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Artificial Intelligence in Classroom: Integrating Technologies to Aid Conventional Lecture

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Abstract: *Creating a conducive and supporting classroom has become an important aspect in creating a better tomorrow's world. Challenges faced by students have been identified from a survey conducted in University of Nottingham Malaysia with a total number of 177 responses. The survey feedback shows that more than half of the responders are facing difficulties such as forgetting assignments' deadlines, feeling uncomfortable with the classroom's temperature, too shy to voice out for questions and not able to clearly see the notes written on board. The purpose of this study is to implement suitable engineering element onto fields that the authors have identified to be the most impactful factor to overcome the issues identified. This work proposes four different effective methods of solving each problem using the same platform for the purpose of integration with the least resources possible. Smart Classroom system includes Smart Camera to convert text on whiteboard and upload text file, Smart Microphone to analyse and process important information from lecturer's teaching using Natural Language Processing techniques, Smart Temperature Controller for automated and user-enabled control on surrounding temperature and Smart Classroom Mobile Application, an extensively integrated platform for users to access the information stored. With the advancement of technologies, our work succeeds by aiding the current teaching and learning environment. Viewing the notes written on whiteboard from any seat in the lecture hall is no longer a problem to students. Besides, all information explained by the lecturers will be available immediately for the students studying in comfortable room temperature. All these features are accessible to students and lecturer using the smartphone application.*

Keywords: smart classroom; text detection; speech recognition; mobile application; Internet of Things (IoT)

1. INTRODUCTION

In this competitive century, education is not just about delivering content to learner; rather, it acts as central role in fostering the potential of a group of people in becoming an active and productive citizen to the society. The phrase

Quality Education is used to address a specifically designed system that focuses on the development in terms of social, mental, cognition and emotion for each student. This should not be limited to certain gender, geographical location and socioeconomic status.[1]

The conventional way of conducting lecture has become less effective due to multiple reasons such as overwhelming of written and verbal information, lacking interaction between students and teachers as well as uncomfortable environment. This leads to students being unable to realize their full potential. Therefore, a conducive learning environment is necessary to make learning a pleasant experience.[2]

Research was conducted to investigate the market available proposed solutions to make classroom “smart”. Besides from being an expensive technology, they are found to be less impactful towards effective learning. Another major issue of these technologies is that they are not integrated as one, meaning that they usually require customized software to operate.

This work proposes four cost-effective smart equipment integrated as one system to improve the overall learning experience. The aim of this project is to develop an integrated classroom system to enable students to learn more effectively in a classroom environment. The specific contributions are fourfold.

1. Develop a handwriting recognition system that can analyze notes written on the whiteboard in image form.
2. Develop an air-conditioner control system that can be turned on or off automatically based on students’ selection or reading from ambient temperature sensor.
3. Develop a microphone system that analyses lecture speech and extract essential information from the speech and update in mobile application.
4. Finally, develop a mobile application that receives information such as analysed notes on whiteboard and assignment deadlines, provide user interface for students to control air-conditioners and asking questions.

2. RELATED WORK

2.1 Hidden Markov Model (HMM)-Based Recognition

Marcus Liwicki and Horst Bunke proposed about a new system to process whiteboard notes on their research paper “Handwriting Recognition of Whiteboard

Notes".[3] eBeam Smartmarker is used to record the handwriting on whiteboard. The received signals are translated into sequence of (x, y) coordinates for location of pen tip with their associated time stamp recorded in xml format. The system consists of six main stages.

The six main stages are consisting of online pre-processing, denoising, segmentation of image into individual word lines, normalization of individual word line images, horizontal scaling, and extraction of feature vectors which formed the input for the recognizer. The recognizer is Hidden Markov Model based cursive handwriting recognizer which is trained for 58 characters including small & capital letters and special characters.

The authors manage to achieve average recognition rate of 65.56% on validation set and 64.27% on test set at after including the bigram language model. Obviously, the present recognition rate is still very low to be useful in real world scenario. Therefore, there is potentially huge room for improvement such as enlarging the training dataset.

2.2 Speech Transcription for Smart Classroom

Ranchal et al. proposed Speech Recognition (SR) for Real-Time Captioning and Lecture Transcription in the classroom. In short, this system is known as SR-mediated lecture acquisition (SR-mLA).[4] Two important methods of SR-mLA which involved Speech Recognition (SR) were proposed in this paper are real-time captioning (RTC) and post-lecture transcription (PLT).[4] RTC offers an immediate conversion of lecturer's speech to text for display for the convenience of students in class while PLT utilized an SR algorithm which is user-independent to produce multimedia lecture notes with synchronized lecture transcripts, audio, and PowerPoint slides for students to access over the internet after class. It is found out that the implementations of SR methods in the classroom have a positive impact on the performances of the students in various tests. By using multimedia notes which is made possible by the PLT method, the students scored higher than without using it.

Another project which is proposed by Alan Chern et al.[5] has discussed about the idea of smartphone-based hearing assistive system (SmartHear) to enable SR and thus enhanced listening clarity for different group of users. SmartHear consists of configurable transmitter/receiver assignment and has features of advanced noise-reduction techniques, audio recording and Speech-to-Text conversion.

2.3 IoT-Based Temperature Controller System

A temperature control system, named TudungSaji was invented to keep the food warm. The controller will turn ON the bulbs, as bulbs will heat up when leaving to be turned ON for a period when detecting surrounding temperature to be less than 60 °C and immediately turn OFF for the vice versa.[6]

Another project proposed by Zairi Ismael Rizman et al. about developing smart surrounding temperature controller using two electric fans and two temperature sensors. The electric fans will be turned ON if the surrounding temperature is higher than preset desired temperature and will be turned OFF if otherwise. The system is also installed with a buzzer that acts as an alarm that would go off if the sensors detected absurdly high temperature for security purposes.[7]

2.4 e-Learning System

There are several studies and implementation of technologies in improving teaching and learning experience in classroom. A back-end e-learning system with dual-channel classroom feedback system is introduced.[8]

Lecturers can know the understandings of students from their instant responses and hence made changes on teaching practices. A learning agent is designed to record and analyze two different responses from students, which are head movements and voice input answers and hence display the collected feedback into a dashboard which is downloadable by instructors for further analysis and assessment.

