognition (STR), MFCC

I. INTRODUCTION

THE history of classrooms dates back to the early Greeks. From the one-room-school to modern day classrooms many classroom technologies have evolved. For example, blackboard & chalk transformed into whiteboard & dry erase marker that are being transformed into Smart boards. Overhead projectors were replaced by traditional wall mount projectors, which are transforming into short throw projectors. The short-throw projectors can transform any surface into a smart board. Slates & chalks were replaced by notebooks and pens, which were replaced by laptops, and currently the laptops are being replaced by tablets.

Despite all these changes, one thing has remained constant; that is the goal of the classroom is to facilitate teaching and learning. The technology is a means to facilitate the teaching and learning process. According to the Association of Educational Communication & Technology (AECT), Educational Technology is defined as the "the study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate technological processes and resources"

With the rise in ubiquitous computing, classroom technologies will continue to evolve. Therefore, it is becoming important to consider how the future classrooms are going to be impacted and how it would change the teaching and learning experience. The future classrooms are not only going be technology-enhanced classrooms but they will be smart as well.

Smart classroom uses advanced high interactive modules like audio, videos, gesture recognition and these visually attractive methods of teaching becomes attractive to students who are already stressed with the old traditional method of teaching in a classroom. However, designing smart classrooms should not only account for the architectural considerations but they should also account for the academic considerations.

II. EXISTING SYSTEM

There are two very distinct kinds of interactive whiteboards: The first is a "virtual" electronic version of a dry-wipe board on a computer that facilitates learners in a virtual classroom to view what an instructor, presenter, teacher or fellow learner writes or draws. It is also called an electronic whiteboard and can be found in conferencing and data-allotment systems. The second type is a huge physical display panel that can operate as an ordinary whiteboard, a projector screen, an electronic copy board or as a computer projector screen on which the computer image can be controlled by touching or writing on the surface of the panel instead of using a mouse or keyboard. Interactive teaching is a two-way process of active participant engagement with each other, the facilitator, and the content.

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III. Literature Review

It is well known that the proper use of technology can have a positive impact on educational experience and learning outcomes. It is also well known that proper use of active and cooperative learning techniques can have a positive impact on educational experience and learning outcomes. This review focuses on the recent developments in the interactive white board technology in schools and other learning institutes.

A. Interactive Board System

The system aims to produce multi interactive boards system which can be done by connecting multi interactive boards in network set up. In addition, user interaction with the system is by using IR glove/IR fingertip. Wireless network is set up by using hub/router as well as installing desktop control software (ex. NetMeeting) on main PC/Laptop. The wireless network is used to connect interactive boards and the software enables sharing the same application between the interactive screens. There are several facilities required to produce multi interactive boards such as PCs/Laptops, Wii remotes, hub, Bluetooth dongles and projectors. These facilities usually are available in school and the more facilities provided the more interactive boards produced. For more explanation of the system, let assumes the system is set up in classroom and students want to play scrabble game. They are divided into several teams to compete each other. Each team uses a single interactive board and each of students has his/her own IR glove/IR fingertip to interact on the screen. Since the main PC/Laptop shares the same screen with the other PC/Laptop, all of students can participate and enjoy playing the game collaboratively. In addition, this system supports any computer applications that are designed to play with mouse therefore students can play games online or download other applications from internet because the availability of applications over internet is broadcast and easy to access. Last but not least, this system can be used for presentation purpose and a single interactive board might be sufficient.
This software enables the other PCs/Laptops to display the same screen as shown on interactive board. Thus, this proposed system improves learning method where each student looks at individual screen and teacher can move freely in front of the main screen.

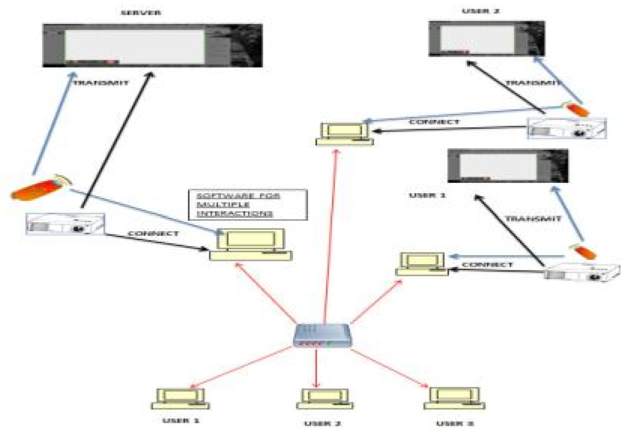

Figure 1. Multiple Interactive Boards

B. IR Glove

Since the main focus on developing interactive whiteboard or electronic whiteboard is for writing/drawing purpose, IR pen or electronic pen has been used with interactive whiteboard. After doing an observation on students working collaboratively with interactive whiteboard, it has shown that writing on the screen with pen is nothing new for children but using electronic whiteboard is new to everyone.IR pen has momentary push button switch to turn ON/OFF IR LED. This is not convenient to use with interactive board for some computer applications, which are naturally played by hand. For that reason, the first design of IR glove using micro button has been developed. It has been tested to justify possible usage with interactive board system.

