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UNDERGRADUATE RESEARCH CONFERENCE (URC 2020)

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Emerging Technologies in Computing

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UNDERGRADUATE RESEARCH CONFERENCE (URC 2020) "EMERGING TECHNOLOGIES IN COMPUTING"

Edited by

Rajesvary Rajoo

Ts. Harlina Harun

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Nilai Education Sdn Bhd
No 1, Persiaran Universiti,
Putra Nilai
71800 Nilai
Tel : 06-8502338 Fax: 06-8502339
herman@nilai.edu.my

FOREWORD

Technology has transformed the way we live over the years. As new technologies continue to emerge, the necessity to embrace these new technologies arises for it has enhanced our lives significantly in the current social and business environment. In the ever-evolving world of technology, innovative ideas and creativity are essential for technological advancement. In line with this, education today is expected to equip learners with not only technical skills but also critical thinking skills to conduct research in emerging technologies. Realizing the need to develop all rounded graduates specifically with attributes associated with communication, critical thinking and problem-solving, Nilai University encourages and supports research activities by providing suitable platforms for students to foster exchange of information and networking amongst industries, academicians and students.

This Conference Proceedings volume contains the written versions of contributions presented during the Undergraduate Research Conference, 2020. The conference took place at President Hall, Nilai University on the 19th of February 2020. The conference created a good avenue for participants consisting of undergraduate students from public and private universities to share and disseminate their knowledge and findings in related disciplines. We would like to thank all participants for their contributions to the conference programme and for their contributions to this proceeding of the conference.

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CONTENTS Page

PERSONALIZED JOURNAL RECOMMENDATION SYSTEM USING HYBRID APPROACH

Liew Pau Ming[*1], Rajesvary Rajoo[1]

[1] Faculty of Engineering, Science and Technology, Nilai University
No 1, Persiaran University, Putra Nilai, 71800 Nilai, Negeri Sembilan
n00016152@students.nilai.edu.my, rajes_e@nilai.edu.my

ABSTRACT

Journals are the primary source of information for researchers in various fields. To obtain new knowledge regarding fields under study, a vast number of journals are necessary to go through. The traditional method of searching based on keyword is time-consuming. To overcome this issue, a journal recommendation system (JRS) capable of filtering information based on personal needs are introduced. To ensure JRS deliver satisfactory recommendation, a lot of research has been focussed on using content-based filtering (CBF). While CBF is powerful for filtering and recommending journals that best suit user' interest, lack of quality in recommendation leading to poor accuracy is still a tricky problem. Thus, combination of CBF and collaborative filtering (CF) called the hybrid approach are proposed. However, certain drawbacks of CF and CBF are inherited in the hybrid approach. Hence, a personalized JRS that is powerful and produces accurate and quality assured recommendation under the sparse dataset is proposed in this project. The contribution of this project include the proposed new architecture of hybrid approach and the utilization of citation to improve the similarity between user.

Keywords: Content-Based Filtering, Hybrid Approach, Model-Based Collaborative Filtering, Recommendation system

1. INTRODUCTION

Due to the rapid development of information technology, more and more digital information is being added to the world wide web freely without examination. As a result, it is also almost impossible for users to properly judge the relevance of a retrieved item for making the right decision without the assistance of the information filtering system. Thus, recommendation system (RS) has been introduced in a large number of fields such as economy, education and scientific research, to effectively retrieve necessary information. The arise of RS change the way user communicate with the web sites as it has replaced the search function users used to rely on. The most prominent application of RS is in the e-commerce website. As many alternatives are offered by a single web site, RS perform the task of item evaluation and present the optimal items to user.

In academic research, JRS has made a huge contribution to researchers since it aims at mitigating information overload and retrieves journals that are relevant to the study which the researcher is currently focussed on. To achieve this, a lot of calculation is indispensable part and the correctness of the result output from the formula applied determine the accuracy of recommendation. Therefore, research has been vastly focussed on updating the recommendation algorithms in order to improve the accuracy of its recommendation. This is due to the fact that different recommendation systems require different recommendation algorithms. For instance, even though the applications of CF in amazon have achieved an outstanding outcome. However, the application of CF alone is not suitable for content critical recommendation system. On the contrary, although CBF alone is powerful enough for content critical recommendation system such as in the book recommendation system, yet, it suffers from the problem of lack of quality in the recommendation.

This project discusses four approaches that are suitable for and have been used extensively in real world scenarios on various kinds of recommendation systems. Advantages and disadvantages of different approaches will be provided in the research. Through the analysis of the limitation mentioned, a personalized JRS based on hybrid approach is proposed with the aim of producing accurate and quality assured recommendation under the sparse dataset.

2. PROJECT OBJECTIVES

- To develop a journal recommendation system using the hybrid approach
- To improve the accuracy of hybrid approach for recommendation system in term of high accuracy under sparse dataset

3. RESEARCH BACKGROUND

3.1 Problem Statement

JRS is developed with the goal of assisting user in mitigating information overload and to effectively choosing the suitable journal for their work. In contrast to the traditional keyword-based search strategy, RS has been proven more effective in retrieving vast amount of data (Xu, Tang, Ma, Liu, & Daneshmand, 2019). Current RS on computer science publications is developed on the basis of paper's description, which assist users in choosing the suitable journal or conference to submit their work, and the accuracy achieved is 61.37% on average (Wang, Liang, Xu, Feng, & Guan, 2018). According to Mu (2018), for RS to produce accurate customized results that meet the interest of each individual user, explicit feedback such as user rating which used to express users' satisfaction play an important factor in determining the accuracy of RS.

However, RS depending on user rating often suffer from data sparsity problem due to the fact that a number of users using the RS are extremely less as compared to the number of items offered by the system (Bai, et al., 2019). As a result of insufficient rating data or high sparseness of user-item rating matrix for similarity calculation between user to user, the coverage of the dataset used for prediction is affected (Wang, Wang, & Zhang, 2018). Tian et al. (2019) stated that in general the user-item rating matrix is as sparse as 99.99% without any additional process being apply before constructing the user-item matrix for prediction. In the case of library recommendation systems, the sparsity of user-book matrix have been successfully reduced to 76.42% through the application of clustering algorithm to group similar user based on the rating user given to books. It demonstrated that by alleviating the sparseness of the user-item rating matrix, the lower the sparseness, the higher the precision. But based on the mean average precision (MAP) achieved in the paper, where roughly 35%

of MAP is achieved for the training set of 50 item for each user, thus, further improvements in the proposed method are needed.

Hence, to develop an JRS unaffected by data sparsity, a new architecture of JRS is proposed based on the concepts of current RS algorithm in this project. The proposed method aims to recommend quality journal that are of interest to each user of the system.

3.2 Scope

The proposed system should be able to recommend quality journals relevant to user's field of interest even under a very sparse dataset. The following is the scope defined that the proposed system must be able to:

i. allow user to inform the system which journals he/she have cited in his/her papers.
ii. generate two personalized list of journals recommendation for each user, one is for the journal cited by similar user while another is for newly published journals or journals unaware by any user but are highly similar to the user's interest.

4. LITERATURE REVIEW

4.1 Collaborative Filtering (CF)

CF is a recommendation approach utilized by users to discover item they might interested in. This approach makes prediction about active user's preference through the collection and analysis of a large amount of data about users taste and recommends what like-minded users prefer. It is considered a mature algorithm in recommendation systems and is the most successful, popular and widely implemented technique in recommender system (Baby & Murali, 2016). The main assumption of CF is that people with similar past interest appear to have identical interests in the future. On the other hand, the availability of user's interest plays a critical role in CF as it relies on historical data to make prediction on user's preference score. In the absence of rating data, CF recommender system is not able to predict the preference active user might have on items, thereby no recommendation is produced (Anitha, Devi, & Devi, 2013). In addition, little data about users' rating also does not provide useful information and, in some situation, lead to poor precision. This problem is known as cold-start problem. Moreover, time required for the process of similarity calculation to find K

nearest neighbour depend upon the amount of data in the dataset because of all the data are necessary to compared with each other. Therefore, CF recommender system usually consumes a vast amount of time to complete the similarity calculation. In order to overcome the above-mentioned issues suffered by CF-based recommender system, several approaches have been proposed including clustering and parallelization (Kadam & Kumar, 2016). Besides that, CF also suffer from a problem known as popularity bias. This problem occur as users tend to rate popular items only even though they consumed unpopular items as well (Singh & Boparai, 2015). CF are categorized into two different type called memory-based and model-based CF.

4.1.1 Memory-based CF

Memory-based CF are further classified into user-based and item-based CF. Memory-based CF bypass the limitation of model-based by provide up-to-date recommendation to each active user each time after user have given feedback to newly discover item. Additionally, the complication of potentially expensive model building stage is not a concern of using memory-based CF. However, since the similarity value is output from common item between users, thus, the recommendation is not reliable if the dataset is sparse (Stephen, Xie, & Rai, 2017). According to Chen, et. (2018), high memory requirement and computation complexity are the shortcoming of memory-based CF as similarity calculation is perform in frequent interval

4.1.1.1 User-based CF

In user-based CF, users who have similar preferences to the active user are identified and grouped. It is then the active user's preference is predicted based on the interests of his/her neighbour (Kim, Chang, & Choi, 2019). Rating vector is the means used to represent the user's interest on items, also known as user profile. It is used to find the similarity between users. Pearson correlation coefficient (PCC) and cosine similarity are the commonly used technique for similarity measure. After similarity measure, the next task is to find the nearest neighbour. K-nearest neighbours (KNN) and setting threshold are the two techniques that receive the most attention for neighbour finding. KNN is a technique where a fix value of k is determined, then user v from the first k highest similarity value are chosen as neighbour of active user regardless of suitability of the similarity value (Cui, 2017). On the other hand, a

threshold δ is specified for threshold method, in which if the distance between active user to user v exceed δ, user v is consider as one of the neighbours of active user (Ayyaz & Qamar, 2017). Sine the number of neighbours affect the accuracy of recommendation and computation time, KNN algorithm is considered to be more effective than setting threshold in term of number of neighbours is manipulatable and therefore requires less time for preference prediction. Next, a matrix comprising of items interested by active users and its neighbour is constructed and value indicating the interest on item i from neighbours are utilized to predict the possible preference score active user may give to item i by using the equation show in figure 1. Finally, a list of top-N items is sorted and present to the active user.

$$\hat{r}_{ui} = \bar{r}_u + \frac{\sum_{v \in N_u} sim_{uv}(r_{vi} - \bar{r}_v)}{\sum_{v \in N_u} |sim_{uv}|}$$

Figure 1 *– Equation for rating prediction*

Figure 1 *– N_u denote the similar neighbour set of user u, $\overline{r_u}$ and $\overline{r_v}$ represent average rating of user u and v* (Chen, et al., 2018).

4.1.1.2 Item-based CF

Unlike user-based CF, item-based CF considers the similarity between items. In other words, item-based CF focuses on which available items are more similar to the item enjoyed the most by the active user. Despite the idea behind item-based is different from user-based, both of them are involved the same tasks, i.e., calculation of distance between two entities and prediction of item preference value (Pinela, 2017). To calculate the similarity between two items, interest score from users on both the underlying item are utilized. Similarity measure used are almost identical to those apply in user-based except that the weights are between items rather than between users. This in turn leading to the average rating in item-based approach tend to stay constant because of the fact that items in general have more rating than the number of rating each user given to item (Shah, 2019). As a result, the computational cost can be reduced by construct the item-item similarity matrix offline as minor alteration to the matrix do not cause obvious changes to the similarity value between items. On the other hand, there is no offline computation for user-based CF. This is due to the fact that minor changes to the rating vector have great impact on the similarity value between users (Bagley, 2017). Furthermore, prediction of preference score for target item can be perform by inserting the rating of items the active user like the most and the distance between those items to the target item i into the equation show in figure 2 (Tomar, 2017). Marisa, et

al. (2019) demonstrated that by measuring the accuracy of both item-based and user-based CF, user-based CF achieve higher accuracy with implicit data whereas item-based CF outperformed when explicit data were used.

$$s(i;u) = \mu_i + \frac{\sum_{j \in I_u} (r_{uj} - \mu_j) w_{ij}}{\sum_{j \in I_u} |w_{ij}|}$$

Figure 2 *– equation for item preference value prediction*

4.1.2 Model-based CF

A model for the prediction of user preferences is developed in a model-based CF. There are two learning methods for developing a model, i.e. probability approach and rating prediction. Bayesian classifier and singular value decomposition (SVD) are examples of probability approach and rating prediction respectively. In term of dealing with data sparsity and scalability, model-based CF capable of producing more specific user-oriented top-N list than memory-based CF (Aditya & Munajat, 2016). Moreover, through the application of latent factor model (LFM), drawbacks of memory-based CF are solved to a certain degree, i.e. high memory requirement and computation complexity. In addition, since the number of users using the recommendation system will increase over time, model-based CF is able to maintain the time efficiency via the clustering technique. By segmenting users into groups consisting of users with similar interests beforehand the searching time could be reduced as the neighbour of the active user can be found from the cluster where the active user was located instead of comparing the active user to all users in the dataset (Phorasim & Yu, 2017).

4.1.2.1 Clustering

Clustering is an unsupervised learning method under machine learning, which has been applied extensively in the field of data mining. Basically, clustering is divided into two main types, including partitional and hierarchical. Partitional clustering algorithm segment data non-overlappingly, thus, each data item after clustering belong to exactly one cluster only. Conversely, data items in hierarchical clustering algorithm can belong to more than one cluster. Among the existing clustering algorithm, K-means algorithm is the most widely used

in model-based CF as a pre-processing stage to mitigate the later stages (Son, Dat, Trung, & Anh, 2017). K-means is a partitional clustering algorithm, which separate users into predefined K clusters based on the distance between users to the centroid of each cluster. Moreover, fuzzy c-mean, a hierarchical type of clustering technique. In which each user classify by fuzzy c-mean belong to predefined c cluster with different degree of membership (Cong, Jang, Won, & Sang, 2019). However, since clustering is implemented with the purpose of minimizing the number of users to be involved in the process of neighbour finding to reduce the search time. Therefore, hierarchical type of clustering is not a best choice in term of recommendation system for user classification.

4.1.2.2 Matrix Factorization

Latent factor model is based on matrix factorization, where the user-item matrix is decomposed into a low rank of user feature and item feature matrices. It is a powerful technique for discovering the factor underlying the interaction between users and items (Bokde, Girase, & Mukhopadhyay, 2015). In short, matrix factorization is designed to solve the problem found in high rank matrix via decomposition and exploration of latent factor. SVD is one of the most powerful matrix factorization models. It is one of the dimensionality reduction techniques that are recognized for its capacity to improve the scalability of recommender system. To leverage the advantages of both clustering and matrix factorization, Zarzour, et al. (2018) proposed the implementation of K-means clustering and SVD in a sequential process, where (i) all the users in the dataset are grouped into K cluster and then SVD is applied to reduce the dimension of matrix output from K clustering by converting the matrix into three matrices, including cluster centres, singular values and item matrices; and(ii), the similarity between users are calculated based on the matrices obtained as a result of decomposition and eventually the prediction task is accomplished. This way, the latent factor of item on users' behaviour can be discovered and merged into the value to provide a more accurate output.

4.2 Content-Based Filtering (CBF)

In contrary to CF, CBF is a recommendation method does not consider the feedback from other users. The main assumption of this approach is that people tend to prefer the thing which reflect their own interest. The concept of CBF and item-based are similar to each other

since both approaches concentrate on finding items unknown to active user but similar to the items enjoyed by active user. Nevertheless, CBF make recommendation based on what active user enjoy in the past instead of relying on peer opinion. Therefore, the common problems suffered by CF have nothing to do with CBF, i.e., item cold start and sparsity problem. As a result, the quality of items has no guarantee as there are no process on item evaluation (Mohameh, Khafagy, & Ibrahim, 2019). Rather, the attributes of items are considered during the prediction process. This provides the advantage of being able to recommend unpopular items but interested by the active user. However, because of the core of CBF is the content analysis, lack of items' attributes is the primary shortcoming in many cases. Thus, in order to process the data collected regarding items into attributes that can be used to build the items' profile, careful selection of feature extraction techniques and information indexing are necessary (Dalvi & Gumaste, 2015). Whereas, for dataset have attributes attached initially to all of its items, there are no requirement for any feature extraction technique. Yet, it is necessary to normalize the attributes for both cases in order to compute the similarity between active user and the target item. The first step of CBF is to create items' profile and users' profile. The item profile is constructed based on the attributes associated with it, i.e., keyword. It is then the user's profile is developed in the form of keywords vector (KV) based on the weights of the features of the interested item. The algorithm is then matching the active user's profile to the items' profile in order to find the similarity between items. Likewise, methods for distance measure between two entities is the same as in CF but focus more on individual past preference.