A new low-cost Classroom Response System (CRS) which student uses mobile devices to respond to several types of questions during workshop activities.[9] The system provides rapid and yet informative feedback for both the students and lecturers which is an ideal form of assessment and students are found to be more interactive and engaging.

2.5 Overall Related Works

The studies on HMM-Based Recognition, SR-mLA, TudungSaji and CRS show that each approach has benefited the education sector respectively. The proposed method of Smart Classroom further enhanced and simplified each of the related approach by integrating the four approaches into a unified system to provide a holistic classroom experience.

3. METHODOLOGY

In this section, methods to setup and develop respective parts of Smart Classroom including Smart Camera, Smart Microphone and Smart Temperature Controller using different technologies, and integrated using a mobile application are described. The list of features available in the mobile application for users including enrolling module details, uploading and deleting notes, weekly timetables, recordings, live notes from lecturer, real-time chatroom and room temperature controller.

3.1 Design Concept

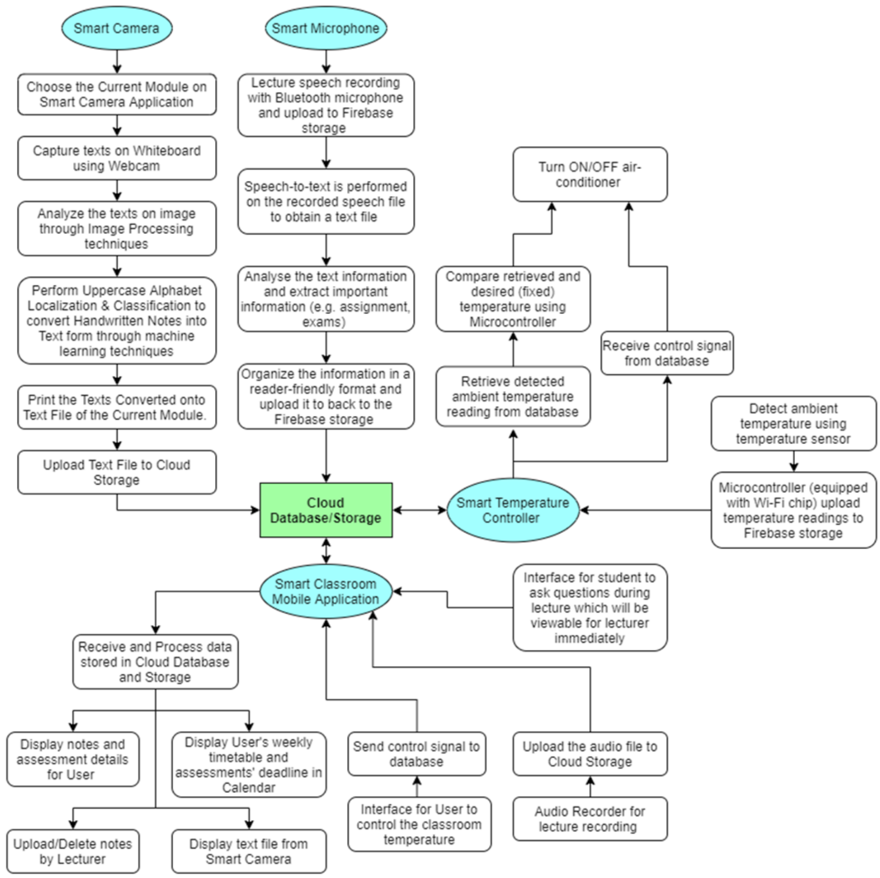

Figure 1: Design Concept of All-in-One System

3.2 Recognizing Whiteboard Notes

3.2.1 Installation and executable application

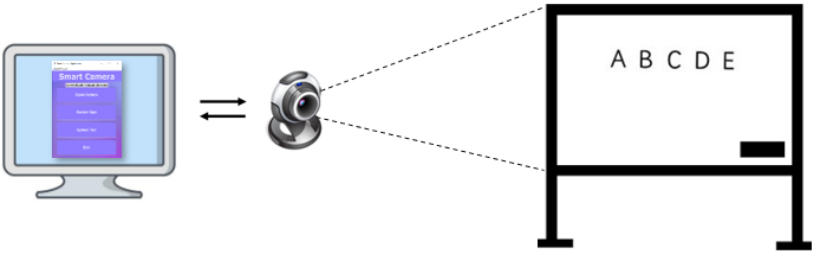

Figure 2: Hardware & Software Setup of Smart Camera

Smart Camera system consists of a USB (Universal Serial Bus)-powered webcam to feed image of whiteboard and a personal computer (PC) with internet access to operate Smart Camera desktop application in user-friendly executable format as well as uploading the generated result to shared cloud platform as shown in Figure 2. All required files to execute the desktop application are compiled as a single distributable installer to circulate the application around PCs at campus easily.

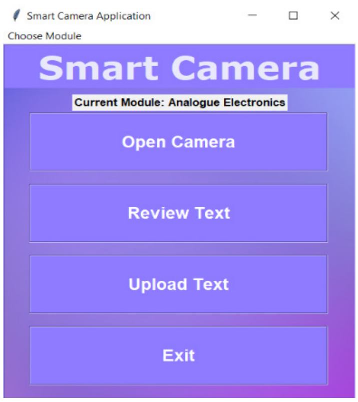

Figure 3: Smart Camera desktop application

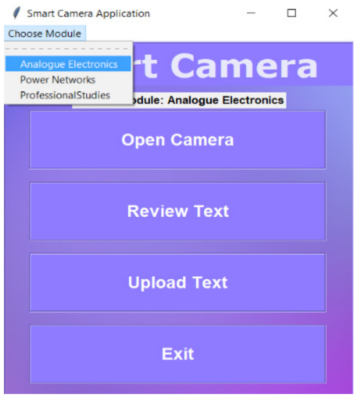

Figure 4: Drop-down menu

As shown in Figure 3 and Figure 4, Smart Camera desktop application consists of four main buttons and one at top corner that provide a drop-down menu for user to choose the different modules name. The "Open Camera" button initialize the webcam view window whereby after the capture key is pressed, backend process will be initiated automatically. The generated result in text file can be reviewed from "Review Text" button and then the text file can be uploaded to specific folder on cloud based on module chosen via "Upload Text" button. Fourth button serves for closing the desktop application.