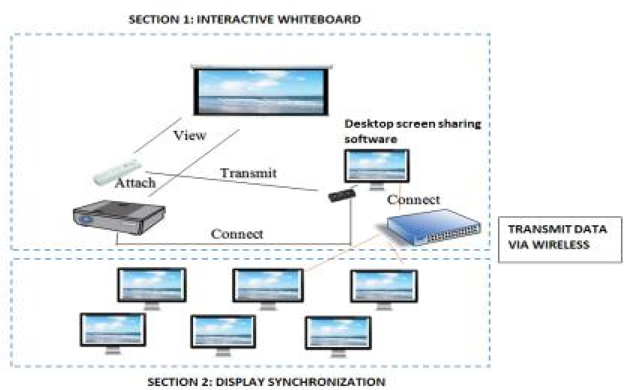

Figure 2. A single Interactive Board with several PC/Laptop prototypes for presentation purpose.

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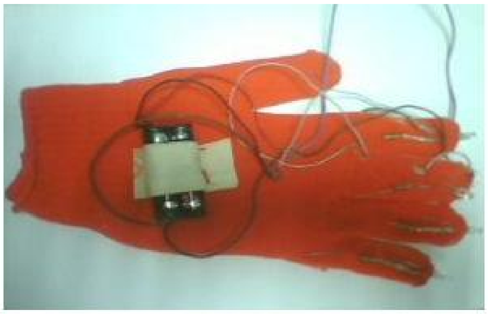

Figure 3. IR Glove

C. IR Finger tip

IR Fingertip has been developed and tested with the interactive board system as well. IR glove and IR Fingertip both are working the same as IR emitters.

Figure 4. IR Finger Tip

IV. PROPOSED SYSTEM

The proposed system aims to add a new feature to the existing interactive whiteboards that is a real time speech to text convertor. The add-on feature would conveniently convert the lecture given by the teacher into readable text to be displayed on the interactive board. This would help the students to understand better and catch up missed information while the teacher explains or dictates important material in class. The teacher would also have a better control of the class as it won't be necessary to turn around and write on the board. The Speech-to-text converter shall also come with a facility of being trained by the teacher who is going to use it. Words can be overwritten if the trainer (teacher) wishes to do so. This feature is essential to add because different teachers would have different accent and speed of dictating their students.

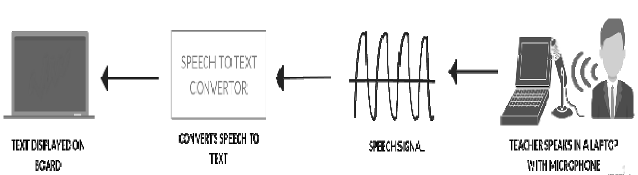

Figure 5. Basic architecture diagram. This diagram narrates the basic process of speech-to-text conversion.

The heart of the above procedure is the speech-to-text convertor. A block diagram for the conversion is given below:

This block diagram of Speech-To-Text conversion system is divided into two phases i.e. training and testing. First in training phase speech utterances of each sentence is recorded. Speech signal is pre-processed and segmented into words. For each word acoustic features are extracted using MFCC method. Such features for each word forming feature vector is stored for reference. In testing phase the speech utterance to be tested is pre-processed, segmented into words and features are extracted for each words. These features are compared with the reference feature vector stored during training phase. This is done by using combination of SVM and Minimum Distance Classifier. The word having minimum difference is given as recognized word.

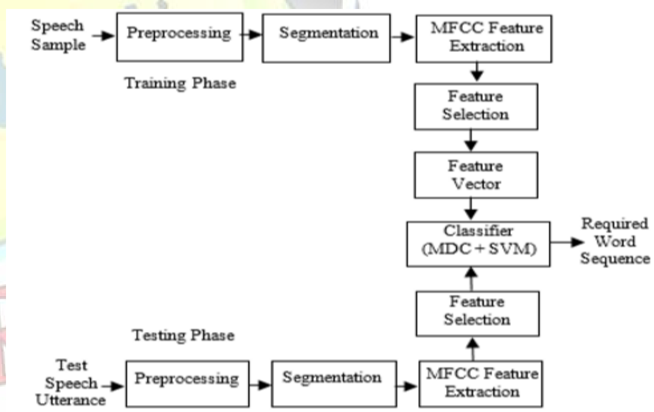

Figure 6. Block diagram of the conversion process using MFCC

Speech Database is the crucial point in the automatic Speech-To-Text conversion system. For any automatic speech recognition system first step is to configure the database.