4.2.1 Term frequency-inverse document frequency (TF-IDF)

TF-IDF is a document level keyword extraction technique. Which is based on the bag of words scheme in which collection of words used in a document can be used to represent the document. Bag of words is a mean for feature generation for a given instance such as a whole document or even just a short sentence. Bag of words perform the process of tokenization, which segment the given instance token by token. Token is a term used to denote a word constitute of characters such as alphabet, which form a word presence feature set from each of the input instance. In other word, all words within the input instance and its frequency are input to create a feature set. Order or words was ignored since bag of words only extract one word at a time and does not concern about the meaning and correlation of words (Waykole & Thakara, 2018).

TF-IDF is developed based on two assumptions associated with TF and IDF respectively. The first assumption is that words with high possibility of representing the document should appear repeatedly within the same document. Conversely, those words important to the specific document should not or rarely appear in the other documents. The weight of word using TF-IDF is defined by using the equation show in figure 3. Based on the two assumptions, if word i is important to document j, word i should have large tf_{ij} and small df_i (Kim, Seo, Cho, & Kang, 2019).

$$\text{TF–IDF}_{ij} = tf_{ij} \times \log\left(\frac{N}{df_i + 1}\right)$$

Figure 3 – *Equation for TF-IDF*

Figure 3 *- tf_{ij} is number of times word i appear in document j, df_i is number of document where word i appear at least once.*

4.2.2 Rapid automatic keyword extraction (RAKE)

Instead of extract only keyword from given instance, RAKE is developed with the aim of extracting key-phrase which are more meaningful to represent a document. Initially, candidate key-phrase for input instance are identified using a list of stop words and a set of phrase delimiter as inputs. Stops words are set of words that are common to all document and have no contribution to the representation of document such as a, the, and, and or. Subsequently, an undirected word co-occurrences graph is created using all the text unit contained in the candidate key-phrase as nodes. Additionally, edges between nodes is draw for text unit appear together in candidate key-phrase, where the number of times the text unit appear together indicate the edge weight. Similarly, edges connected to node itself is draw and its weight is equivalent to the number of times the text unit appear in the candidate key-phrase. The score of each node can be compute using the two weights obtained through the equation as show in figure 4. Finally, the score of each candidate key-phrase can be obtain by adding up the scores of its text unit and the top N key-phrases are identified (Figueroa, Chen, & Chen, 2018).

$$S(V_i) = \frac{\sum_{V_j \in \text{Out}(V_i)} w_{ij}}{w_{ii}}$$

Figure 4 *– Equation for node's score*

Figure 4 *- $Out(V_i)$ is the set pf nodes that are connected to V_i, w_{ii} is the weight of the edge connects to V_i itself.*

4.3 Hybrid Approach

To solve the problems faced separately by CF and CBF while enhancing the performance of recommendation system, a combination of both approaches have been proposed called hybrid algorithm. Such proposal is with the aims of leveraging the strengths of CF to complement CBF and vice versa. In general, there are three strategies that can be used to develop a hybrid system based on CF and CBF: 1) combine and form a new top-N list from the individual implementation of CF and CBF, 2) integrate the desired capabilities of CF into CBF or vice versa, and 3) unifying CF and CBF into one model (Tian, Zheng, Wang, Zhang, & Wu, 2019). However, since there are more than two algorithms available for recommender system, therefore, it is possible to hybridize or take the advantages of approaches other than CF and CBF such as decision tree classifier and so on. According to James & Rajkumar (2017), several studies empirically evaluate the performance of hybrid approach, pure CF and CBF and show that hybrid approach outperform pure CF and CBF in term of higher accurate top-N list is generated. Nonetheless, for hybrid based on CF and CBF, there are still some common limitation retained such as user cold start, data sparsity and overspecialized (Gohari & Tarokh, 2017).

5. RESEARCH METHODOLOGY

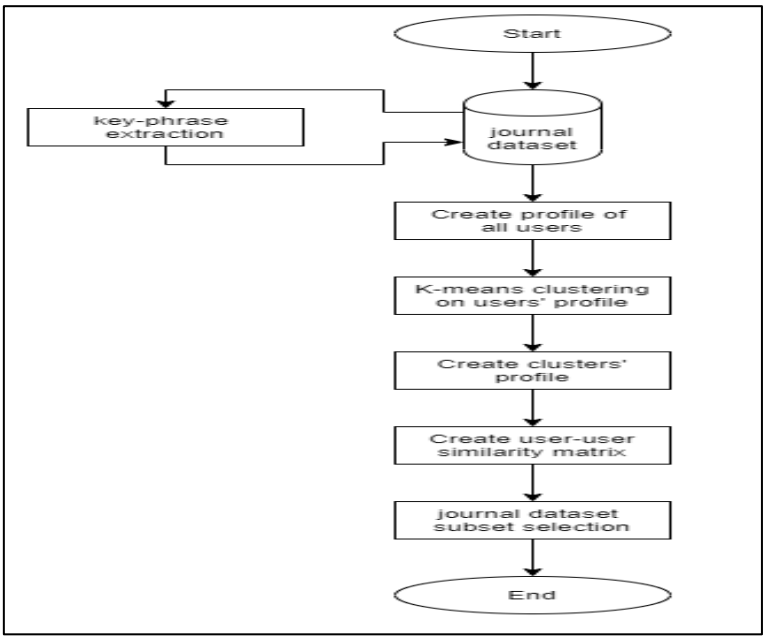

Figure 5 *– Flowchart of the proposed hybrid-based journal recommendation system (offline part – learning phase)*

As show in figure 5, before constructing the users' profile, also known as user key-phrase vector, from the journal dataset and user database, features for represent each paper contained in the journal dataset need to be identify by using key-phrase extraction technique. Part of speech (POS) tagging was applied as the first step of key-phrase extraction to identify and assign POS to each word in the given title and abstract. Each key-phrase are form when the next word in sequence are not fall under the group of defined POSs or the next word consist of only one character. However, in case the extracted key-phrase consist of only one word, that key-phrase is drop as single word is insignificance. Additionally, to further narrow down the numbers of key-phrases extracted, spacy model was implemented to identify and extract the top-10 keywords contained in the given abstract. Subsequently, out of the extracted key-phrases from previous step, only key-phrase with at least one of the top-10 keywords are consider as valid for represent the given journal.

Next, profiles of all user are created as input for user clustering. Sources of users' profile include key-phrase from users' searching history and key-phrase from journals user have cited. Jaccard similarity was selected to measure the distance between user since the measurement does not involve any representative values, instead, number of key-phrase co-exist in the user's profile are consider. K-means clustering is opted to group user into exactly one of the predefined k clusters, where k will be determined in the testing phase of system development. K-means algorithm start by randomly select k distinct user as the centroid of each k cluster. The system will then randomly choose user from the database and use Jaccard to measure the distance between the selected user to all centroid of k cluster. The selected user is assigned to the cluster where the distance to the centroid is the shortest among k centroid. Subsequently, after all user have been assigned to a cluster, mean of each cluster is calculated to define the new centroid of the cluster. Processes of measuring the distance between user to the centroid of each cluster, reassigning of user to another cluster and finding new centroid for each cluster will iterate for 50 times to ensure user within the same cluster are most similar to each other.

After the K-means clustering, each cluster are assigned with two profiles, key-phrase vector and users id vector. The key-phrases vector is builds by taking key-phrases from the users' profiles while user id vector is simply a vector made up from the id of users within the cluster. Afterward, the user's id vector is applied to extract journals cited by user within the cluster. It is then a normalized paper-key-phrase dictionary are developed via the application

of the equation $v = 1/sqrt(n)$ into all the journals extracted, where v is the value of each key-phrase of a paper and n is the number of key-phrase per papers. Furthermore, in order to obtain the value for representing the weight of each key-phrase for each user, the system will first normalize the user searching profile through the similar equation mentioned. Afterward, the system will assign value to each key-phrase from journal cited by taking value from the normalized paper-key-phrase dictionary. The value of each key-phrase are incremental and the higher the value indicate the stronger the interests. Following the value assignment step, a user-co-cited matrix is constructed for the number of co-cited between each pair of users within the cluster. Purpose of counting the number of co-cited is to enhance the similarity between each pair of users by multiply it into the result from cosine similarity. Additionally, the system will proceed to extract subset of journals from the entire dataset for each cluster. Where only journals with at least one of the key-phrase contained in the cluster's key-phrase vector will be selected since the purpose of this step is to reduce the time require for user-paper similarity measure during the online stage.

Lastly, the final step of model development is to save some of the previously created data into CSV file as well as using python pickle module to serialize and de-serialize data necessary for online stage into text file. Such data include list that contained the users' id and cluster label, cluster key-phrase vector, user-key-phrase dictionary, user-user similarity matrix, journals cited by users within the cluster and dictionary that contain the un-cited similar papers.

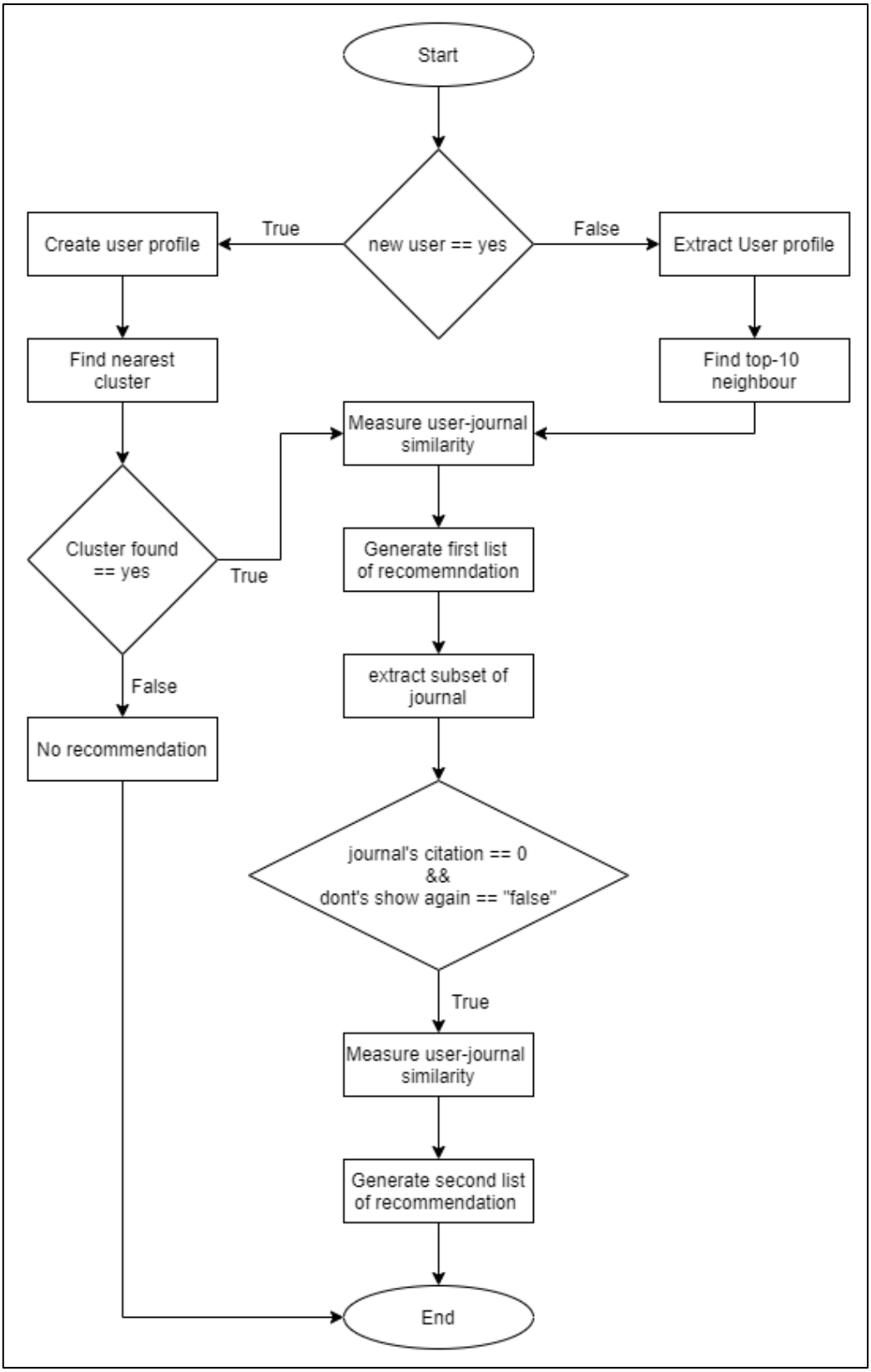

Figure 6 *– Flowchart of the proposed hybrid-based journal recommendation system (online part)*

For online stage, once the user has login into the system using their personal account, two list of personalized recommendation will be present to them except for new user where the

system does not aware about his/her interest. First of all, the system will check whether the active user have been assigned to any of the k cluster since the last update of the model. In case the active user are not belong to any of the k cluster, the system will apply Jaccard similarity to compute the similarity between active user's profile and cluster's profile. In case there are no cluster with similarity to the active user, there is no single recommendation will be generated since the system does not have information regarding the active user preference. Otherwise, similarity between active user and all journal cited by users within the cluster are calculated. On the contrary, for user who have been clustered, the system will proceed to find the top-10 neighbour of active user using the user-user similarity matrix developed in offline stage. Subsequently, similarity between active user's profile and journal that have been cited by neighbour are calculated using cosine similarity. From the output generated, only papers with top 5 similarity value will be recommended to the active user.

Next, for the second list of recommendation, it mainly focus on newly published journal or journal that have no citation record but are highly related to the interest of active user. To avoid recommend journal which are not usable to the user, the proposed system allow user to tell the system which journal the user does not want the system to show again. Where the input for the second list of recommendation are journal contained in the uncited similar papers dictionary from the cluster where active user located. The system will check whether the journal have been cited by the active user to avoid recommend journal that have been cited by the active user after the model was developed. It is then again using the cosine similarity to calculate the similarity between journal and active user's profile. Similarly, only the top-5 papers will be presented to the active user.

6. EXPECTED OUTPUT

Since the implementation of the methodology proposed are under progress, thus, this paper will present the expected output based on the flowcharts provided. For instance, let's assume the profile of the active user contained the following key-phrases: similarity measure, recommendation system, collaborative filtering, content-based filtering and hybrid approach, the proposed system should recommend journals contained at least one of the aforementioned key-phrase with high key value to ensure similarity between user and papers as well as papers with high citation record within cluster to ensure the papers recommended are helpful for the user's current study. Key values are value used to indicate the importance of particular key-phrase for particular papers or user. The first list of recommendation is comprised of journal cited by similar user with high similarity value to the active user. While journal that have no citation record from user but with high similarity value to the active user are input for the second list of recommendation. The proposed system is expected to achieve an 80% of accuracy for each of the personalized recommendation generated.

7. CONCLUSION

In conclusion, in order to produce recommendation not only consist of journal relevant to user's interest but also takes into account the quality of the journal, a hybrid-based personalized JRS are proposed. The proposed approach can be considered as a new hybrid approach since it is different from the current hybrid approaches. The proposed system requires a testing phase to develop a model in advance to discover knowledge about user's interest and is employed to make recommendation on real time. Since the objective of this project was to increase the accuracy of JRS in term of sparse dataset, K-means clustering are applied to divide the large user-item citation matrix into several cluster user-item citation matrix. From each of the cluster user-item citation matrix, it is further divided into two matrices for generate two list of high accuracy recommendation. Citation is chosen as substitute for commonly used rating as it is difficult to gather rating from user in term of JRS. In addition, utilization of citation is free from user bias since it does not allow user to express their own point of view using the rating scale.

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MULTIPLE FACE RECOGNITION BASED ATTENDANCE SYSTEM USING CONVOLUTIONAL NEURAL NETWORKS

Hew Xin Yee[*1], Harlina Harun[1]

[1] Faculty of Engineering, Science and Technology, Nilai University
No 1, Persiaran University, Putra Nilai, 71800 Nilai, Negeri Sembilan
whitneyhew98@gmail.com, harlina@nilai.edu.my

ABSTRACT

Attendance taking is a vital daily routine for lecturers in educational institutions. In Malaysia, many institutions are still adopting the traditional attendance taking approach, which is laborious, distracting and time-intensive particularly for large class sizes. To overcome these shortcomings, this paper proposes the adoption of face recognition technology in attendance system so that lecturers can take the whole class attendance easily through facial verification with just one click. The current issues of facial biometrics are identified and researched. Among the issues, this paper focuses on solving the pose variation issue by introducing a multiple face recognition based attendance system using conventional neural networks (CNNs) for higher face recognition accuracy. In this system, a dlib CNN face detector model is applied for face detection and a CNN face recognition model trained through transfer learning is used for facial recognition. With the proposed CNNs, the system has successfully achieved 92.78% detection accuracy, 90% frontal face recognition accuracy and 66.67% profile face recognition accuracy.