3.2.2 Text detection and post-processing

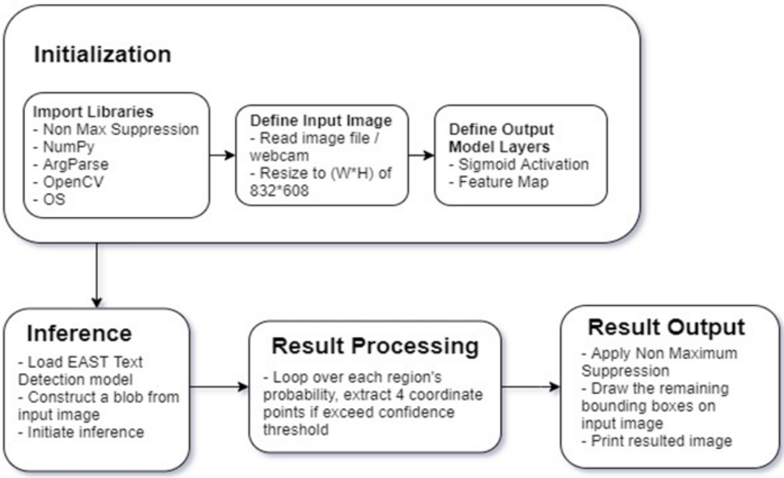

Figure 5: Text Detection Task Workflow

The captured image will go through text detection step using Efficient and Accurate Scene Text Detector (EAST) neural network model.[10] First, it will undergo Binary Large Object (BLOB)[11] extraction to serve as input for text detection inferencing whereby the inference results are stored in two output layers known as “Output Sigmoid Activation” and “Output Feature Map”. First layer that stores the probability value of a region containing text is looped over to filter weak detections denoted by value lesser than 0.5 (default parameter of the script) while second layer is storing the bounding boxes coordinates. However, the filtered result is still containing overlapping bounding boxes as shown in Figure 6. Therefore, by applying Non-Maxima Suppression technique[12], boxes with weaker probability are eliminated and the outcome is only one box for each text detected on whiteboard.

The post-processing step involves cropping every text detected as image , sorting the image sequence based on own sorting algorithm and convert every pixels to either black, 0 or white, 255 px at threshold level of 120 px (Figure 7).

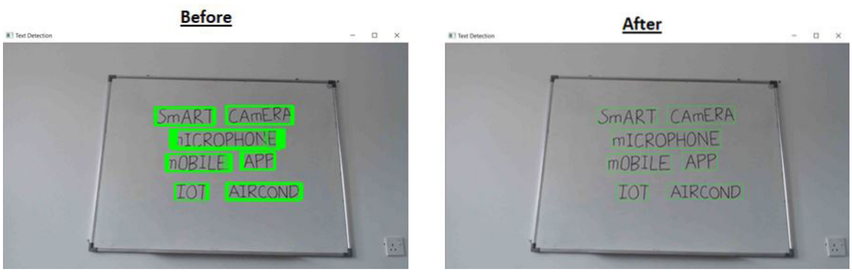

Figure 6: Before and After Non-maxima Suppression

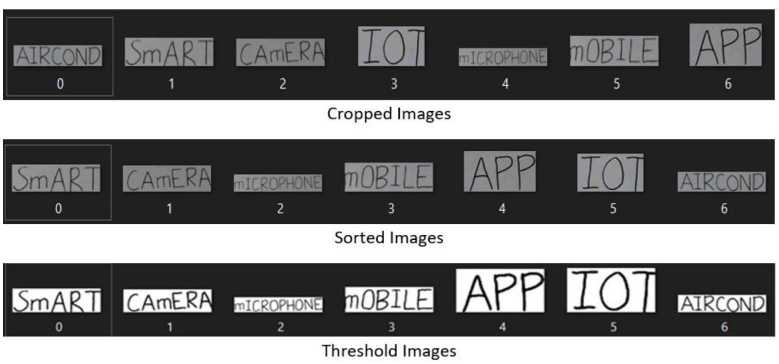

Figure 7: Processed Images

These images will act as inputs for the upcoming uppercase alphabet recognition step.

3.2.3 Model training and inferencing

The neural network model capable of localizing and classifying 26 complete uppercase alphabets is trained using dataset collected from Kaggle A-Z Handwritten Alphabets in white ink and black background.[13] The pixels are inverted to suit the application of inferencing on whiteboard image. Pre-trained Faster-RCNN Inception V2 model is used as starting checkpoint to initiate transfer learning until 200000 steps on TensorFlow framework with total dataset split into 70% as training set and 30% as test set.[14] Multiple attempts are carried out to train the model and finally come out with the best among all.

Dataset used in first attempt consists of 25000 clean images of randomly concatenated alphabets to mimic word form. No filtering, cropping, and augmentation are done. Although the inference outcomes show that most of the alphabets on clear background with high contrast image can be detected, the detection result is very poor on blurry and noisy background while localization accuracy is also not satisfying.

The dataset for second attempt consists of extra 25000 images by performing data augmentation on the original 25000 images using Imgaug library.[15] The inference results show noticeable improvement on blurry and noisy background. However, the localization of alphabet detected is still poor. The third attempt which is the final one shows satisfying result by observing the losses graph from Tensor Board as shown in Figure 8 whereby the fluctuations are settling down while the model is being trained which indicate that the model able to find the right setting for weights and biases through tweaking to actually solve the problem.