In any automatic speech recognition system first and the most important step is to extract features. i.e. To identify useful components of speech signal that are used to identify the linguistic content and discarding all the other stuff which carries information like background noise, emotion etc. Two main purposes of feature extraction are: first is to compress the input speech signal into features, and second is to use these features which are insensitive to speech variations, changes of environmental conditions and independent of speaker.

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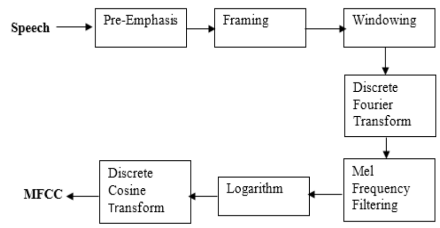

Figure 7. MFCC block diagram

Steps of MFCC feature extraction are as follows:

A. Pre-emphasis

Pre-emphasis is applied to spectrally flatten the input speech signal. First order high pass FIR filter is used to pre-emphasize the higher frequency components.

B. Framing

An audio signal is constantly changing, so to simplify things we assume that on short time scales the audio signal doesn't change much. So we frame the signal into 20-40 ms frames. Hamming window is applied on each frame and it rid of some information at start and at end of frame so to reincorporate this information back into our extracted features overlapping is applied on frames.

C. Windowing

To avoid or reduce the unwanted discontinuities in speech segment and distortion in spectrum introduced by framing process windowing is performed. Mostly Hamming window is used in speech recognition.

D. Discrete Fourier Transform (DFT)

Spectral estimation can be done by DFT. FFT is very efficient algorithm to implement DFT. The magnitude frequency response of each frame is obtained after FFT execution i.e. Spectral coefficients of the speech frames are complex numbers containing both magnitude and phase information. The phase information is usually discarded for speech recognition and only the magnitude of the spectral coefficients is retained.

E. Mel Frequency Filtering

Normally each tone with an actual frequency 'f' is measured in Hz. For speech signal, the ability of human ear to understand frequency contents of sounds does not follow a linear scale. So that for every tone a subjective pitch is measured on a scale called the 'Mel' scale. Below 1000 Hz, Mel frequency scale is linear frequency spacing and above 1000 Hz it is a logarithmic spacing. The following formula gives the transformation of a given linear frequency 'f' Hz into corresponding 'Mel' frequency.

$$Mel\,(f) = 2595*log10\left(1 + \frac{f}{700}\right)$$

As non-linear characteristics of the human auditory system in frequency are approximated by Mel filtering in the same way natural logarithm is used to approximate the loudness non-linearity i.e. the relationship between the human's perception of loudness and the sound intensity is approximated by natural logarithm. Multiplication in frequency domain, become simple addition after the logarithm. The log Mel filter bank coefficients are computed from the filter output as:

$$S\,(m) = 20log10\sum_{k=0}^{N-1} |X(k)\,H(k), 0 < \mu < M$$

Where, M is the no. of Mel filters (20 to 40), X (k) is N-point FFT of specific window frame of the input speech signal; H (k) is the Mel filter transfer function.

F. Discrete Cosine Transform (DCT)

For transforming the Mel coefficients back to time domain discrete cosine transform is performed. The result of this step is called the Mel Frequency Cepstral Coefficients (MFCC). The inverse Fourier transform of the log magnitude of Fourier transform of the signal is called as Cepstrum. As coefficients of the log Mel filter bank are real and symmetric, we can replace the inverse Fourier transform operation by DCT to generate the Cepstral coefficients. The smooth spectral shape or vocal tract shape is represented by lower order Cepstral coefficients. While the excitation information is represented by higher coefficients. The Cepstral coefficients are the DCT of the M filter outputs obtained as:

$$\sum_{m=0}^{M-1} s(m) = \cos\left[\frac{\pi n(m-\frac{1}{2})}{n}\right]$$

Typically first 13 Cepstral coefficients are used. Generally MFCC coefficients are less correlated than the log Mel filter bank coefficients this is the biggest advantage.

G. Pattern Classification

1)Minimum Distance Classifier (MDC)

In speech recognition or STT conversion there are mainly two phases first is training phase and second one is testing phase. For classification, during training phase zero crossing points (ZCP) corresponding to the different words are pre computed and stored as reference ZCPs. Minimum distance classifier computes Euclidean distance between the zero crossing points of the uttered word and zero crossing points

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of words from database. The word having least Euclidean distance is declared as uttered word.