Keywords: Attendance System, Convolutional Neural Network, Detection, Profile Face, Recognition

1. INTRODUCTION

Student absenteeism has always been a long-term concern for educational institutions as it not only adversely affects education outcomes but also negatively influences student attitude and behaviour, potentially leading them to serious social ills in the future. Besides, in most institutions, good attendance has been set as one of the basic requirements for students to avoid being barred from final examinations. Hence, attendance taking has become a vital daily routine for lecturers. In Malaysia, many academic institutions are still adopting the traditional attendance taking approach which involves passing a name list around for the students to sign. However, this simple conventional approach is laborious, distracting and time-intensive particularly for large class sizes. Furthermore, it leads to a higher possibility of attendance fraud as students can sign on behalf of their absent friends without being easily noticed by the lecturer. Additionally, improper record keeping may also result in the loss of attendance records. In response to these shortcomings, this paper proposes a multiple face recognition based attendance system using CNNs to replace the manual approach. This system is designed to automatically detect and recognize student faces on a captured class image using CNNs and take attendance accordingly without disrupting the lecture. It reduces the possibility of attendance fraud as it identifies students based on facial contours, which are difficult to be faked or replicated. In addition, it improves the efficiency and effectiveness of attendance taking as it able to take the whole class attendance by just processing the captured class image.

As this system takes attendance according to the recognition result, its accuracy in attendance taking depends heavily on the accuracy of the face biometric technology. Recognizing faces in a crowded image is complicated due to uncontrolled factors like busy backgrounds, the changes of face distance and head position in an image sequence caused by human motion, as well as the occlusions on faces. For sure, high accuracy can be easily achieved when the faces are captured under constrained conditions, in which they are free from any occlusion and are completely facing towards camera. However, in real world, it is impossible to ensure that the position of each student head is staying statically and facing towards the camera throughout the lecture. Therefore, this paper focuses on dealing with the head pose variation issue in face biometrics. As studied by Sengupta, et al. (2016), many existing face recognition technologies suffer from a drop of a minimum 10% accuracy and increase more than doubles error rate when comes to frontal-profile face recognition. This is

because the increase of a face's yaw orientation angle can lead to a degradation of facial details and affect the recognition accuracy. Thus, large pose variation is a challenging issue to be overcome in face recognition based attendance system as it could mislead the system to result in no recognition or inaccurate attendance taking. As a solution, a dlib CNN face detector model and a CNN face recognition model trained through transfer learning are introduced in this paper. With these models, this paper aims to develop a multiple face recognition based attendance system that can achieve high recognition accuracy even when dealing with multi-view faces with yaw angle between -90° to 90°.

The rest of the paper is organized as follows: Section 2 discusses the related work, Section 3 presents the methodology, Section 4 shows the results and discussion, and lastly, Section 5 holds the conclusion and recommendations.

2. RELATED WORK

In face recognition based attendance system, there are basically two critical stages involved, which are face detection and face recognition. Face detection involves locating the presence and exact location of each face in an image, while face recognition is about extracting important facial features from detected face, matching and comparing the features with similarly processed face images stored in the database for identity classification. In the past decade, there are many techniques proposed for face detection and recognition. As this paper concerns on coping the pose variation issue, the following will review and discuss some popular multiple face detection and recognition techniques as well as their abilities in handling profile face recognition.

2.1 Face Detection Techniques

2.1.1 Viola-Jones algorithm

Viola-Jones algorithm is a widely used learning-based mechanism for face detection (Paul et al., 2018). It is the first visual object detection framework that provides rapid image processing and high detection rate proposed by Viola & Jones (2001). In Viola-Jones framework, there are four stages involved, including Haar-like features, integral image, adaptive boosting (Adaboost) and Cascading classifier. First, Haar-like features are

rectangular features that made up of black and white regions which moved over an input image to identify the presence of similar features for face detection. Integral image was introduced to store the input image in an intermediate form which allows for rapid feature computation. AdaBoost learning algorithm is used to eliminate irrelevant facial features and form a strong classifier through a weighted linear combination of weak classifiers while cascading classifier is applied to determine whether the given sub-window contains a face. With integral image, AdaBoost and cascading classifier, Viola-Jones algorithm not only possesses high detection speed which enables it to support real-time applications, but also possesses high detection accuracy due to its robust classifier that minimizes the false positive rates (Viola & Jones, 2004). However, due to the simple nature of Haar-like features, its high accuracy performance is restricted to controlled conditions, in which the captured faces must be fully facing toward the camera in frontal position (Mittal & Shivnani, 2016). To demonstrate, based on the research done by Islam, Naeem, & Hasan (2017), Viola-Jones method can only tolerates face orientation angle up to 45° and the accuracy will drop significantly when the angle goes above 45°. This shows that Viola-Jones algorithm is relatively weak in profile face detection.

2.1.2 Convolutional Neural Network (CNN)

CNN is a multi-layers feed-forward artificial neural network that commonly used in face detection and recognition (Coskun, Ucar, Yildirim, & Demir, 2017). It is designed specifically to capture complicated visual variations for face detection by learning features from image or 2D (2-Dimensional) spatial data through a large dataset training (Li, Lin, Shen, Brandt, & Hua, 2015; Mukherjee, et al., 2017). There are basically three main types of layers stacked in a typical CNN architecture, which are convolutional layers, pooling layers and fully connected layer. Convolution and pooling layers play a critical role in face feature extraction, while fully connected layer is used to map the extracted features into the final output, classification. During classification, CNN classifier will output a class score, which is a probability ranging from 0 to 1 for each face and non-face classification (Triantafyllidou, Nousi, & Tefas, 2018). Then, the window of the input image with a higher score in face classification will be classified as a face. Compared to Viola-Jones algorithm, CNN model is more diverse in handling unconstrained input as it learns facial features by itself through sample set training, so it is more robust in dealing with head pose variation. However, as

CNN is heavily data driven, its tolerant face orientation angle relies heavily on the pose variety in its training dataset.

2.2 Face Recognition Techniques

2.2.1 Convolutional Neural Network (CNN)

As mentioned in subsection 2.1.2, CNN can also be used in face recognition. Similar to detection, CNN based face recognition model is also made up of three main layers, which are convolutional layer, pooling layer and fully connected layer. The only difference is on the output of the CNN classifier, in which for detection, the output will be either face or non-face, while for recognition, the output will be either the identity of the recognized known face, or unknown face. When a face is recognized, the identity label with the highest probability among the known labels will be set as the recognition result.

2.2.2 Principal Component Analysis (PCA)

PCA is a statistical technique commonly applied in the appearance-based approaches for dimensionality reduction and feature selection (Devi & Hemachandran, 2014). The use of PCA in human recognition system was first proposed by Turk and Pentland (1991) to perform face recognition in two-dimensional geometry. For facial recognition, PCA uses an orthogonal transformation to convert a collection of training face images into a set of uncorrelated variables known as eigenfaces to represent the characteristic features of a human face (Paul & Sumam, 2012). The whole facial recognition using PCA is divided into two processes, which are initialization and recognition. During initialization, eigenfaces with the highest eigenvalues that represents important human face features are obtained from the training datasets. Training images are projected into the eigenface space and calculated for the feature weight. During recognition, the input face image is projected into the face space. The average distance between the input face feature vector and all the training feature vectors are calculated. Lastly, Euclidean distance classifier classifies the image by searching the minimum distance between the input image and the training images. The face image with the minimum distance is classified as the recognized image. According to Paul & Sumam (2012), PCA outperforms other face recognition approaches in terms of its simplicity, high speed and insensitivity to small variations on the face. Nevertheless, due to the high correlation between

the training dataset and the recognition data, the accuracy of PCA can be affected by various unconstrained factors, in which PCA technique will result in poor performance if the recognizing face is not taken in a full frontal position with controlled environment (Rekha & Ramaprasad, 2017; Jaiswal, Bhadauria, & Jadon, 2011). Hence, compared to CNN, it is weaker in dealing with profile face recognition.

3. METHODOLOGY

Based on the literature review in previous section, CNN is chosen to be applied in developing the multiple face recognition based attendance system due to its ability in handling profile faces. Thus, in this section, the methodologies of face detection, training the proposed CNN face recognition model, as well as the overall process of attendance taking using the developed system will be discussed in detailed.

3.1 Face Detection Methodology (CNN Face Detector)

As detection is the first and key step in facial biometric, to ensure it can effectively handle profile faces, the use of a CNN face detector called mmod_human_face_detector is proposed to work with the dlib package in Python. According to Gupta (2018), this CNN face detector is trained with face images from a huge variety of public datasets like AFLW, WIDER, ImageNet, etc., so it copes well with different orientation faces. Hence, face detection is conducted in the developed system by inputting the CNN detector's weights to dlib.

3.2 Face Recognition Methodology (CNN Face Recognition Model)

To ensure the developed system can obtain high accuracy result, the proposed CNN face recognition model must be first well-trained with dataset that possesses good face representations and adequate variation samples for feature extraction. As training a CNN model from scratch requires massive dataset, time and computational power, transfer learning is implemented to aid the model training process of the recognition classifier. The proposed transfer learning technique for CNN training is conducted by using the patterns learned by a pretrained face model for feature extraction and then utilizing the extraction results to train the classifier for face verification. Basically, transfer learning splits the CNN model into two parts, which are feature extraction modules and classification module so that the feature

extraction process can be automated to produce a good face representative set of features and use it for face classification. By doing so, the proposed CNN model not only can result in a higher recognition rate but also can be built in a more timesaving manner as well as with a lower computational cost. Also, with the optimized network weights offered by the pretrained model, the proposed CNN can be converged faster until it is no longer have significant error decline or performance increase. In this paper, the pretrained model used for the network training is VGG_Face_net, which has been trained with more than two million face images that contains huge diversity in age, pose, lighting and race of 2622 subjects from WildFace dataset (Dar, 2018).

3.2.1 Training Methodology

The flowchart depicted in Fig. 1. shows the nine stages involved in training the proposed CNN model for face recognition.

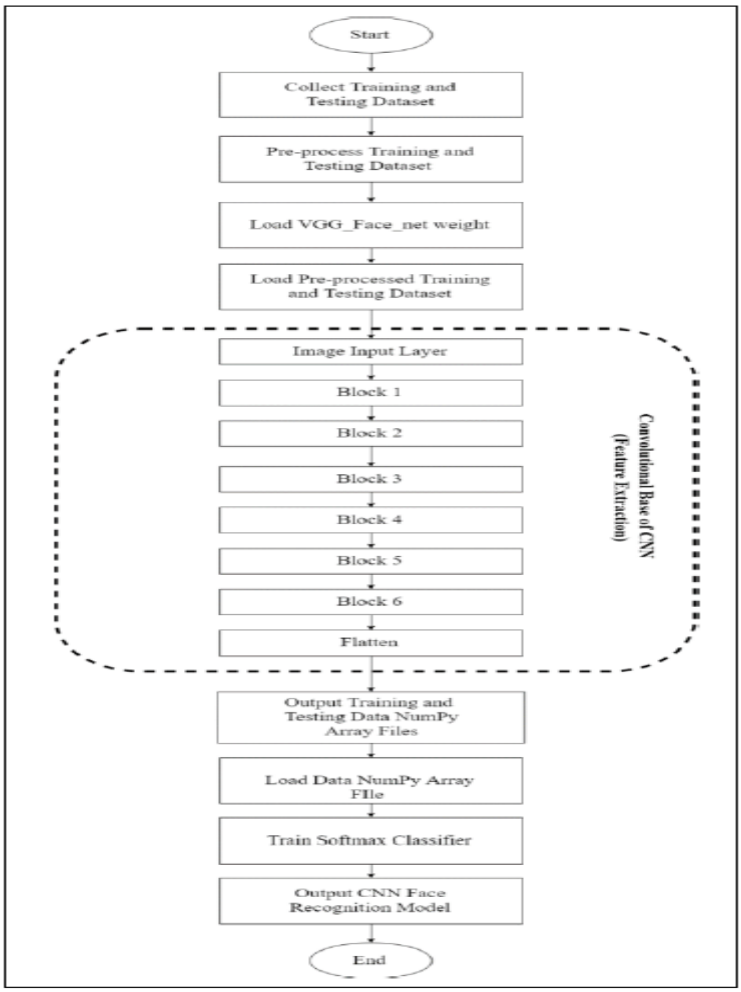

Fig. 1. Flowchart of the proposed training methodology for CNN face recognition model

Stage 1: Collect Training and Testing Dataset

The first stage before starting the CNN model training is to collect students' face images to build the required training and testing datasets. This is done by capturing images of each student's face in a successive motion of rotating from -90° to 90° in front of a white background using mobile camera in burst mode. Then, among the bursts of each student, *m* number of face images are selected for the training set to serve as a set of data points for model learning, while another *n* number of images are added into the testing set for later unbiased assessment of the model skill on the training set. Lastly, the training set of each student is saved in a sub-folder named upon the student's ID under the "train_img" folder and same goes to testing set which is stored under the "test_img" folder.

Stage 2: Pre-process Training and Testing Dataset

Pre-processing is performed by loading every face image under each student sub-folder, resizing it, converting it to grayscale, extract its face region with CNN face detector, and lastly store the output into the respective folder. The extracted face images are saved into the particular sub-folder belonging to their identities under the corresponding "train_img_extract" and "test_img_extract" folders. The overall pre-processing process is illustrated in the following flowchart (Fig. 2.):

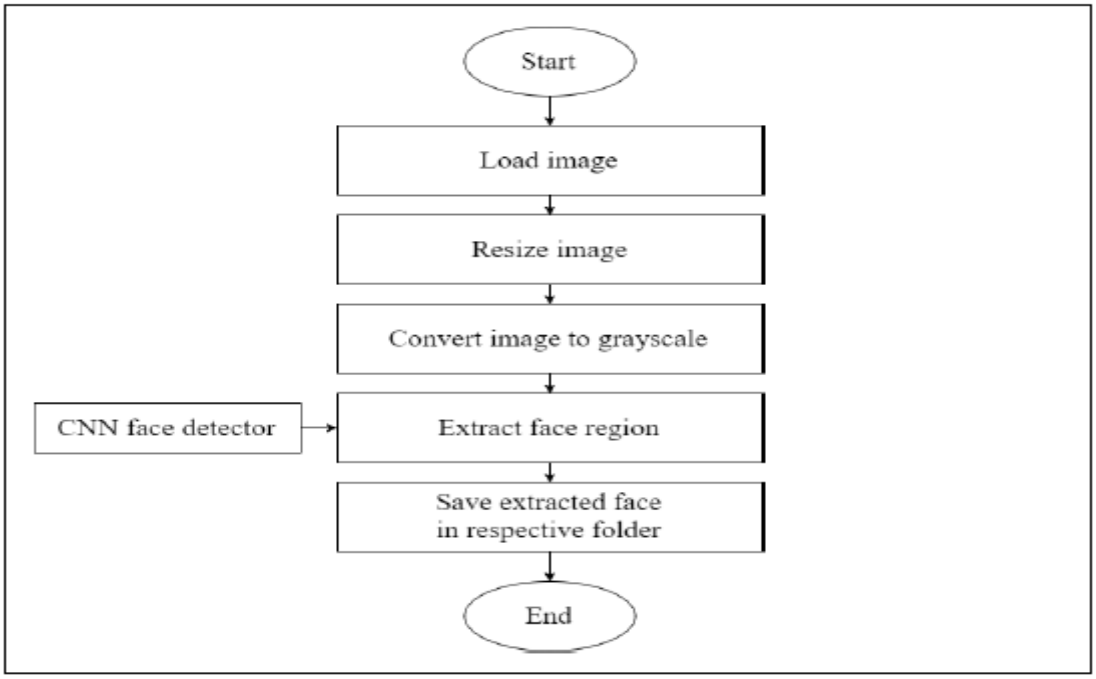

Fig. 2. Flowchart of image pre-processing process

Stage 3: Load VGG_Face_net weight

This stage involves loading the weight of the pretrained model VGG_Face_net in .h5 format into the proposed CNN model structure for transfer learning.