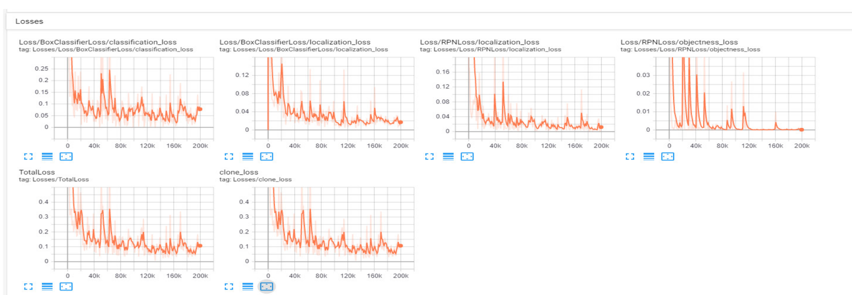

Figure 8: TensorBoard result for third training attempt

The classification and localization losses graph able to reach convergence at the end of model training which indicate the model able to find the right weights and biases setting for both parameters. The effort comes from perform manual filtering to eliminate unusable dataset, cropping to remove redundant white space around the alphabet, concatenating to form a word image, random resizing for variance in image height and augmentation to enhance recognition robustness. The final dataset consists of 200000 clean images and 200000 augmented images.

Each image from text detection post-processing step is passed towards handwriting recognition inference process where every localized and classified alphabet as shown in Figure 9 is sorted in order and printed on text file with spelling check feature using PySpellChecker as shown in Figure 10 and Figure 11.[16]

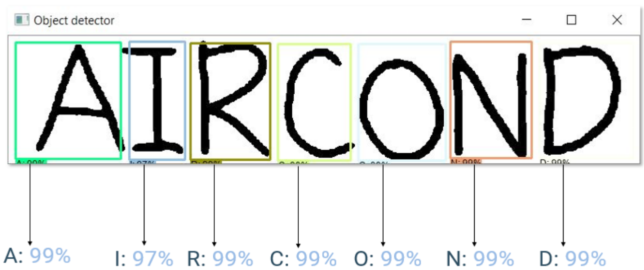

Figure 9: Inference result with confidence level in percentage number

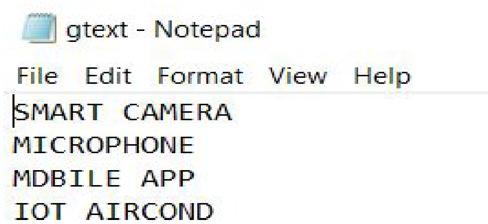

Figure 10: Before PySpellChecker

Figure 11: After PySpellChecker

3.2.4 Live notes

The text file is then uploaded to Firebase storage as our shared cloud platform and available in the Smart Classroom mobile application as shown in Figure 12. Users are able to view the analysed notes by clicking on the “Reload” button on the bottom left of the screen.

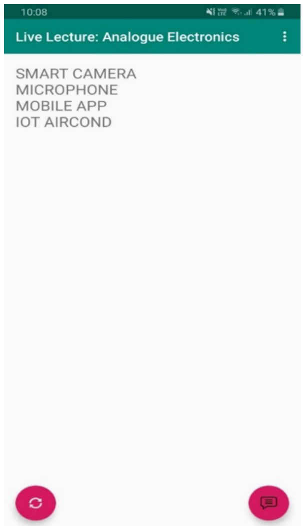

Figure 12: Mobile application displaying words written on whiteboard

3.3 Extracting Important Information from Lecture Speech

3.3.1 Cloud based speech recording system

Figure 13: Overall setup of Smart Microphone

Figure 13 shows Smart Microphone consists of three devices which works synchronously with each other which are Bluetooth headset, smartphone, and a processing machine such as a desktop. Firstly, the lecture speech is recorded with a Bluetooth headset which is connected to the Audio Recorder of Smart Classroom Mobile Application in a smartphone. The speech information is then uploaded to Firebase storage which act as a shared cloud platform which can accessed by multiple devices and desktop simultaneously. The speech information that is uploaded to the Firebase storage will be processed using the methodology shown in Figure 14. The processed information is then displayed on the Smart Classroom Mobile Application.

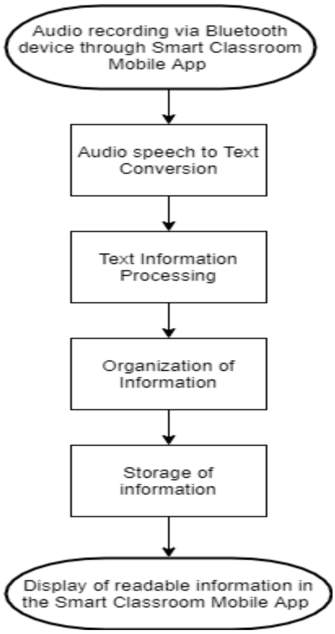

Figure 14: Overall Methodology of Smart Microphone

3.3.2 Audio recorder

Lecturers are able to record their lecture for extracting important features by using a Bluetooth headset and this mobile application. The lecture contents are recorded in Waveform Audio File (WAV) format which is a standard uncompressed audio file formats developed by Microsoft and International Business Machines Corporation (IBM) and is compatible with most operating system such as Windows and MacOS. [17] This can be done by using Android's application programming interface (API) AudioRecord to set Bluetooth headset as microphone input and record in raw file before converting into WAV format. Table 1 shows the configuration of recording file. This is because the Bluetooth headset only support single audio channel. Pulse Code Modulation (PCM) 16 bits per sample is chosen as this is guaranteed supported by all android devices and 8000Hz of sampling rate is chosen to prevent an over large audio file recorded after a typical two hours lecture. Once the recording is stopped by the lecturer, it will be automatically uploaded to cloud storage which can be processed for essential information extraction.

Table 1: Configuration of audio recorder

Parameter	Value
Audio Channel	Mono
Sampling Rate	8000 Hz
Audio Format	PCM 16 bits per sample

3.3.3 Speech to Text conversion

Google cloud Speech to Text recognition is used in converting the content of the speech into a text file in the format of '.txt'.[18] This conversion allows the information to be read and manipulated easily with regular expression and natural language processing algorithms for the purpose of text mining. The text file generated by the speech to text conversion is lack of punctuation which causes difficulties for the text processing algorithms to be implemented. Hence, the text file is punctuated with an open-source text punctuating algorithm known as Punctuator with the help of a deep learning method known as Recurrent Neural Network (RNN).[19]

3.3.4 Extraction of essential text information

The main techniques that are used in the extraction of information are as follows:

1. Tokenization [20]
2. Text matching
3. Stop words removal
4. Organization of information using Python dictionary

Tokenization is used to split the words in a sentence and store them into a list. This enables the words in a sentence to be analysed individually. The method of tokenization of paragraph and sentences helps to dissect a huge chunk of information or data into many pieces of smaller information to be understand which is the core purpose of utilizing Natural Language Processing (NLP) [20] in this project.