Euclidean distance is given as:

$d^2(\bar{x}, \bar{p}) = \sum_1^k (x_i - p_i)^2$

Where, x and p ZCP database.i.e.

x is a ZCP vector of uttered word.

p is a ZCP vector of different words.

i varies from 1 to k (i.e. no. of ZCPs of a particular word). The sum of squares of the difference between the individual zero crossing points is computed to calculate the Euclidean distance i.e. distances between the uttered word and all words in the database is found out. The word in the database with least distance is declared as the uttered word.

2) Support Vector Machine (SVM)

SVM is one of the effective methods of pattern classification. SVM use linear and nonlinear separating hyper-planes for data classification. First input is mapped into a high dimensional space and then with the help of hyper-plane it distinguishes the classes. The inner product, kernel which is caused by the high dimensional mapping is a crucial aspect of opting SVMs successfully i.e. a high dimensional feature space is implicitly introduced by a computationally efficient kernel mapping and in a high dimensional feature space SVM finds a separating surface with a large margin between training samples of two classes . And large margin implies better generalization ability. SVM uses discriminative approach. The classification of any fixed length data vectors is possible by SVM. It cannot be readily applied to task involving variable length data classification. The support vector classifier uses the function:

$f(x) = ([\ a * K_s(x)]) + b$

Where, $K_s(x) = [k(x, s1), \dots k(x,s_d)\ ]^T$ is a vector of evaluation of kernel functions centered at the support vectors.

$f(x) = ([\alpha * K_s(x)])+b$ Which are usually subset of the training data.

The classification rule is defined as:

$q(x) = \{1\ for f(x) \geq 0$

$\{2\ for f(x) < 0$

And multiclass classification function and rule is defined as:

$f_y(x) = (\alpha_y + k_s(x)) + b_y,\ y \in Y$

$Q(x) = \arg\max f_y(x),\ y \in Y$

3) SVM-MDC Combination:

The proposed system uses the combination of SVM and MDC for classification. It translates large class problems into small class problems i.e. multiclass problems are converted into binary problems. So solving these problems becomes easy. MDC is mainly used for coarse tuning and SVM performs fine tuning.

V. Benefits

The STR (Speech-to-text Recognition) synchronously transcribes text streams from a lecturer's speech input and shows them to students on a whiteboard or computer screens. The pedagogical usefulness of STR-texts to enhance learning was emphasized in several studies. The STR can be applied to enhance learning of students with cognitive or physical disabilities, online students, and students learning in traditional classrooms. STR-texts were displayed to students and could be used to verify and clarify what has been said by the lecturer and take notes. The STR-texts are useful to understand speaker's speech, catch up missed information, take notes, and complete homework.

The STR has a potential to be an instructional support mechanism. Non-native speaker students, due to their language barrier, admitted that STR-texts are useful for Non-native speaker students, due to their language barrier, to follow the instructor, clarify lecture content, and enhance their understanding. STR-texts facilitate learning performance.

Apart from the academically benefiting the students, STR also helps in maintaining discipline. The teachers would get a better control of the entire class as it won't be necessary for them to turn around and write on the board. Also, the slow writers would be highly benefited as they will be able to refer the text from the board and not look for it from their peers. The more disciplined the classroom, the more will be the impact of teaching.

VI. Future Enhancements

The idea presented has a scope for some future enhancements. They are listed as:

1. Displaying of mathematical content by the use of STR can be worked upon.
2. The speed of speech and accent of every professional varies. This affects the accuracy rate of the system. An effective measure can be taken to ensure that the accuracy rate of the system increases.
3. The interface of the entire system can be improvised for ease of use by the candidates.
4. The display of complicated or 3-D diagrams on the interactive board can be done with the help of a scanner. The process of displaying can be illustrated as:

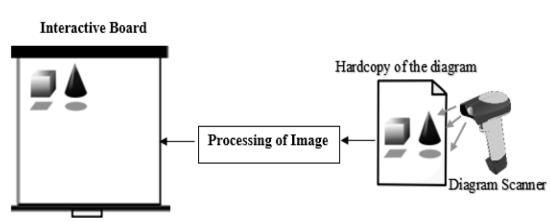

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Figure 8: Diagram Scanner Proposal

VII. Conclusion

New technology in class offers many teaching and learning opportunities. The suggested enhancement in the existing model of interactive boards is sure to create an interesting and fun classroom environment. This will also lead to increased digital competencies for the teaching staff and more motivated and proactive students. Since the students will be able to catch up missed information using this technology, this will result in enhanced learning capabilities.

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