Stage 4: Load Pre-processed Training and Testing Dataset

In this stage, pre-processed dataset stored under "train_img_extract" and "test_img_extract" folders are loaded and rescaled to a size of 224 x 224 (height x weight) to feed into the feature extraction module of the proposed CNN to generate face embeddings for network training.

Stage 5: Feature Extraction

In this stage, feature extraction is performed by passing each 224 x 224 image with RGB (3) color channel through the convolutional base (feature extraction module) of the proposed CNN to output the corresponding face embedding. Fig. 3 shows the architecture of the convolutional base.

Layers		No. of Pad	No. of Filter	Kernel Size	No. of Stride	Feature Map Size
Image Input Layer		-	-	-	-	224 x 224 x 3
Block 1	ZeroPadding2D	1 x 1	-	-	-	226 x 226 x 3
	Convolution2D+Relu	-	64	3 x 3	1 x 1	224 x 224 x 64
	ZeroPadding2D_1	1 x 1	-	-	-	226 x 226 x 64
	Convolution2D_1+Relu	-	64	3 x 3	1 x 1	224 x 224 x 64
	MaxPooling2D	-	-	2 x 2	2 x 2	112 x 112 x 64
Block1 2	ZeroPadding2D_2	1 x 1	-	-	-	114 x 114 x 64
	Convolution2D_2+Relu	-	128	3 x 3	1 x 1	112 x 112 x 128
	ZeroPadding2D_3	1 x 1	-	-	-	114 x 114 x 128
	Convolution2D_3+Relu	-	128	3 x 3	1 x 1	112 x 112 x 128
	MaxPooling2D_1	-	-	2 x 2	2 x 2	56 x 56 x 128
Block1 3	ZeroPadding2D_4	1 x 1	-	-	-	58 x 58 x 128
	Convolution2D_4+Relu	-	256	3 x 3	1 x 1	56 x 56 x 256
	ZeroPadding2D_5	1 x 1	-	-	-	58 x 58 x 256
	Convolution2D_5+Relu	-	256	3 x 3	1 x 1	56 x 56 x 256
	ZeroPadding2D_6	1 x 1	-	-	-	58 x 58 x 256
	Convolution2D_6+Relu	-	256	3 x 3	1 x 1	56 x 56 x 256
	MaxPooling2D_2	-	-	2 x 2	2 x 2	28 x 28 x 256
Block1 4	ZeroPadding2D_7	1 x 1	-	-	-	30 x 30 x 256
	Convolution2D_7+Relu	-	512	3 x 3	1 x 1	28 x 28 x 512
	ZeroPadding2D_8	1 x 1	-	-	-	28 x 28 x 512
	Convolution2D_8+Relu	-	512	3 x 3	1 x 1	28 x 28 x 512
	ZeroPadding2D_9	1 x 1	-	-	-	30 x 30 x 512
	Convolution2D_9+Relu	-	512	3 x 3	1 x 1	28 x 28 x 512
	MaxPooling2D_3	-	-	2 x 2	2 x 2	14 x 14 x 512
Block1 5	ZeroPadding2D_10	1 x 1	-	-	-	16 x 16 x 512
	Convolution2D_10+Relu	-	512	3 x 3	1 x 1	14 x 14 x 512
	ZeroPadding2D_11	1 x 1	-	-	-	16 x 16 x 512
	Convolution2D_11+Relu	-	512	3 x 3	1 x 1	14 x 14 x 512
	ZeroPadding2D_12	1 x 1	-	-	-	16 x 16 x 512
	Convolution2D_12+Relu	-	512	3 x 3	1 x 1	14 x 14 x 512
	MaxPooling2D_4	-	-	2 x 2	2 x 2	7 x 7 x 512
Block1 6	Convolution2D_13+Relu	-	4096	7 x 7	1 x 1	1 x 1 x 4096
	Dropout	-	-	-	-	1 x 1 x 4096
	Convolution2D_14+Relu	-	4096	1 x 1	1 x 1	1 x 1 x 4096
	Dropout_1	-	-	-	-	1 x 1 x 4096
	Convolution2D_15	-	2622	1 x 1	1 x 1	1 x 1 x 2622
Flatten Layer		-	-	-	-	2622 (channels)

Fig. 3. Convolutional base architecture of the proposed CNN face recognition model

Stage 6: Output Training and Testing Data NumPy Array Files

The final output from the previous stage will be a set of face embeddings with labels that represents the vector features of student faces stored in a list of the corresponding train and test data. In this stage, the train and test data lists are converted into NumPy arrays and saved in npy format. Consequently, this can ensure the efficiency of the developed system as face recognition can be performed later on in the system by just loading the .npy file without the need to repeat the overall training process.

Stage 7: Load Data NumPy Array Files

This stage involves loading both train and test data .npy files saved in previous stage for training the face recognition softmax classifier. The files possess the facial features extracted from convolutional base, so they will be fed into the classifier for learning the classification pattern.

Stage 8: Train Softmax Classifier

In this stage, the data .npy files are passed through a three-layer softmax regressor for multi-class classification training. The adopted softmax regressor contains of three dense layers and each of their hyperparameters like number of hidden units, activation function and initializer are adjusted and tuned through trial-and-error testing. Aside from that, for regularization purpose, batch normalization layer and dropout layer are applied after each of the first two layers. Batch normalization will normalize the layer's activations and standardize the inputs to each layer to reduce covariate shift for training acceleration, whereas dropout will randomly eliminate some features every iteration so that the hidden units are not overly depend on any specific feature. This aims to ensure the model performs better as a face identity predictor and prevents it from overfitting. Next, for optimization, sparse categorical cross-entropy loss function which uses to minimize prediction error is adopted. Other than that, the metric chosen for model performance measurement is Accuracy. Thus, the model accuracy will be measured during the testing stage. The output of this stage will be the probability distributions of a list of potential target classes in vector form.

Stage 9: Output Face Recognition Model

Once the classifier training is completed, the output CNN face recognition model is saved in .h5 format. The model will then be used for student identity prediction in the system to support the face-recognition based attendance taking process.

3.3 Attendance Taking Methodology

According to the flowchart shown in Fig. 4., the following will explain the stages involved in the proposed multiple face recognition based attendance taking process.

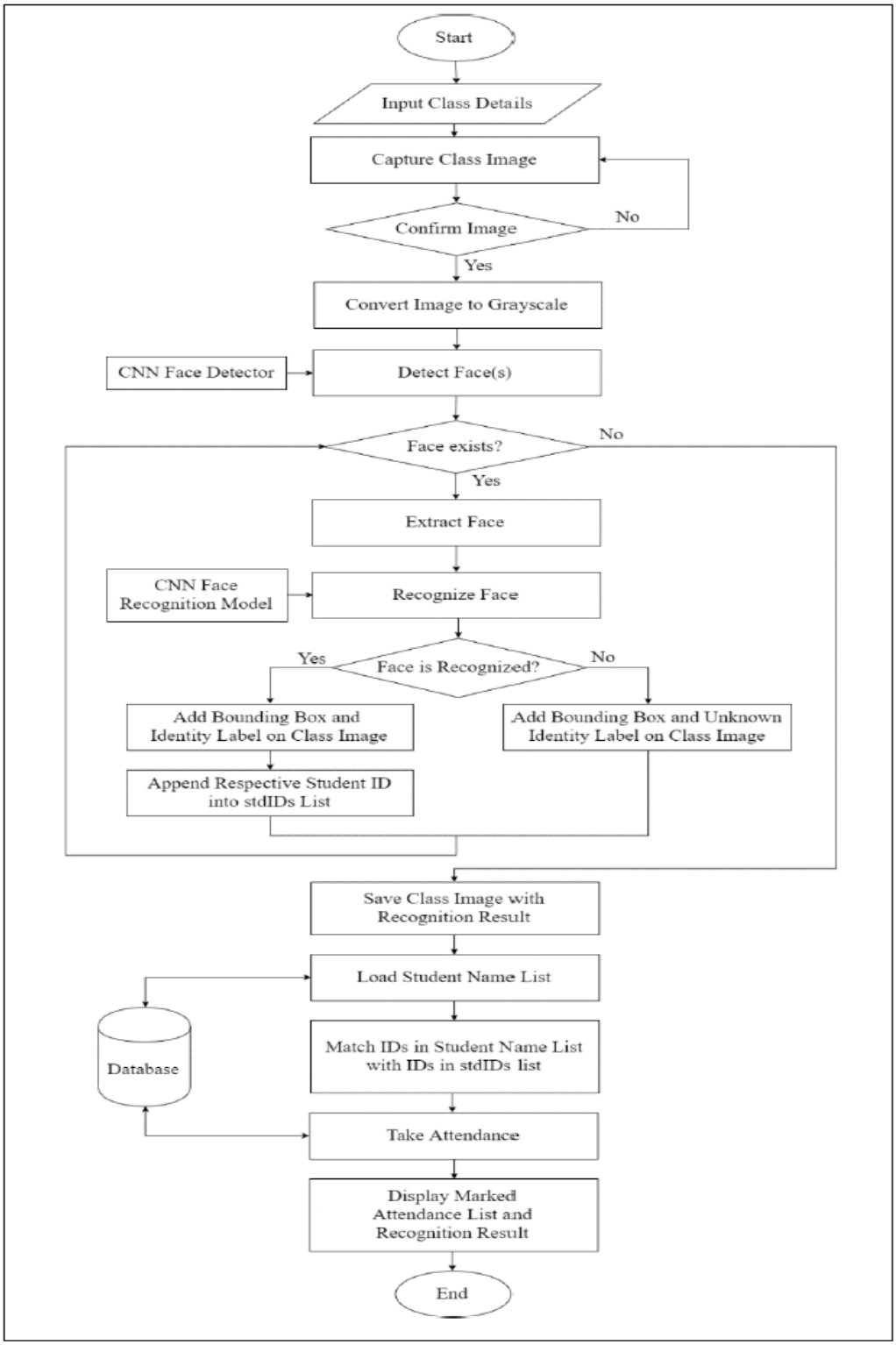

Fig. 4. Flowchart of the methodology of CNN face recognition based attendance taking process

Stage 1: Input Class Details

The first step to take attendance is to input class details by selecting subject and class session from the available options as shown in the right area of Fig. 5 for the system to load the corresponding student name list for attendance marking.

Fig. 5. Take Attendance User Interface (UI)

Stage 2: Capture Class Image

This stage involves capturing the classroom image with capturing device such as camera for attendance taking by clicking "Take Attendance" button as shown in Fig. 5.

Stage 3: Convert Image to Grayscale

Once user confirmed to proceed with the captured class image, the image is converted from RGB to grayscale in order to speed up the face detection process by eliminating the unnecessary color channels.

Stage 4: Detect Face(s)

After color-to-grayscale image conversion, CNN face detector is used to identify and localize faces available in the image.

Stage 5: Extract Face

For each detected face region, if its detection confidence score is more than 0.5, the location points of its leftmost, topmost, rightmost and bottommost corners are obtained for extraction. The extracted faces are then saved in the "temp" folder.

Stage 6: Recognize Face

In this stage, each extracted face is loaded, rescaled to a size of 224 x 224, converted to array with expanded shape, pre-processed and encoded to generate its face embedding. After that, the embedding is applied to the CNN face recognition model for identity prediction. The identity that possesses the highest similarity probability after matching the face among the known identities will be returned by the model as the recognition result. If the face is recognized by the system, its bounding box and recognized identity will be labelled on the class image, and its respective student ID will be appended to stdIDs list for attendance taking afterward. Conversely, if the face is failed to be recognized, bounding box with "Unknown" label will be added around the face on the class image. As a result, the output of this stage will be a list of student IDs of all recognized faces and a class image labelled with the recognition result.

Stage 7: Save Class Image with Recognition Result

In this stage, the class image with recognition result (Fig. 6) is saved in the "temp" folder to allow user to view for checking purpose once the attendance is taken.

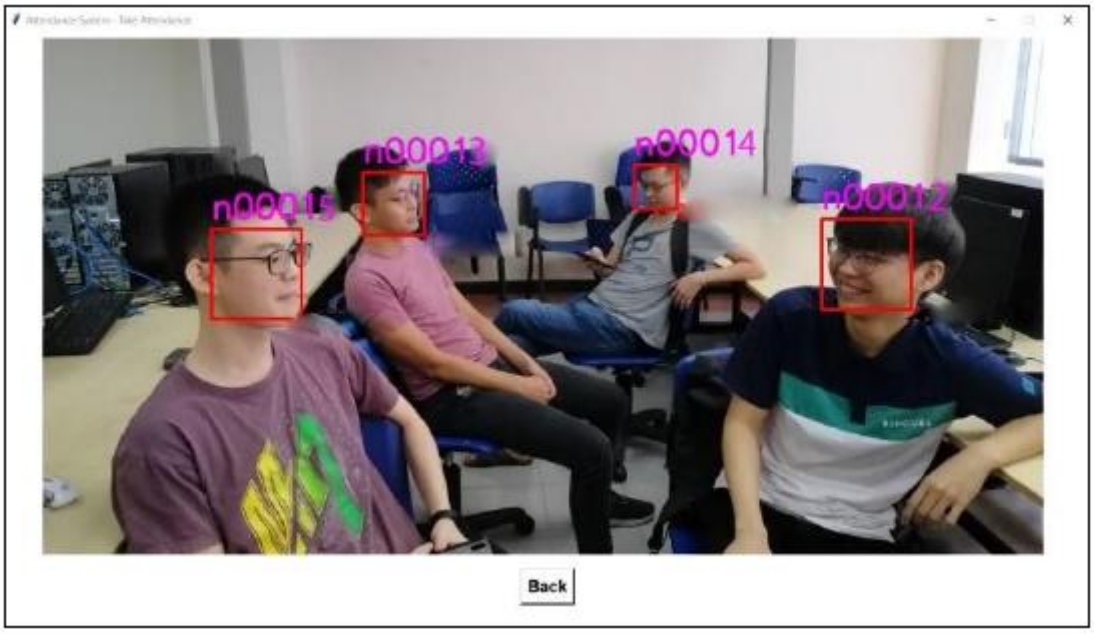

Fig. 6. Example of recognition result

Stage 8: Load Student Name List

This stage involves loading student name list from the system database based on the class details inputted into the system at the beginning of the attendance taking process. The name list provides student information including student ID and name for attendance marking.

Stage 9: Match IDs in Student Name List with IDs in stdIDs list

After getting the corresponding student name list, each student ID in the list is compared with each ID in the stdIDs list in order to determine each student's attendance status.

Stage 10: Take Attendance

Each student's attendance is taken based on the matching result obtained from the previous stage. In the proposed system, attendance status is divided into two types, which are "Present" and "Absent". If the ID in student name list found a match with the ID in stdIDs list, the particular student of the ID will be marked as "Present". Conversely, for those with no matching result with any ID in stdIDs list will be marked as "Absent". This stage will be ended by updating the marked attendance list to the system database.

Stage 11: Display Marked Attendance List and Recognition Result

In this stage, an editable marked attendance list will be generated and displayed in a table form alongside with the class attendance details for user to view and check. Also, the class image with recognition result can be view optionally by clicking the "View Recognition Result" button as shown in Fig. 7.

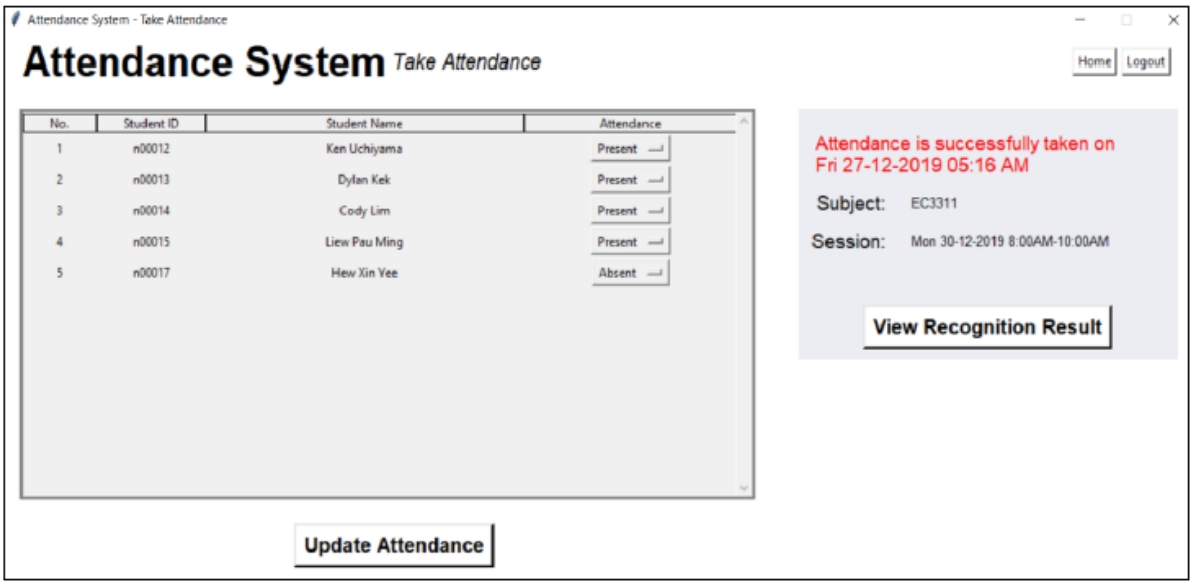

Fig. 7. Generate Attendance UI

4. RESULTS AND DISCUSSION

This section discusses the results of the performance testing on both dlib CNN face detector model and CNN face recognition model. As the main concern of this paper is on face biometric, the metric used to evaluate the performance of the two proposed CNN models is Accuracy. Thus, during the testing, the accuracy of the CNN models in detecting and recognizing both frontal and profile faces are measured in order to identify their abilities in dealing with the pose variation issue. In this paper, Accuracy is defined as the ability of the classifier to predict the class label correctly. In face detection, the classifier works on two type of labels, which are face and non-face. While in recognition, the class labels will be student IDs.