Text matching is done by matching the text information with the pre-defined keywords which is considered as essential information for the students.

A list of pre-defined keywords is stored in a Python list which is used to detect the presence of such words in the text data. Next, the sentences that include the keywords are extracted and stored in a different Python list.

Stop words removal are performed on the list of extracted sentences. Conversion of data into something as is understandable by a computer is known as pre-processing.[21] Filtering out non-informative data is an essential part of pre-processing. In the field of Natural Language Processing, these words are known as Stop Words. A stop word is commonly used word (such as "the", "a", "an", "in") that does not contribute important information to the data. Stop words will take up extra storage space in the database and hence increases the processing time if it is not removed. Therefore, stop words in the required information are removed by using a Natural Language Toolkit (NLTK) library as the library contains a list of stop words.

Key-value pair is used extensively in the organization of information. The key is the keywords that are matched in the text data and the value is the sentence which includes the information that is attached with the keywords. The key-value pairs of information are being arranged in a tabular format which will then be easily uploaded to the Firebase Realtime Database as shown in Figure 15. The information is to be displayed by Smart Classroom Mobile Application for usage by students and lecturers.

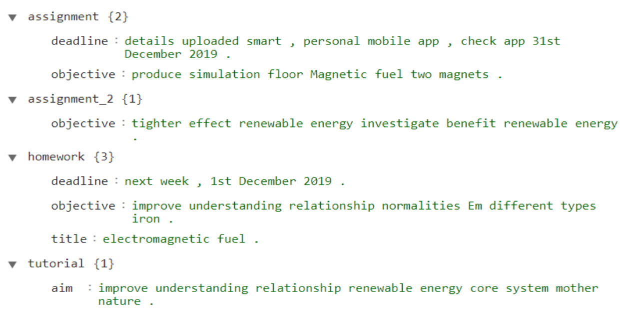

Figure 15: Organized Information on Firebase

Additional data cleaning techniques are also implemented in ensuring the processing of information is done efficiently. Singularization of words is done to avoid the processing of repetitive words that carries the same meaning. Next, keywords indexing are done to avoid the overlapping of information due to the presence of same keyword in the dictionary. Lastly, database optimization is done to ensure that the database is not overloaded with data that has been processed.

This is done by deleting the recorded speech files in the cloud storage once is has been processed into text data. Hence, the storage of the cloud database can be optimized for continuous recording of speeches which consumes a huge amount of spaces.

3.3.5 Deployment in Smart Classroom Mobile Application

Smart Classroom Mobile Application displays the organized information from Smart Microphone in a presentable format which is easily understandable by the user as shown in Figure 16. This will greatly help the students in terms of revision as they are able to remember the information in the lecture easily. The processing time increases logarithmically with the increase in speech processing time. Therefore, the lecturer does not need to worry about the length of speech recorded will increase the processing time.

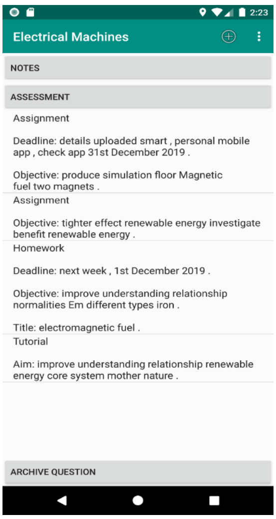

Figure 16: Organized Information in Mobile Application

3.4 Developing Temperature Controller System

3.4.1 Installation of System

The overview of Smart Temperature Controller system is as shown in Figure 17, where it consists of temperature sensing unit, a real-time database, controller for the air-conditioner integrated with Smart Classroom apps. The controller will obtain temperature readings of the classroom at intervals using temperature sensing unit.

After the data is sent to the database, it controls the air-conditioner depending on several situation. All components are compatible to be programmed using Arduino IDE.

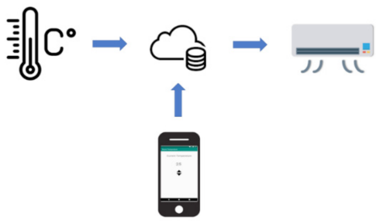

Figure 17: Overview of Smart Temperature Controller

3.4.2 Automatic control

The overview of automated control of Smart Temperature Controller is shown in Figure 18. Under this mode, temperature sensor connected with Wi-Fi module, ESP01 detects ambient temperature of classroom, and then the reading is sent to database. The microcontroller will then compare the detected temperature reading and reference temperature reading, i.e., turn on the air-conditioner when reference is lower than detected reading and vice versa.

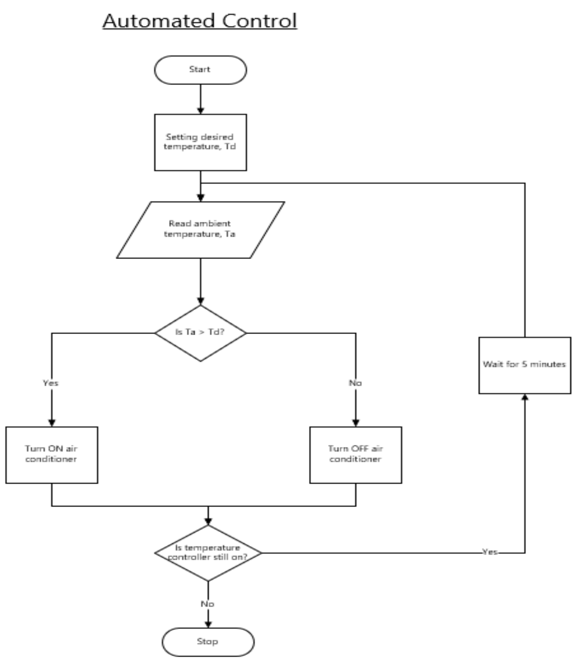

Figure 18: Flowchart of automated control

3.4.3 User-enabled control

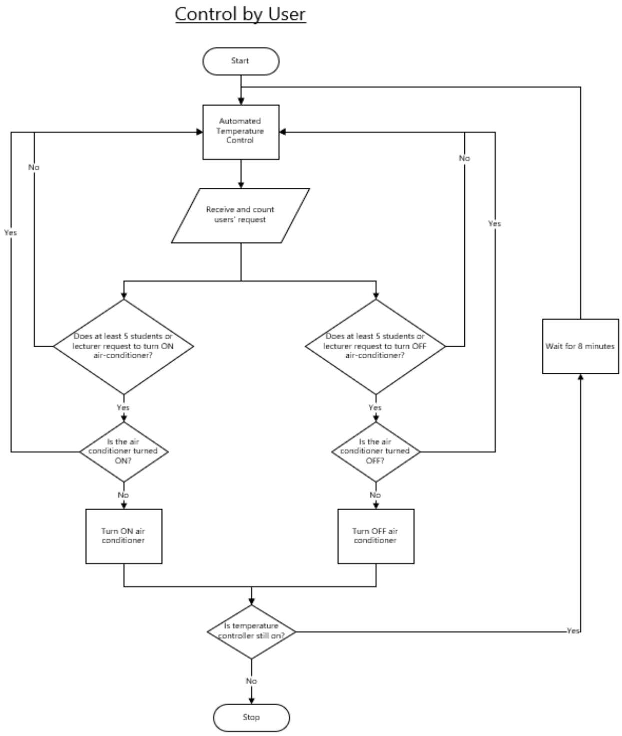

Figure 19: Flowchart of user-enabled control

Based on the survey conducted with 177 students from University of Nottingham Malaysia, they felt very uncomfortable with classroom temperature due to either too hot or too cold. Therefore, Smart Temperature Controller is integrated with Smart Classroom Application to enable students to adjust temperature using phone. Since the main purpose of this controller is to provide a comfortable environment for students in the classroom, thus when fixed minimum number of users in the same classroom request to turn on or off the air-conditioner, it will overwrite the automated control mode if the controller detected that the air-conditioner is operating at the opposite way.

A restriction is set on the temperature controller for user-enabled control, is that every user may only request to change temperature once before a control signal is triggered, i.e., when certain number of users request to adjust temperature. This is to provide protection to the controller and air-conditioner by preventing users from frequently changing temperature.

The mobile application is also able to view the current room temperature detected by Smart Temperature Controller as shown in Figure 20. Besides, it also provides a room temperature controller interface where users can request for temperature changes once. This is to make sure that all students are given equal opportunity in the classroom. The requests from users are processed by Smart Temperature Controller.

Figure 20: User interface of temperature controller

3.5 Implementing Mobile Application as Integrated Platform

3.5.1 Modelling mobile application

Smart Classroom Mobile Application serves as an integrated platform for all users to access all features such as viewing handwritten notes on whiteboard and important information extracted during lecture. According to the statistic made, there are 79.7% of smartphones in Malaysia is running on Android Operating System and 86.8% of the Android smartphone is running on Android 5.0 or newer operating system as of April 2020.[22,23] Hence, this mobile application is an Android application which is developed with Java programming language with minimum version support of “Lollipop”, Android 5.0.

This mobile application provides multiple features, but some are only accessible depending on users’ role, which is either Lecturer or Student. A full list of features can be found in Table 2.

Table 2: Features of Smart Classroom Mobile Application

Features	Lecturer	Student
Enrolled Module Details	✓	✓
Upload and Delete Notes	✓	×
Weekly Timetable	✓	✓
Calendar	✓	✓
Recording Lecture	✓	×
Live Notes	×	✓
Chatroom	✓	✓
Room Temperature Controller	✓	✓

In the backend of this application, it constantly fetches data from real-time database and server storage. This is to ensure that the mobile application is always updated and displaying accurate information.

3.5.2 Realtime chatroom features

Chatroom features allows students to ask questions anonymously where lecturers are able to view the questions immediately on the mobile application. According to the survey conducted with 177 students from University of Nottingham Malaysia, there are students commented that they felt shy to ask questions in front of the class. Hence, this provides a good alternative for students to ask questions. Students are able to ask questions by clicking the "Submit" button at the bottom right of the pop-up window. The questions asked will be stored to Realtime Database anonymously and are viewable by lecturers immediately as shown in Figure 21.

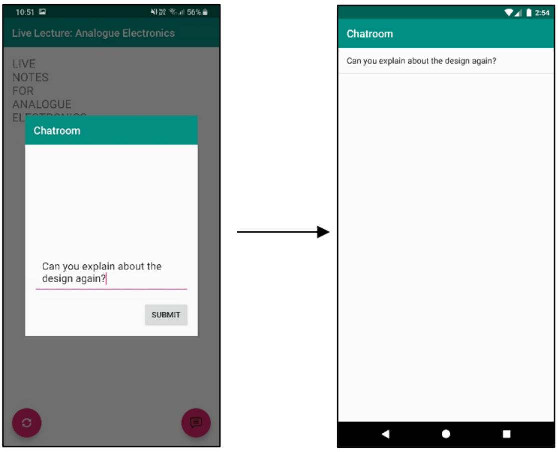

Figure 21: User interface to ask anonymously and display asked questions

However, in order to prevent students from misusing it, a list of offensive words is loaded into the mobile application to prevent impolite questions being asked.[24] A warning message of reminding the user to ask questions politely will be shown at the bottom of the User Interface as shown in Figure 22. All questions asked will be saved and stored which can provide an option for lecturers to review on which topic do students faced difficulties in understanding in order to make better preparation for future classes.