4.1 Face Detection

First, for face detection, the proposed CNN face detector has been tested with two groups of images. The first group is used to test the detector's overall accuracy in localizing multiple frontal and profile faces. It contains 180 images collected randomly from Google based on the category of number of faces ranging from 1 to more than 8. There are 20 test images for each category. To avoid bias in testing, the 20 images are further divided into two groups, in which 10 of them with frontal faces and another 10 with profile faces. Fig. 8 shows some sample images from the group. Next, to determine the ability of the CNN detector to detect face with yaw angle between 0° to 90°, 200 images from Our dataset by Robotics (n.d.) are adopted for testing. Based on the image labels in the dataset, face images of 20 subjects with orientation angle ranging from 0° to 90° (in an interval of 10°) are selected for the second group of test data as show in Fig. 9.

Fig. 8. Sample images from the first group of test data for detection

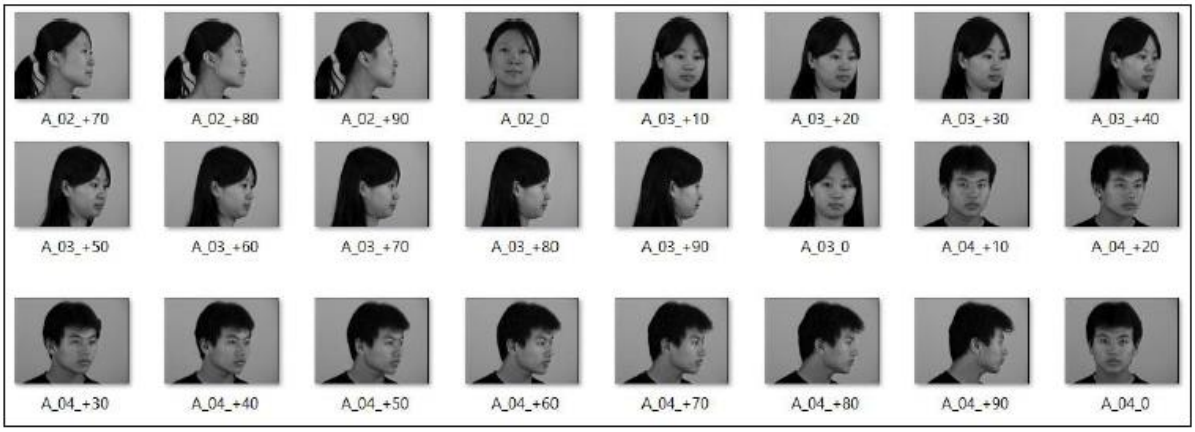

Fig. 9. Sample images from the second group of test data for detection

The accuracy of the dlib CNN face detector for handling one to multiple faces and frontal to profile faces will be measured using the following formula:

***Accuracy (%)** = (Number of Test Images with Correct Detection / Number of Test Images) x 100*

Table below shows the results of testing the overall accuracy of the proposed CNN face detector with the first group of test data (Fig. 8).

Table 1. Result of testing the overall accuracy of the proposed CNN face detector.

Number of Faces	Number of Test Image with Correct Detection	Number of Test Image	Accuracy (%)
1	20	20	100
2	19	20	95
3	20	20	100
4	18	20	90
5	18	20	90
6	20	20	100
7	19	20	95
8	18	20	90
>8	15	20	75
Total:	168	180	92.78

As shown in table 1, the CNN face detector has achieved an overall accuracy of 92.78%, which is considered high in facial biometric as it involves detecting multiple faces instead of a single face at one time. From the testing outputs, it shows that the detector copes well with pose variation issue when comes to multiple face detection (Fig. 10). However, factors like face-like object, small face size, poor lighting condition, and occlusion can affect the performance of the CNN detector and lead it to a lower accuracy. For example, the upper image in Fig. 11 shows that the detector has wrongly identified the face-like sun as human face, while for the image below, bright light and large group size that causes a decrease in each person's face size have led the detector to miss out some faces.

Fig. 10. Samples of positive detection testing output

Fig. 11. Samples of negative detection testing output

Next, table below shows the results of testing the robustness of the CNN face detector against different yaw angle faces using images chosen from Our dataset (Fig. 9).

Table 2. Result of testing the robustness of the CNN face detector against different yaw angle faces

Face Yaw Angle	Number of Test Image with Correct Detection	Number of Test Image	Accuracy (%)
0°	20	20	100
10°	20	20	100
20°	20	20	100
30°	20	20	100
40°	20	20	100
50°	20	20	100
60°	20	20	100
70°	20	20	100
80°	20	20	100
90°	20	20	100
>90°	200	200	100

Refer to table 2, the 100% accuracy proves that the proposed face detector model is robust to handle face oriented between 0° and 90° both left and right. However, for sure, 100% accuracy is impossible to be obtained in real world since there will be other factors like light conditions, image quality and occlusions that could affect the detection performance. Hence, the accuracy in this testing is to certify that the proposed detector can really work well with non-frontal face of yaw angle up to 90° instead of indicating the overall accuracy of the detection function.

4.2 Face Recognition

For face recognition, the overall accuracy of the proposed CNN face recognition model for handling frontal face and profile face is measured by testing the model against 30 faces in frontal view and 30 in profile position. For faces in each frontal and profile category, 15 of them are known identity and another 15 are unknown. Fig. 12 shows some examples for the recognition testing. Since the developed system recognizes face based on each extracted facial region, different number of faces in an image will not be a factor that degrades the recognition performance. Thus, the recognition accuracy is calculated without considering number of faces as part of the metric.

Fig. 12. Sample images for recognition testing

Since recognition classifier works on more than two class values, confusion matrix is used to measure the accuracy of the proposed CNN face recognition model. The following shows the accuracy result obtained from the confusion matrix for both frontal and profile face recognition.

Table 3. Confusion matrix for frontal face recognition testing

Confusion Matrix (Total=30 Frontal Faces)		**Actual Result**	
		Unrecognized Face	Recognized Face
Predicted Result	Unknown Face	10	2
	Known Face	1	17

Accuracy (%) *= (10+17)/ (10+2+1+17) x100 = 90%*

Table 4. Confusion matrix for profile face recognition testing

Confusion Matrix (Total=30 Profile Faces)		**Actual Result**	
		Unrecognized Face	Recognized Face
Predicted Result	Unknown Face	10	7
	Known Face	3	10

Accuracy (%) *= (10+10)/ (10+7+3+10) x100 = 66.67%*

As shown in table 3, the proposed CNN face recognition model has obtained 90% accuracy in recognizing frontal face. While based on table 4, it shows that the model has achieved an accuracy of 66.67% in profile face recognition. The accuracy is not as high as in frontal face recognition due to several reasons including different illumination conditions between the testing and training image, change of hairstyle and similar face between two different persons. Although the model is currently well-trained with the suitable parameters, the dataset used for training are still insufficient to well represent each individual's facial features in different type of variation like lighting and hairstyle. Thus, the model requires further enhancement in terms of training with more appropriate set of data.

5. CONCLUSION AND RECOMMENDATIONS

In conclusion, as a replacement for the manual attendance taking approach, this paper introduces a multiple face recognition based attendance system using CNNs which is well suited for crowded classroom. As the accuracy of attendance taking depends heavily on the accuracy of face detection and recognition, this paper aims to propose methodologies that can ensure the system remains its high recognition accuracy even when dealing with pose variation issue. By applying the proposed CNNs, the developed system has achieved 92.78% detection accuracy, 90% frontal face recognition accuracy and 66.67% profile face recognition accuracy. However, there is still room for improvement as the accuracy achieved by the proposed CNN model in profile face recognition is just 66.67%. Thus, in future, it is recommended to reconstruct and retrain the CNN face recognition model with a better set of data that well represent each individual's unique facial features. Also, for more efficient implementation, it is proposed to adopt face frontalization technology into the system. With face frontalization, the necessity to train the recognition model with enormous amount of training data can be eliminated since every profile face will be converted into frontal view before feeding into the recognition classifier. As a result, it will be more practical for educational institutions to bring this attendance system into realization as they would be free from the burden of managing a huge database for model training. Besides pose variation, factors like facial similarity, different illumination, changing appearance, occlusions, etc. can also significantly compromise both detection and recognition accuracy. Therefore, future work should not only focus on improving the accuracy of profile face recognition, but also concern on minimizing the impact of these factors on the system accuracy so that the

attendance system is robust in maintaining its high accuracy performance while dealing with different face variations.

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SUSTAINABLE WATER PUMPING SYSTEM

Nurul Shahrizan Shahabuddin[*1], Jayianthi Supamaniam[1]

[1] Department of Electrical Engineering,
Faculty of Engineering, Science and Technology, Nilai University,
No 1, Persiaran University, Putra Nilai, 71800 Nilai, Negeri Sembilan
sharizan@nilai.edu.my

ABSTRACT

The poor water quality and electricity supply are the main issues in rural area in Malaysia especially in Sabah and Sarawak. The poor water quality supply will trigger health problem. Malaysia is a country in sunbelt region with lots of availability of sun irradiance which is very suitable for the utilization of a photovoltaic (PV) system. Therefore, this project focuses on providing water supply in a rural area by the implementation of the PV water pumping system. The abundant of sun irradiance was utilized to power up the PV water pumping system. Water level sensor was used to enable the water pump to pump the water until it reached the maximum water level. The pump was controlled automatically using a microcontroller. It is found that PV water pumping system can pump 240 L of water per hour. This project proven that, sustainable water pumping system is promising alternative method to replace conventional electricity pumping system especially in rural area.

Keywords: photovoltaic, solar powered pump, sustainability, microcontroller

1. INTRODUCTION

PV pumping system has many advantages such as low operating cost, low maintenance, sustainability and flexibility (Maurya et al. 2015). Photovoltaic (PV) works on the principle of the photovoltaic effect. When exposed to sun, the solar array grip photons and release free electrons. This phenomenon is named as the photoelectric effect. The effect is a process of generating direct current electricity. Solar panels or modules are designed to supply electric power at a definite voltage, but the current generation is directly dependent on the light intensity. Solar powered water pumping system consists of solar array that power up the motor. Once power up the motor, the water pump will be activated automatically to control the motor by sensing the water level in storage tank. The water is pumped from water source such as river or well. African, south Asian and Latin American countries are exposed to sun throughout years, allowing photovoltaic system to be a viable energy source. Solar powered water pump system is made up of two basic components, namely solar panel and water pump. Solar water pump system is a system that operate using power generated from solar photovoltaic (PV) system. The system will convert the solar energy into electricity. It can be used for power up the water pump system (Kaspedia, 2017).

Solar powered water pump basically run on power from the sun. It converts solar energy into electrical energy for pumping water. In solar powered water pump system, microcontroller can be used to control the pump automatically. This is done by sensing the water level in a storage tank. As reported by Al-Badi and Yousef (2016), PV water pumping system was implemented to replace diesel powered water pump to pump water for irrigation, livestock and drinking in remote areas in Oman. The system consists of PV, inverter, AC motor, centrifugal pump and storage tank. The implemented pump system is connected directly to an inverter. The inverter is design to control and protect pumping system. However, in this report, the pump can be used in sunny days only. Most of the PV water pumping system use centrifugal pump (Al-Badi & Yousef, 2016). It is designed to flow water from one place to another place continuously. The centrifugal pump is a pump that uses a rotating impeller to move water or other fluids by using centrifugal force. Generally, centrifugal pump suitable for liquids with a relatively low thickness that pours like water and oil.

Microcontroller controlled solar pumping system can be applied for irrigation (Dursun & Ozden, 2012; Biswas & Iqbal, 2018). A programmed sensor module can be applied to detect the temperature, humidity, soil moisture level and sends the information to microcontroller. A water level sensor observes the water level and sends the data to the microcontroller unit. The output of the microcontroller is connected to a normally open type relay to control the motor pump operation. The microcontroller controls the motor operation by sending trip signals to the relay. A 10K potentiometer is used as water level sensor in storage tank. The potentiometer measurement is recorded into in term of scale from 0 m to 3 m as the height of the tank decided as 3 m. Biswas and Iqbal, 2018 used the information and boundary conditions so that the microcontroller decides either to start or to stop the pump motor. The ESP32 microcontroller also sends results to the web server.

Anwari et al., 2009 presents a model of a PV water pumping system using Two Maximum Power Point Tracker (MPPT) algorithms. The algorithm, subsystems and control methods are modelled and simulated using Matlab and Simulink with actual irradiance data. The proposed water pumping system is stand-alone 150 W system without backup battery. The system consists of a single PV module, a MPPT and a direct current (DC) water pump. In the simulation, positive displacement pump are used for its low-volume pumps and cost-effective. The water pump selected was a submersible solar pump which is a diaphragm-type positive displacement pump equipped with a brushed permanent magnet DC motor.

In this paper, a microcontroller controlled photovoltaic based pumping system is proposed. In this project, PV panel is connected to a charge controller. The charge controller is connected to a battery to store the energy. The charge controller limits and regulates the voltage from the solar panel to avoid overcharging the battery.

2. METHODOLOGY

The solar powered water pump system is made up of two basic components; PV panel and pump. The photovoltaic array converts the solar energy into electricity, which is used for running the motor pump set. Fig.1 shows a flowchart of the solar powered water pump system

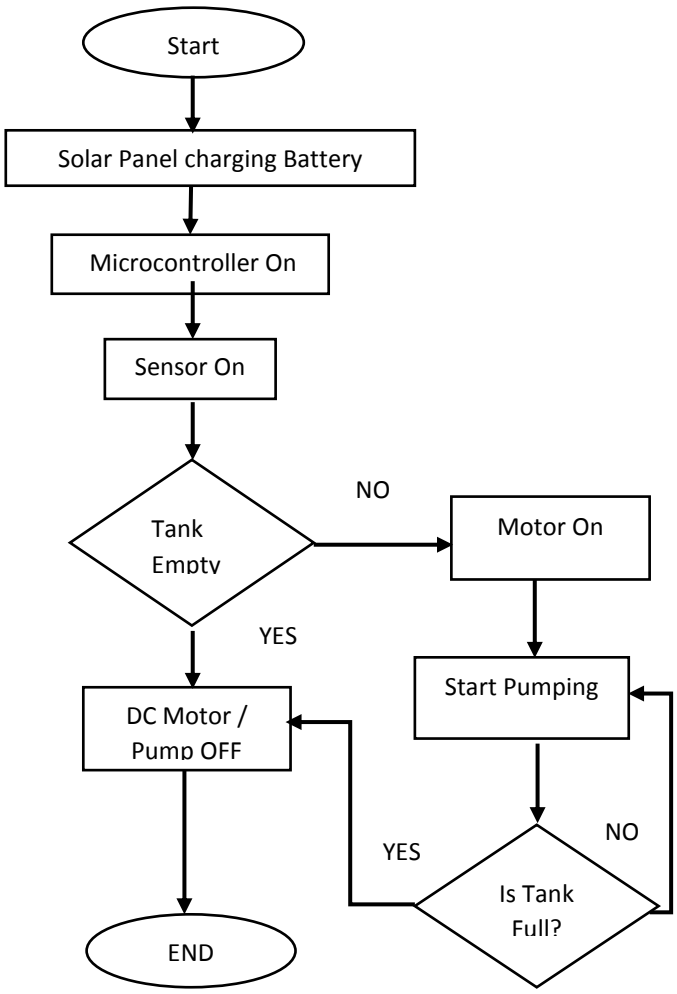

Fig. 1. Flowchart of the system.

Fig. 2 shows the block diagram of the project. It consists of photovoltaic (PV) panel, charge controller, battery, pump controller, sensor, regulator, tank and 12 V DC water pump. Charge controller or charge regulator is basically a voltage and/or current regulator to keep battery from overcharging. While DC loads are used, the controller does not allow the battery to get discharge. It regulates the voltage and current coming from the solar panels going to the battery (Majaw et al. 2015; Frenjo, Wogasso & Muthiya, 2007). PWM charge controller has rated voltage 12 V /24 V, rated current 30 A, maximum PV voltage 50 V, maximum input power 390 W and 780 W for 12 V and 24 V, respectively.

The electrical current produced by monocrystalline PV panels during daylight hours charges the battery. Then, the battery in turn supplies power to the pump anytime water is needed. The use of battery allows the pumping process over a longer period of time by providing a steady operating voltage to the DC motor of the pump. 8051 Microcontroller is

used to control the DC motor pump. The microcontroller sends the information to sensor to indicate whether the storage tank is full or empty. Once the sensor received the information, the DC motor pump will be switched ON automatically if the water level if low or empty. If the storage tank is full the DC motor pump will be switched OFF. The system can deliver a constant flow of water throughout the day.

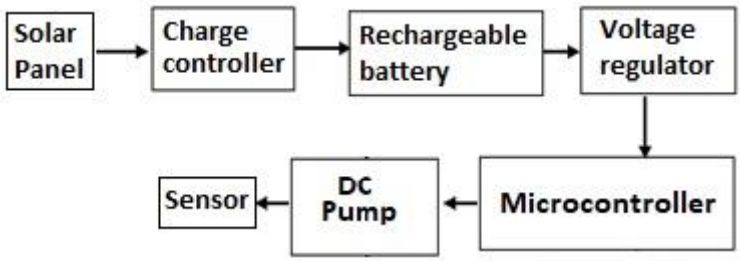

Fig. 2. Circuit block diagram

3. RESULT AND DISCUSSION

Fig. 3 shows the measured PV output voltage from 0800 to 1700 hours. The measurement was done in February 2019 in Nilai, Negeri Sembilan. The voltage shown is the average voltage value for 5 consecutive days data was taken. As shown in the figure, the output voltage ranges from 18.4 V to 21 V depending on the sun radiation. The radiation peaks at 1400 hours.

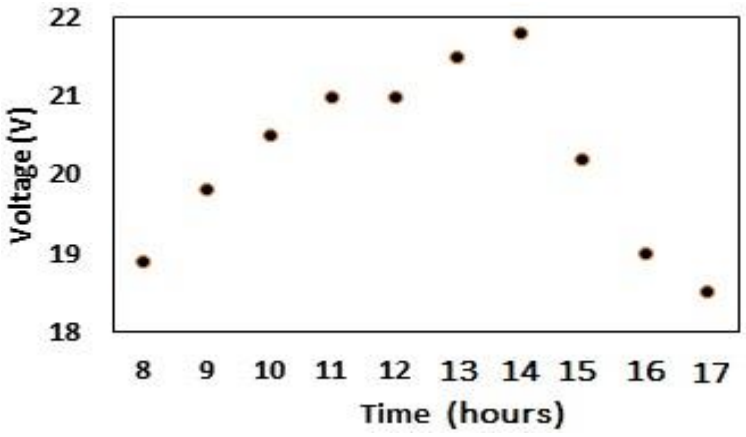

Fig. 3. Output voltage.

Fig. 4 shows the water level in litre (L) that DC motor pumped for an hour from time 10.00 am to 11.00 am. The reading was taken for every 15 minutes to identify the rate of water flowing into the tank. As the time increasing, the volume of water also increasing. From that result shown, it is found that the DC water pump can pump 4 L of water per minute. Thus, the DC pump motor can pump 240 L water in one hour. This is more than required water consumption of 165 L per day per capita as stated by World Health Organisation (Howard & Batram, 2003).

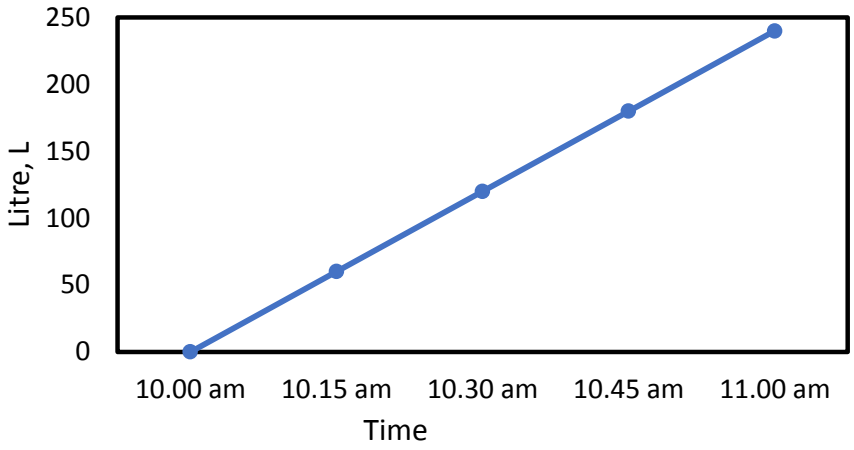

Fig. 4. Water flow rate.

4. CONCLUSION

An automatic PV pumping system using microcontroller has been reported. The system can pump water up to 240 L per hour. The system can be operated for at least 9 hours in a day even without the battery. The system can be operated at night since the battery can be charged during the day. Photovoltaic systems can be designed to supply water and irrigation in areas where there is no mains electricity supply. Their main advantages over hand pumps or internal combustion engine pumps are their practically low maintenance, do not require fuel, do not contaminate, and finally easy to install. The charge controller can allow different DC loads to be used. Thus makes PV system to be flexible. In general, photovoltaic pumps are economic compared to diesel pumps or even grid electricity for long term. PV pumping system is an environment friendly, low maintenance and cost effective alternative.

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STUDENT FEEDBACK MINING ON LECTURER AND COURSE EVALUATION USING SENTIMENT ANALYSIS

Tong Poh Soon*[1], R. Rajesvary[1]

[1] Faculty of Engineering, Science and Technology, Nilai University
No 1, Persiaran University, Putra Nilai, 71800 Nilai, Negeri Sembilan
n00016152@students.nilai.edu.my, rajes_e@nilai.edu.my

ABSTRACT

Students' evaluation on courses and lecturers are important to improve courses and lecturers' performance in academic institutions. Usually, academic institutions use evaluation forms to collect the feedback from the students and analyze the students' rating on courses and lecturers' performance. However, the problem of this method is there is not much analysis on the opinion and emotional expressions of the students. The result from this method is just focus on the rating parts which is more to quantitative. This causes the evaluation result to become not accurate and not useful to the academic institution because the students might simply give the rating. This project is aims to solve the problems by using the open-ended questions in the evaluation form which are analyzed using sentiment analysis. The sentiment analysis can provide the result that contain the sentiment expression of the students, acts as reference to prove the rating and to provide useful information to the institutions for their improvements. The findings of this project show the importance of sentiment analysis in the evaluation form because the students might simply rate the course and lecturer as they don't want to read the questions. However, they will fill up their opinion in the form to commend on the courses and their lecturers. The opinion analyzed by sentiment analysis and the quantitative analysis of the ratings are compared to produce result which shows the satisfaction of the students among the courses and lecturers.

Keywords: sentiment analysis, emotional expressions, feedback mining, evaluation on teaching

1. INTRODUCTION

Sentiment analysis is a technique for the opinion mining by using text which help the business to understand how the social feels on them (Gupta, S., 2018). It had been often used in customer management system for the company, bank, restaurant, shop and so on. The customers will give their feedback and opinion through the form or other applications, and the system will analyze their sentiment to determine whether the customers are satisfied with the goods and services provided by the company.

There are a lot of methods has been used for the sentiment analysis which mainly divided into two approaches which are machine learning approach and lexicon-based approach (Medhat et al., 2014).

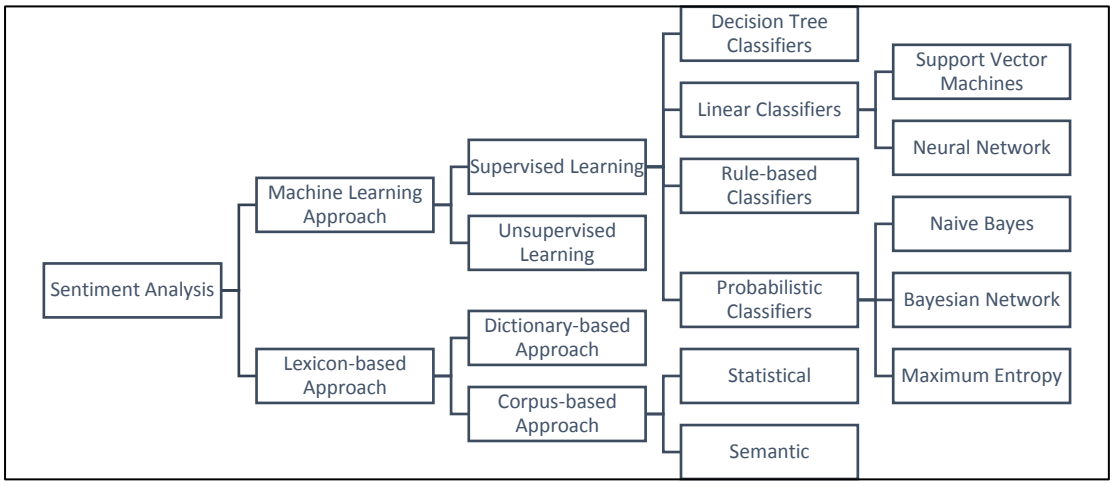

Figure 1 Methods Used in Sentiment Analysis
Source Sentiment Analysis Algorithms and Application: A Survey. Ain Shams Engineering Journal, 1093-1113

In figure 1, the machine learning approach contains two type of techniques which are supervised learning and unsupervised learning. There are four classifiers in the supervised learning which are Decision Tree Classifiers, Linear Classifiers which contain Support Vector Machines and Neural Network, Rule-based Classifiers and Probabilistic Classifiers which contain Naïve Bayes, Bayesian Network and Maximum Entropy. In Lexicon-based Approach, there are two techniques which are Dictionary-based Approach and Corpus-based Approach which contains Statistical Classification and Semantic Classification.

With those techniques, the sentiment analysis can be applied in applications which other than customer management system. For example, academic institutions' course evaluation system. In this research, the sentiment analysis is used in the course and lecturer evaluation to analyze the opinion and the emotion of the students regarding the course and lecturer. The proposed system will use the rule-based classification as the method of sentiment analysis, which can analyze the text and also emoticon.

According to Bernile, R., et al. (2014), course and lecturer evaluation is a very important process to the academic institutions. It allows the management of the institutions and the lecturers to understand what their students are thinking about the course and the lecturers' teaching way, thus can make improvements on the course syllabus and the lecturers' performance. However, the traditional way of lecturer and course evaluation is inefficient and hard to analyze the students' feedback and their opinions on the lecturer and the course (Ullah, M. A., 2016). This is because they use physical form with the questionnaire which ask their students to give the rating only, even there are some open-ended questions for the students to fill up their opinion, but most of the students will just simply give the rating on the form only. These problems can be solved by using the online open-ended question form for lecturer and course evaluation with the sentiment analysis. The students are allowed to fill up the form in the way they like, and their opinions and feedback will be analyzed by using sentiment analysis to produce the better results for the lecturer and course evaluation.

The remainder of the report is organized as follows.

1.1 PROBLEM STATEMENT

According to Maitra, S., et al. (2018), the suitable action to focus on students' centered teaching is not taken due to the low quality of the feedback mining done by the management of institution. This is because of the current evaluation form does not analyze students' opinion and their emotion. The current evaluation form only focuses on the data from the questionnaire form which focus on the quantitative results only. Even there is some comment section, but usually the students won't fill up the comments because most of them feel that is not necessary.

The feedback of the students is very important to the academic institutions because it allows the management and lecturer to understand their students' opinion, thus improve the

teaching ways and the courses. If the management take action to make changes on the course and improve the students' study environment, this will attract more students to study in the academic institutions.

For this, a course evaluation form is must to get the opinions and recommendations from the students but not using the questionnaire form. Replacing the questionnaire form with the open-ended question form will allow the students to fill up their opinion. With the sentiment analysis, the management and lecturers will understand how students feel on their courses and lecturers' performance. Based on the results, the management and lecturers can make some changes on the course and the way of teaching.

2. METHODOLOGY

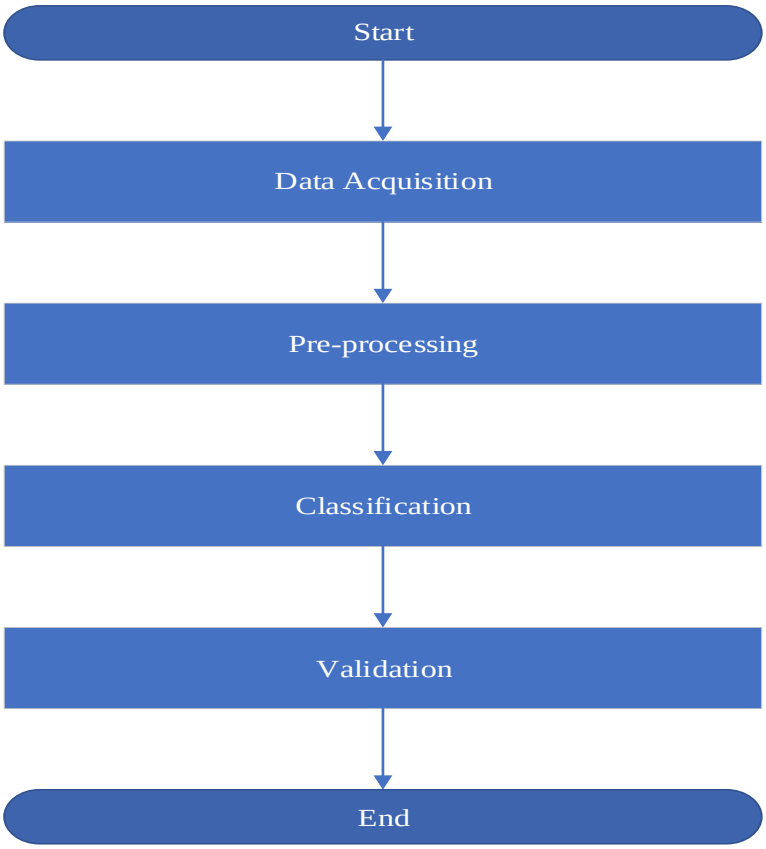

Figure 2 Flow chart

There are four main steps which are Data Acquisition, Pre-processing, Classification and Validation.

In Data Acquisition, there are three main data need to be collected which are feedback from students, sentiment words list and stop words list.

In Pre-processing, the feedback from the students will be processed for the analysis use. There are two steps in the pre-processing which are tokenization and stop word removal.

In Classification, the rule-based classifier had been used as the method in this sentiment analysis. There are two rules which are emoticon-based rules and sentiment lexicon-related rules.

In Validation, the results of the sentiment analysis will be explained and showed to the users.

2.1 DATA ACQUISITION

For collection of the student's feedback, an online google form with the open-ended question will be used. This is because online form will be more convenience and open-ended question allows students to write down their real opinion, not just simply give a mark or rating. After getting the feedback from students, the users need to download the google form response and save as the excel file.

The sentiment words list is getting from the VADER Sentiment Lexicon List which is an online dataset of the sentiment words. This sentiment words contain the emoticon and a set of positive words list and negative words list which are useful for the sentiment analysis.
The stop words list also will get from the online. This list will be used in the pre-processing for the stop word removal. The example of the stop word such as "the", "with", "in" and so on. In this system, the stop word list is using the NLTK's English Stop Word List.

All the data will be stored in the excel file in the system's library. The system will read the excel file to execute the implementation.

2.2 PRE-PROCESSING

There are two main steps in the pre-processing which are tokenization and stop word removal.

Before the tokenization, the students' feedback will be analyzed by using the rule-based classifier with the Emoticon Related Rules to determine the emoticons and store into the database. This is because after the tokenization and stop word removal, only the processed texts will be stored into the database, all the punctuation and symbols will be removed. If the students had fill up their feedback with some emoticons such as :D, :(and :P, then the system will be able to analyze these emoticons because sometimes the students can express their emotion using the emoticons rather than using text.