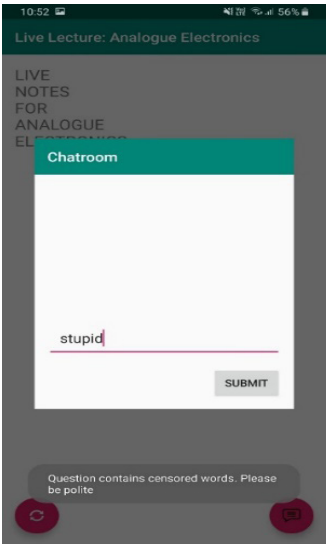

Figure 22: Filtering system which blocks questions with unpolite words

3.6 Summary of System Architecture

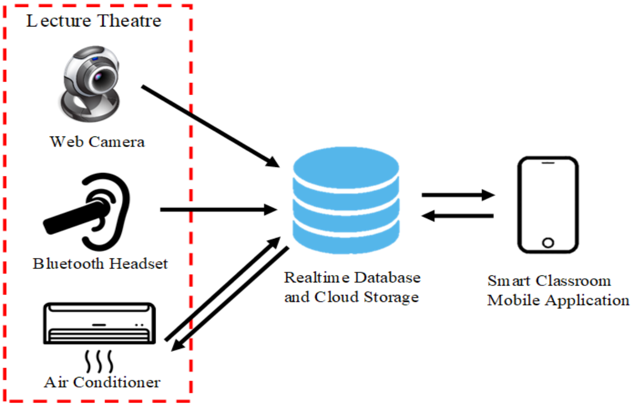

Figure 23: System architecture of Smart Classroom System

Figure 23 shows the system architecture of Smart Classroom which includes web camera, captures lecture notes on whiteboard, Bluetooth headset, record important content during lecture and send all data to real-time database after being processed using computer and Smart Temperature Controller which enables all users to adjust temperature of classroom after temperature reading is sent to database. All contents and temperature control are available for all users who used Smart Classroom Mobile Application which is integrated with parts mentioned above.

4. RESULTS AND DISCUSSION

4.1 Intersection over Union Calculation

In order to quantify the correctness and accuracy of bounding box on localizing and classifying object detected, Intersection over Union (IoU) calculation is used. It is a ratio between "The Intersection" and "The Union" of predicted box and ground truth box whereby the area overlapping between both boxes are "The Intersection" while the total area spanned is "The Union" as shown in Figure 24.

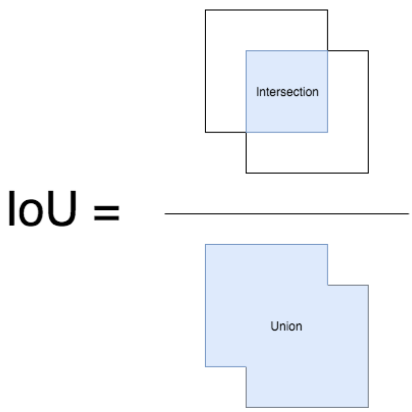

Figure 24: IoU ratio calculation

For calculating Average Precision (AP), we first have to identify whether each detection on evaluation dataset is correct (True) or wrong (False), known as True Positive and False Positive using IoU ratio. The most commonly used IoU threshold is 0.5.[25] If the IoU is larger than 0.5, it is a True Positive, else it is a False Positive. Average Precision value for each uppercase alphabet classes are then calculated using Equation 1 below.

$$\text{Average Precision} = \frac{\text{Number of True Positive}}{\text{Number of True Positive} + \text{Number of False Positive}}$$

The mean AP (mAP) is the mean of total average precision values across all 26 classes. Depending on how the classes are distributed in the dataset during training phase, the individual AP might vary from very high for some classes to very low.

Before releasing the trained model to inference on practical real-world scene, it was evaluated using the test dataset split from total dataset. Besides from mAP, the classification and localization loss for Region Proposal Network and Box Classifier inside the Faster R-CNN architecture are evaluated as well using TensorFlow framework. Table 3 shows the tabulated evaluation result using test dataset.

Table 3: Evaluation results using test dataset

Box Classifier	Classification Loss	0.153156
	Localization Loss	0.049961
Region Proposal Network	Localization Loss	0.593065
	Objectness Loss	0.437371
Mean Average Precision (mAP) @ 0.5 IoU		0.999153

The mAP obtained is good considering that the test dataset is also came from the similar source Kaggle as training set. This reflects that the model can generalize itself well on the training data (No Overfitting), able to react to new unseen data and make accurate predictions.

Another important task is to also evaluate the model for real practical usage, where the images used for evaluation will be collected from real world scenes such as capturing from whiteboards at different lighting condition. Around 261 images in single word format, consist of different number of alphabets are collected from real person handwriting. Table 4 below shows the tabulated evaluation result using real world scene images.

Table 4: Evaluation results using real world scene images

Box Classifier	Classification Loss	0.650316
	Localization Loss	0.381657
Region Proposal Network	Localization Loss	0.081497
	Objectness Loss	0.570698
Mean Average Precision (mAP) @ 0.5 IoU		0.886376

4.2 Accuracy of Organizing Speech Information

The accuracy of the information organizing algorithm is mainly affected by two factors which are speech recognition and punctuation of text data. The example of wrongly detected words is shown in Table 5 below.

Table 5: Original Word and Detected Word

Original word/phrase	Detected Word by speech recognition
field	fuel
ecosystem	core system

Besides, the accuracy of the punctuator also affects the structure of the sentence to be processed. Table 6 shows that the two original sentences have been merged into one sentence as the full stop is not detected correctly at the end of first sentence by the punctuator.

Table 6: Comparison of Original Sentence and Punctuated Sentence

Original sentences	The details have been uploaded to the smart classroom mobile app. Do check it out in the app. The deadline will be on the 31st of December 2019.	3 sentences
Punctuated sentences	the details have been uploaded to the smart, personal mobile app , do check it out in the app the deadline will be on the 31st of December 2019	1 sentence

This cause the information of two sentences being processed together instead of only original sentence which contains the keyword. Therefore, the processing algorithm is unable to extract the information in the original sentence.

The inaccuracies of speech recognition and punctuator can be caused by a few reasons such as:

1. Accent/pronunciation of English spoken by the speaker
2. Speed/pace of speech delivered by the speaker
3. Sentence structure in the speech
4. Usage of pause in between sentences spoken

4.3 Processing Speed of Executing the Smart Microphone Algorithm

Figure 25shows the comparison of speech lengths and its respective processing time. It is shown that the longer the length of the speech recorded, the longer the time needed for the algorithm to process the information contains in the speech. The processing time increases logarithmically with the increase in speech length.

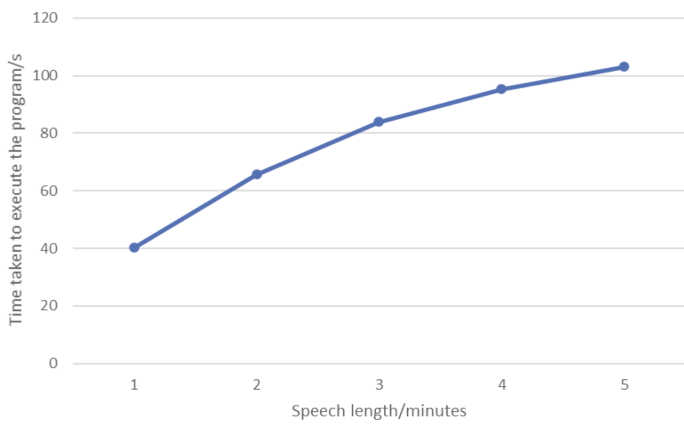

Figure 25: Time Taken to Execute Smart Microphone Algorithm Against Speech Length

4.4 Smart Temperature Controller

In this testing, the condition is set as Table 7which means that the controller supposed to turn ON the air-conditioner.

Table 7: Temperature Testing Condition

	Value (°C)
Desired Surrounding Temperature	25
Detected Surrounding Temperature	38

When a user made a request to increase the temperature (turning OFF the air-conditioner) via Smart Classroom Mobile Application, the value of *requestTemperature* changes from '0' to '1' in the database as shown in Figure 26.

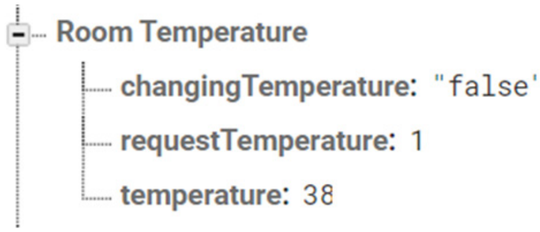

Figure 26: Changes in requestTemperature to Request Turning OFF Air-Conditioner

When the value of *requestTemperature* increased to "+5", the remote control will increase the temperature and disregard the automated control algorithm.

4.5 Smart Classroom Mobile Application

The results of testing and outcomes of the mobile application is displayed in Graphical User Interface (GUI). The application is tested with an Android Smartphone running on Android Operating System Version 9.0.

Figure 27is the interface which display all enrolled modules by the user. In this scenario, the user is enrolled to two modules which are "Analogue Electronics" and "Electrical Machines".

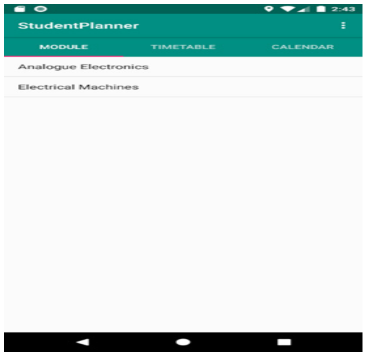

Figure 27: User Interface Displaying All Enrolled Modules of The User

Figure 28 shows the weekly timetable. The timetable shows the module and location of the lecture, which is sorted by time. When there is no lecture on that specific day, "No Class Today" will be displayed to users.

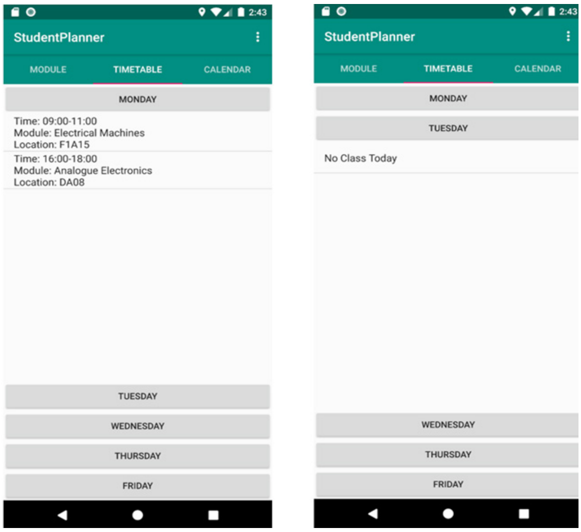

Figure 28: User Interface to Display Weekly Timetable of the User

The user interface of the calendar is shown in Figure 29. A blue dot will appear on the assignment's deadline and its title will be shown when clicked on the date. For example, there is an assessment due on 12th March 2020 with the title of "Motor Design".

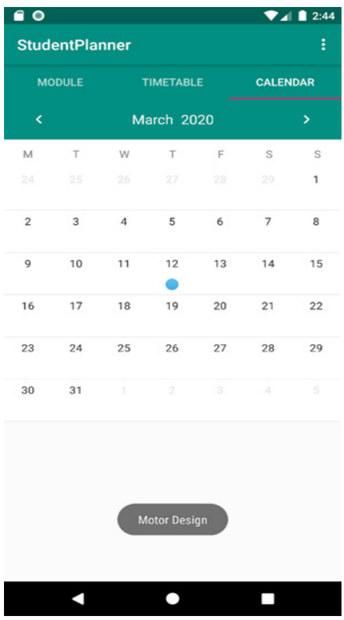

Figure 29: User Interface of Calendar

4.6 Overview

As the result shown, it proves that teaching and learning experiences can be enhanced with the proposed method of Smart Classroom system. Meanwhile, all users are able to be benefited from this holistic classroom experience with a unified platform.

5. CONCLUSION

In this paper, several methods to bridge the gap between conventional classroom system and technologically enabled classroom in a real university campus have been outlined. By implementing the proposed methods, the classroom have been equipped with an integrated classroom learning system powered by a mobile application which connects multiple AI enabled IoT system to function effectively. The teaching and learning experience are enhanced with the presence of Smart Classroom system with three main features, Smart Camera, Smart Microphone and Smart Temperature Controller. With Smart Classroom, students can access the written information on the whiteboard and speech information in the class on their personal mobile devices at their fingertips. Students can focus in class with temperature that is automatically adjusted to suit their needs. All these features are accessible to students and lecturer with an Android smartphone application. Based on the observation of classrooms in various universities across the globe it is found that basic infrastructures such as web cameras and computers are available in all lecture theatres. Therefore, the implementation of our Smart Classroom system in universities is cost-effective.

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