In tokenization, each students' feedback from the database will be separate into sequence of token. The separation will be based on the white space, line break and the punctuation. After the separation, the words will be group with their synonym.

The stop word removal is the technique to remove the stop word. The stop words list will be used, and the system will compare the text with the list, thus remove the stop words from the text.

2.3 CLASSIFICATION

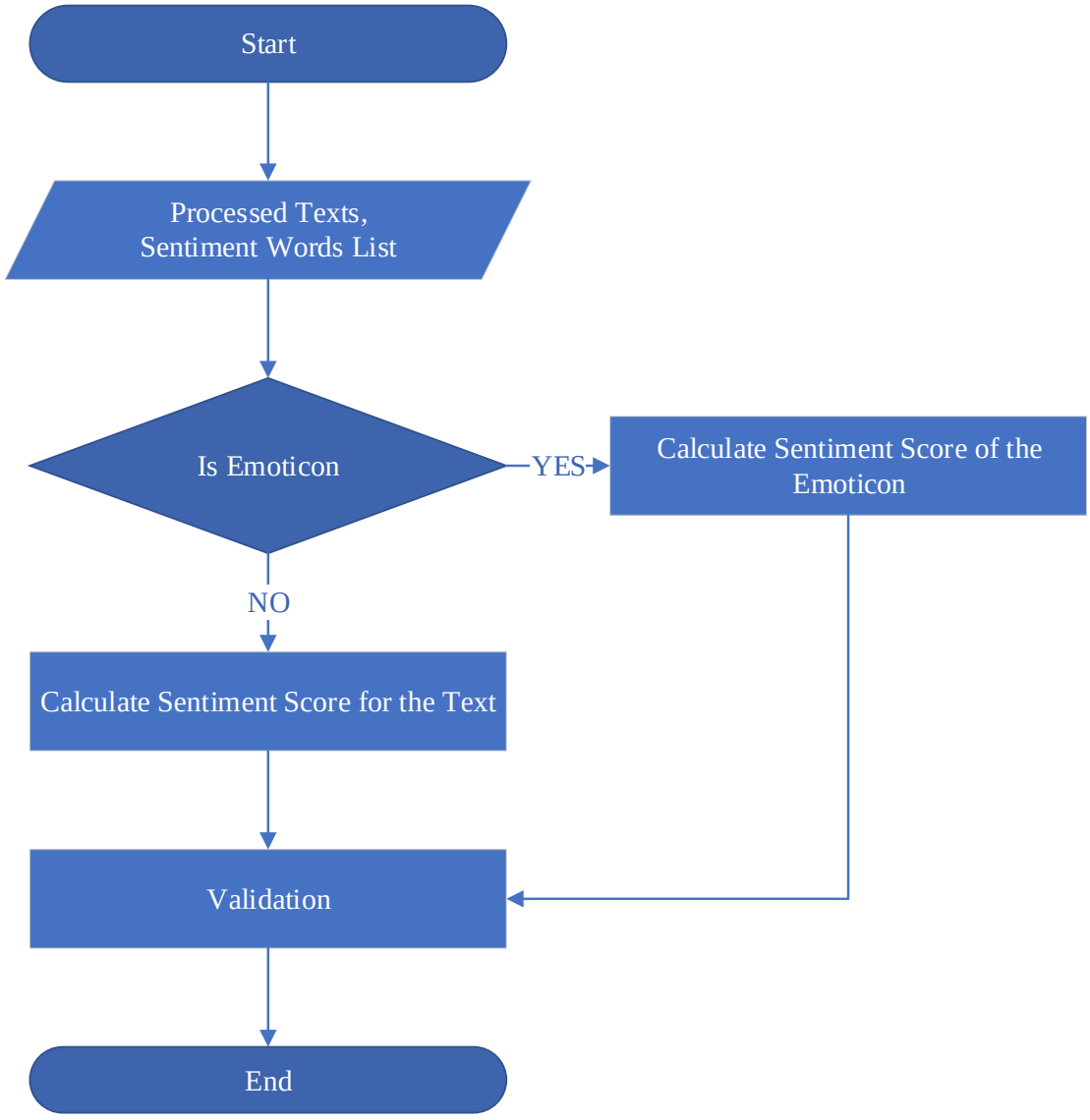

Figure 3 Classification

After the pre-processing, the rule-based classification will be used for the sentiment analysis. Firstly, the processed texts will be identified into emoticon or text. Then the system will calculate the sentiment score of the text by comparing them with the sentiment word list.

The score calculated will be stored into the database. After all the texts has finish calculate their sentiment score, the system will give the average of the sentiment score as the results.

3. RESULTS AND DISCUSSION

3.1 RESULTS

3.1.1 PRE-PROCESSING – TOKENIZATION

Table 1 Result of tokenization

Input	Output (Actual)
Comments of Course EC3333: “good recommend” “bad” “I am student”	Words: [good, recommend, bad, I, am, student]
Comments of Lecturer TONG POH SOON: “lol” “kind” “punctual” “I like it :D”	Words: [lol, kind, punctual, I, like, it, :D]

3.1.2 PRE-PROCESSING – STOP WORD REMOVAL

Table 2 Result of Stop Word Removal

Input	Output (Actual)
Words: [good, recommend, bad, I, am, student]	Words: [good, recommend, bad, student]
Words: [lol, kind, punctual, I, like, it, :D]	Words: [lol, kind, punctual, like, :D]

3.1.3 SENTIMENT RESULT

Token: [good, recommend, bad, student]

Table 3 Sentiment Analysis Result 1

Words	Sentiment Score (VADER Lexicon)
Good	1.9
Recommend	1.5
Bad	-2.5
Student	NOT FOUND
Sentiment Score	0.23

Token: [good, recommend, bad, student]

Table 4 Sentiment Analysis Result 2

Words	Sentiment Score (VADER Lexicon)
Lol	2.9
Kind	2.4
Punctual	NOT FOUND
Like	1.5
:D	2.3
Sentiment Score	0.92

3.2 DISCUSSION

3.2.1 INITIATE THE LIST OF LECTURER AND COURSE

The initiation of the list of the lecturers and courses is work perfectly. Generally, there will be a lot of redundancies in the lecturer's name and the course codes in the evaluation form. In this system, there is a function to remove the redundancy of the lecturer name and course code and return the distinct value to the view class. This system doesn't require any SQL and the server database, and the function of getting distinct values is not as simple as in the SQL code such as "SELECT DISTINCT". To perform this task, this system is implemented using HashSet from Java Collection Framework. As the result, the HashSet worked fine in getting the distinct values of lecturer name and the course code.

3.2.2 PRE-PROCESSING – TOKENIZATION

The tokenization in this system which separate all the comments into a sequence of words is working perfectly. This feature is done by using Vector from Java Collection Framework and a nested loop-function. First, the system will load all the comments and add into a Vector, Vector A. By using the for-loop, the comments will be separated into the string array and then using an inner for-loop to add the elements in that string array into the new Vector, Vector B. After the for-loop is end, a sequence of words will be stored in the Vector B. This is how the system to perform the tokenization. The tokenization is an important process in this system, because the sequence of words will be using in the stop words removal and also the generating of sentiment score.

3.2.3 PRE-PROCESSING – STOP WORD REMOVAL

Stop words are the words which does not contain any emotion express in a text. It is better to remove to ensure that the sentiment result is correct and also can shorten the time taken for calculating the sentiment score. However, the stop word removal might not perfect as expected. As the rule-based concept, the stop word removal is a process which highly rely on the dataset, which is stop word list. In this system, the stop word list is using Natural Language Tool Kit's (NTLK) English Stop Word List. It is a common stop word list which widely used by the developer, but it does not mean that all the stop words will be included in this list. As the result of testing, the word "student" does not contain the sentiment expression, but it is also not included in the NLTK's English Stop Words List. So, it will not be removed from the tokens and will proceed to the calculation of the sentiment score part.

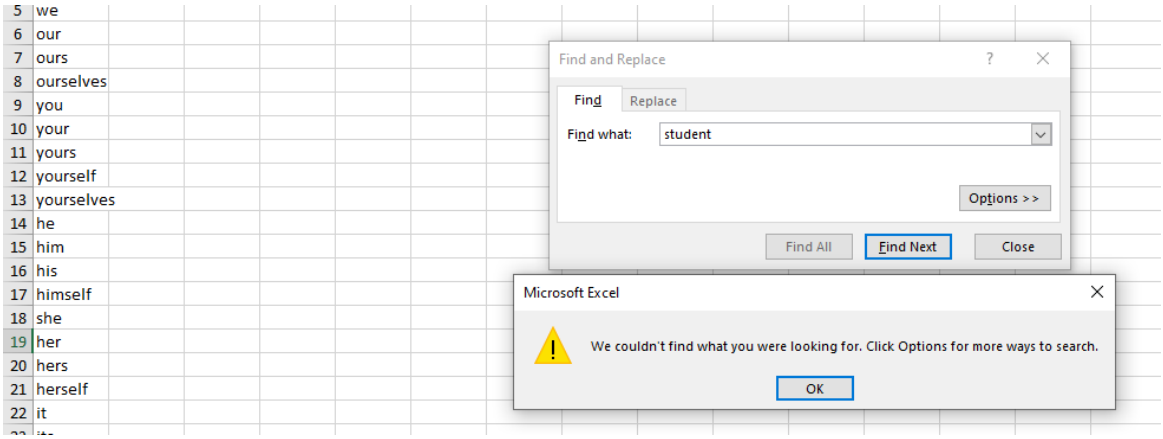

Figure 4 Searching "student" in NLTK's English Stop Words List

The effect of the stop words failed to remove will be discussed in next section.

3.2.4 SENTIMENT ANALYSIS

To calculate the sentiment score of the text, the VADER Sentiment Score Formula which discussed in Section **Error! Reference source not found.** will be used.

Equation 1 VADER Sentiment Score Formula

$$score_{actual} = \frac{score_{total}}{\sqrt{(score_{total} * score_{total}) + a}}$$

After the tokenization and stop words removal, the words which contain emotion expression will be stored into a sequence and called as "Token". There are two testing implemented. As the result:

Token: [good, recommend, bad, student]

Words	Sentiment Score (VADER Sentiment Lexicon)
Good	1.9
Recommend	1.5
Bad	-2.5
Student	NOT FOUND
Sentiment Score	0.23

Token: [good, recommend, bad, student]

Words	Sentiment Score (VADER Sentiment Lexicon)
Lol	2.9
Kind	2.4
Punctual	NOT FOUND
Like	1.5
:D	2.3
Sentiment Score	0.92

The sentiment score of the words is getting from the VADER Sentiment Lexicon List. In this list, most of the words which contain sentiment expression will be listed and their sentiment score between -4 to 4. As the result above, the failed of removing the stop words doesn't affect the result of sentiment analysis, but it may affect the time taken to generate the result if there is a huge number of words. The result of the sentiment score is not affected may because of the system is developed using the rule-based methodology, if the system does

not recognize the words from the VADER Sentiment Lexicon List, it will skip it and do not add or subtract any number to the score. Moreover, the VADER Lexicon contains the emoticons also. With this, the system doesn't require another dictionary to calculate the sentiment score of the emoticons. This will partially improve the efficiency of the system and the students also allow to type the emoticons into the evaluation form.

According to Calderon, P (2017), in VADER Sentiment Analysis, the result will be divided into three type of polarity which is "Positive", "Negative" and "Neutral". If the sentiment score is between -0.05 to 0.05, the polarity will be "Neutral", else if the score is more than 0.05, then the polarity will be "Positive", else, it will be "Negative". The polarity is representing the emotion expression of the students in the text. In another words, "Positive" means that the students have a good impression to the lecturer and the course, so they will use some words which contain positive sentiment during fill up the evaluation form, meanwhile "Negative" means that the students may do not like the particular course or teaching style. "Neutral" means that the students' emotion expression in the text is balance. There are two cases which may cause the result to become neutral. First, there might be some of the students recommend the lecturer or course meanwhile some of them are not. Second, the students might really do not have any idea to write the comments in the evaluation form.

3.2.5 COMPARISON BETWEEN QUANTITATIVE RESULT & SENTIMENT RESULT

The feedback was taken for four lecturers and four courses using the google forms. Each lecturer and course were filled up by around 20 to 30 students.

Target	Average Rating (Overall)	Sentiment Score
Course: BA3312	4.22	1.00
Course: BA3323	3.80	0.82
Course: BA3101	2.98	-0.99
Course: MPU3113	3.62	0.93
Course: MPU32113	3.47	1.00
Lecturer: Pang	4.51	0.97
Lecturer: Faizuddin	3.22	0.99
Lecturer: Mr. Gan	4.48	0.99
Lecturer: Edward	4.35	-0.27
Lecturer: Victor Lim	3.28	-0.32

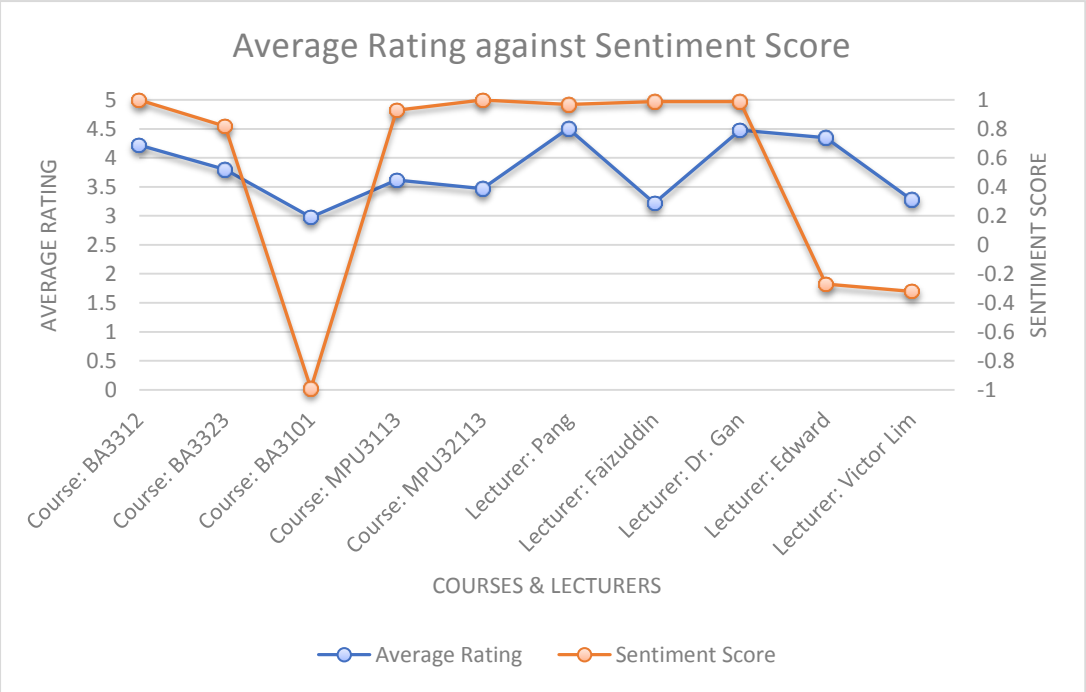

Figure 5 Result of the evaluation form

The result above was collected from the students for five courses and for five lecturers. The average rating has three categories which is good, normal and bad that are proportional to sentiment polarity, which is positive, neutral and negative. As the maximum of average rating is 5 and minimum is 0, the rating can be categorised as below:

0.00 – 1.50: bad; 1.51– 3.50: normal; 3.51– 5.00: good

Form the results above it is known that quantitative result shows the average rating of the statements from the students, for courses and lecturers' performance. However, the students might just simply put the rating without reading the statements. This will cause the average rating to become not accurate so that the management of academic institution cannot take the correct action to improve their course syllabus and the lecturers' teaching style. To overcome this problem, it is better to have open-ended questions in the evaluation form, so that the students can feel free to write their opinion and comments on the courses and lecturers. The open-ended questions analyzed by using the sentiment analysis, so the management of the academic institution will know the emotion expression of the students.

Different with the quantitative result, the sentiment analysis is more focus on the comments written by the students. The sentiment result will show the sentiment polarity and its score which represent the emotion expression of the students on the text. Besides that, the frequency of occurrence of the words will show the most used keyword by the students, this may help the staff to have a better understanding of the opinion of the students.

This can be used as an evidence to prove that the rating of the statement in quantitative result and also can help to determine the problems or issues when there is low rating. As the system will show the most occurrence words and display all the comments written by students, so the management can refer that to figure out the problems of getting low rating. Thus, they can take the suitable action to improve their institution efficiently and effectively.

4. CONCLUSION

With the rule-based classification, the system doesn't require a large amount of memory space to store the dataset, low execution time and can process the analysis without the internet connection. However, there is still some limitation of the system. The system able to recognize the emoticons, but it cannot determine the punctuation which may impact the sentiment score. For example, "I like her teaching style" and "I like her teaching style!!!". The second sentence shows that the student has more emotion than the first sentence. However, the main sentiment lexicon still able to calculate, it may lower the accuracy of the sentiment result, but it won't make the result totally incorrect. Although there is some limitation on the system, but the system still achieved the objectives which are develop a course and lecturer evaluation system using sentiment analysis and analyze the evaluation and provide feedback to the management and lecturers. The first objective is achieved by the system had been developed successfully and all the functions is working well. The second objective is achieved by the system will return the sentiment result and the quantitative result to the users. There are some future works need to be done to improve this Student Feedback Mining on Lecturer and Course Evaluation System. First, it should add more implementation on the rule-based classification. This is for the system can be able to determine whether the sentence contain the punctuation such as exclamation mark and question mark, because sometime these punctuations will represent the emotion express which will affect the sentiment analysis. With this, the system will generate a better and more accurate sentiment

result. Other than that, it should add one more classification such as dictionary based. This is for the system to produce more useful results such as the system will generate and display the comments based on the sentiment results, the comments should give some useful advice to the management of the academic institutions to have a better idea on the improvement.

5. ACKNOWLEDGEMENTS

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AMERICAN SIGN LANGUAGE RECOGNITION USING CONVOLUTION NEURAL NETWORK

Aashish Thapa Magar[1], Pramod Parajuli[1]

[1]Padmashree International College
Raja Janak Marg, Kathmandu 44600, Nepal

ABSTRACT

Hand gestures represent a vast amount of information that can be used for basic communication by people with disabilities as well as augment communication for others. As the information of hand gestures rely on movement sequences, identifying hand gestures with accuracy in real-time is challenging. In the domain of human-computer interaction, hand gesture recognition models have been developed for mouse pointer movement, playing games with specific actions, etc. Various techniques such as HOG transforms, SIFT, BRIEF, ORB have been used to identify the region of interest and for classifying the region of interest techniques such as Support Vector Machines (SVMs), Hidden Markov Models (HMMs), etc. are being used. These methods demand heavy computational resources. This paper presents a novel method for recognizing American Sign Language (ASL) using image pre-processing methods and a Convolution Neural Network (CNN) for classification that is implemented in Raspberry Pi3. Images captured from the Raspberry Pi camera module are pre-processed for better clarity and region of interest isolation so that a better set of features are extracted. These features are then fed into CNN for classification. Executing the model on Raspberry Pi3 has resulted in a satisfactory output as the classification result and time taken by the system have been acceptable to end-users.

1. INTRODUCTION

Hearing-impaired people are facing problems interacting with others causing the communication gap. The only communication mechanism to deliver their thoughts and their feeling are by using the hand sign which is not understandable by many others due to which communication with those who do not understand hand signs is not possible. Therefore, as a solution to the problem, the hand gesture recognition system has been a highly anticipated topic. Much researches have been performed to solve the issues but most of them require input devices like-colored globes or the sensors which can add extra resource requirements.

Moreover, to reduce the communication gap between the hearing-impaired people and normal people, there are two possible ways either every people should learn hand gesture-based communication or create a system that can translate the hand gestures to normal text readable to most humans.

There are mainly two types of gestures; first, static gesture, and second, dynamic gesture. The static gesture is the gesture where the stationary hand or the images are used for attaining the information whereas the dynamic gesture is a gesture with moving hands or the sequences of the images are used for revealing information. The computing resource required for processing the static gesture is relatively lower than for the dynamic gesture as the static gesture uses a single posture whereas the dynamic gesture requires the sequence of postures for processing. The hand gesture recognition system can be used for multiple purposes. It can also be used as the translator to translate the gesture to the texts and can be used for human-computer interaction to ease the interaction between the human and the machines.

This paper is focused on developing a static gesture recognition system that can translate the hand gesture to text-based output.

1.1. OBJECTIVES

- To develop the model for hand gesture recognition system using an open-source library (Open CV) and Convolutional Neural Network.
- To develop the prototype of a hand gesture recognition system that can be used to recognize the gesture and generate text-based output.

DETAIL OBJECTIVES

- To implement an Open CV pre-built function for image pre-processing.
- To implement the Convolutional Neural Network model for training and classification.
- To develop a prototype of the proposed system on Raspberry Pi3 with a camera module.
- To evaluate the working system for end-user acceptance.

1.2. PROBLEM STATEMENT

Natural interaction has been most desirable for interaction with the computer but the computer is unable to decode it. In the case of the hand gesture recognition system, the computer vision should be able to distinguish the hand from other objects (Zabulis et al., 2009). The next task is image classification. Many kinds of research perform image classification and object detection by using high-cost equipment like Kinect sensor, depth camera, colored globes, etc. Besides the use of the costly hardware other researcher has developed the image pre-processing methods which are highly dependent on the learning environment (Cruz et al., 2009). Another crucial problem for the development of the hand gesture recognition system is object localization. Unstable objects also make it difficult for object localization. Therefore, the gesture recognition systems would be unable to respond during the change of one gesture posture to another gesture posture.

1.3. SCOPE

The proposed hand gesture recognition system is intended to recognize the simple static American Sign Language and translate it into text-based output.

2. LITERATURE REVIEW

The hand gesture recognition system is a common field of studies for human-computer interaction purposes. As mentioned in the problem statement, one of the problems for the gesture recognition system is hand tracking. To solve it, input materials like colored globes for tracking hand and locating the fingers are being used. Tracking hand can be a

difficult job due to the complex background and shadows and the system is unable to segment the color (Mutha et al., 2015). The skin coloring model is another model to address the problem of hand tracking and eliminate the input-based gesture system (Hasija et al., 2014).

Image pre-processing is the most important step while working with computer vision. Image pre-processing is the operation performed on images for the lowest level abstraction which the main purpose is to improve or enhance some feature of image for further processing and analysis task.

Image classification requires multiple steps; first, image capture/acquisition step to capture an image through multiple sources such as camera, file stream, etc. The second step to perform filtering, smoothing, color conversion, binary conversion, etc. the captured image. Then in the third step, the feature is extracted. Then finally image is classified using Artificial Neural Networks (ANNs).

In addition to hand-tracking, image segmentation has been another problem to be solved during the development of the hand gesture recognition system. Efficient hand tracking and segmentation are the must feature for the development of a hand gesture recognition system to work properly. The extraction of raw postures and gesture data for recognition in the globe-based gesture system requires the globe to be attached to the computer and users are must wear the globe (Pradipa et al, 2014). The histogram-based technique has been quite a popular approach for image processing. In this approach, the vector is used based on the orientation histogram (Patel et al., 2018). The histogram orientation methods follow the pattern recognition and use black and white-colored images for the digitization of the image. The detection and compression of the gesture are eased by the digitization of the image and the pattern recognition.

Image classification is introduced to reduce the gap between human vision and computer vision by training the model with the data. Differentiating the image into the prescribed category based on the content of the vision helps to achieve the image classification (Neelima et al., 2018). Deep learning method can be best for image classification as the machine learning consists of features extraction module to extract the important features such as edges, texture, etc. and classification module can classify based on the features extracted.

ASL is one of the hard sign languages where multiple gestures look similar to the other. Though the human eye can easily distinguish the gesture it is hard for a computer model to easily distinguish the gesture.

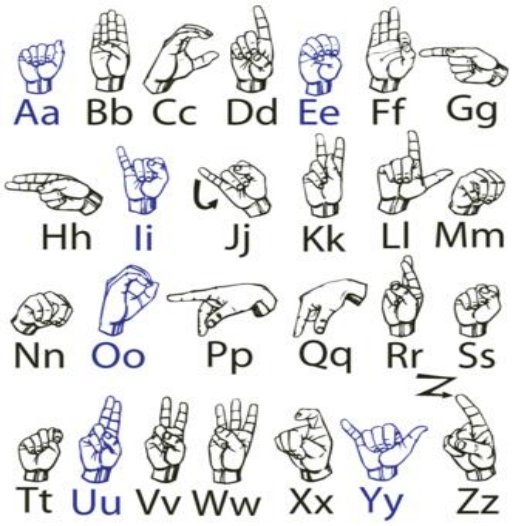

Figure 2.1: American Sign Language Gesture and Characters

2.1. RESEARCH GAP

Though there is much research that is related to the hand gesture recognition system, most of them require special input devices to be attached to the computer like a globe-based system. The proposed hand gesture recognition system will be addressing the problem where the special input devices will not be required for the recognition of the hand gesture and will be able to recognize the static gesture and provide text-based output.

3. RESEARCH METHODOLOGY

Initially, the user has to provide static gesture input. The gesture will be captured by the camera module and will be transferred to the internal process. During the internal process, the received image will be processed studying the image color depth, the histogram. Then the image is shaped out to a vector to generate features. The generated features will be used to train and classify the image. The corresponding label of a class will be the text-based output of the system. The architecture of the proposed system is depicted in figure 3.1 and the process is outlined in figure 3.2.

3.1. PROPOSED MODEL

The proposed system is intended to run on Raspberry PI and will be using the Raspberry pi camera module for capturing the image. The system captures the image using the camera module and the image will be processed for the feature extraction and is stored in the feature set. For the generation of the feature set, the system will be using the CNN model. The extracted feature will be classified and the gesture is recognized and the text is output.

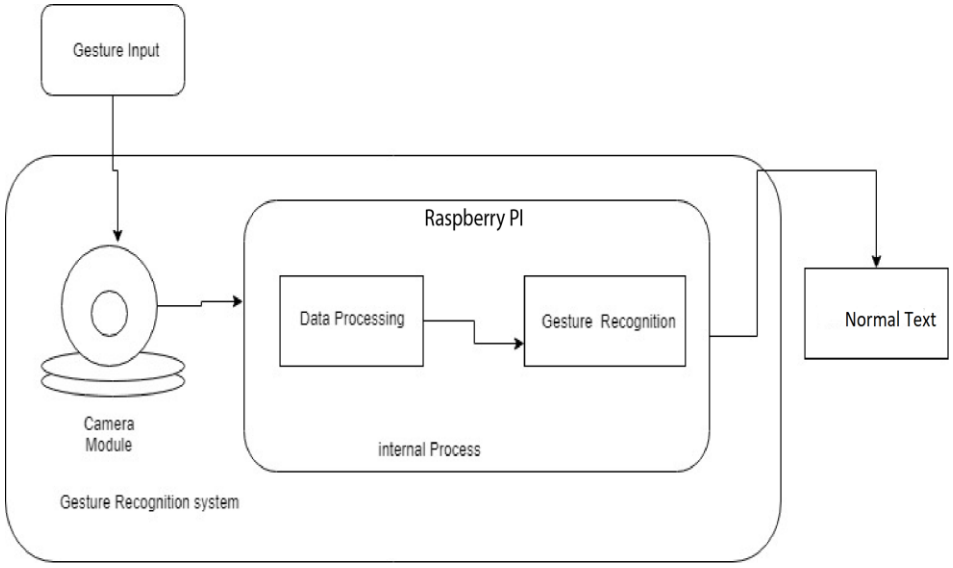

Figure 3.1: Schematic Diagram of Hand Gesture Recognition System

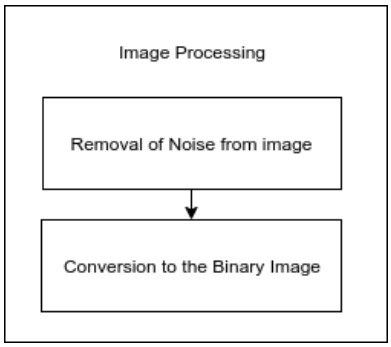

Figure3.3: Image Processing Section

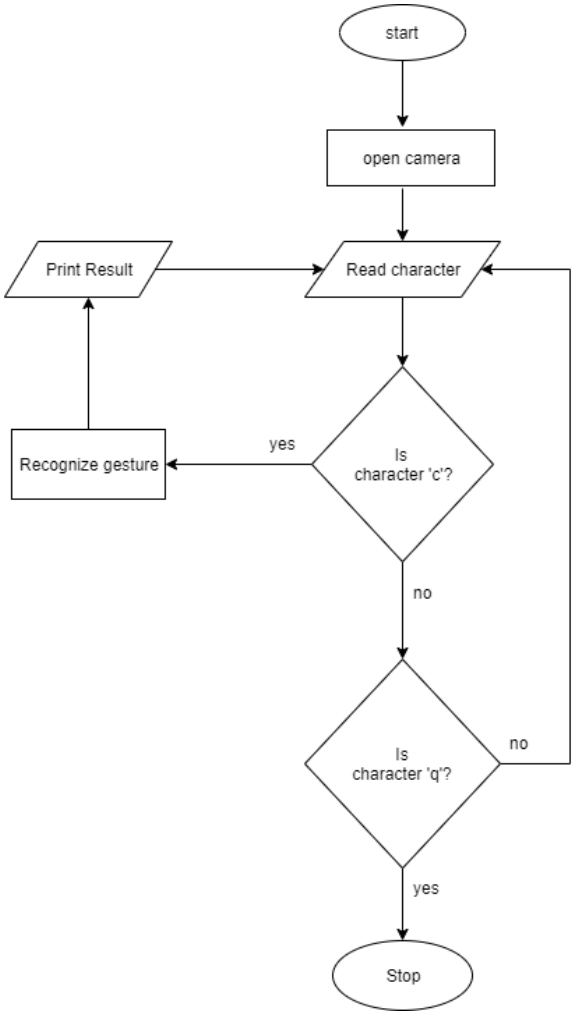

Figure 3.2: Flowchart of the recognition system

During Image Processing step two main tasks take place they are: -

1. Removal of noise from the image and
2. Conversion to the binary image.

Removal of noise is done by using the Gaussian filter as shown in eq(i).

$$G(x,y) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{\frac{-x^2+y^2}{2\sigma^2}} \dots\dots\dots\dots (i)$$

where x is the distance from the origin in the horizontal axis, y is the distance from the origin in the vertical axis, and σ is the standard deviation of the Gaussian distribution.

The conversion of the image to binary is done by the thresholding process as shown in eq(ii).

$$T = T[x, y, p(x,y), f(x,y)] \dots\dots\dots\dots\dots (ii)$$

where T is the threshold value, x and y are the coordinates of threshold value point, p(x, y) and f(x, y) is the gray level image pixels.

The CNN model consists of two basic parts of feature extraction and image classification. Feature extraction consists of multiple layers followed by the *max-pooling* and *ReLU activation* function. In the convolution layer, the input image is filtered which is extracted by scanning a certain portion of the image which is 3 pixels by 3pixels in dimension. The output of element-wise multiplication forms the feature map. This step takes place until the whole image is scanned.

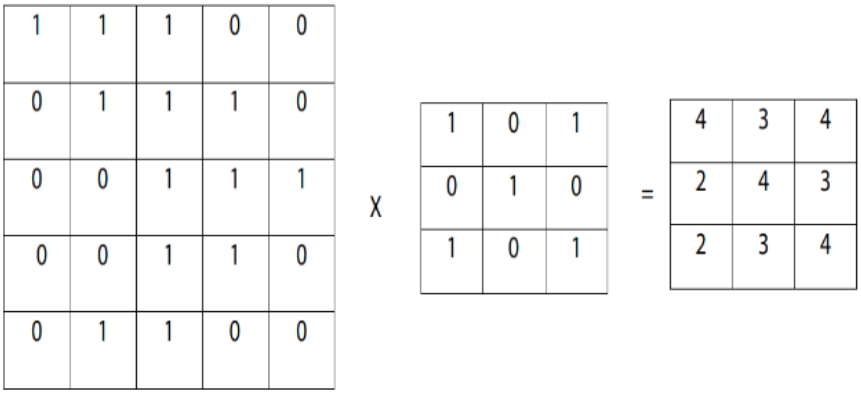

Figure 3.4: Convolutional Layer

At the end of the convolution operation, the output is subjected to the activation function for non-linearity which is also known as the ReLU activation function. At this phase, all the negative values are replaced by zero. After the steps of the ReLU the max-pooling steps take place which the main task is to reduce the dimension of the input image. The final layer of CNN is the fully connected ANN. The main goal of the ANN is to analyze the features of the input and combine them into different attributes that perform image classification.

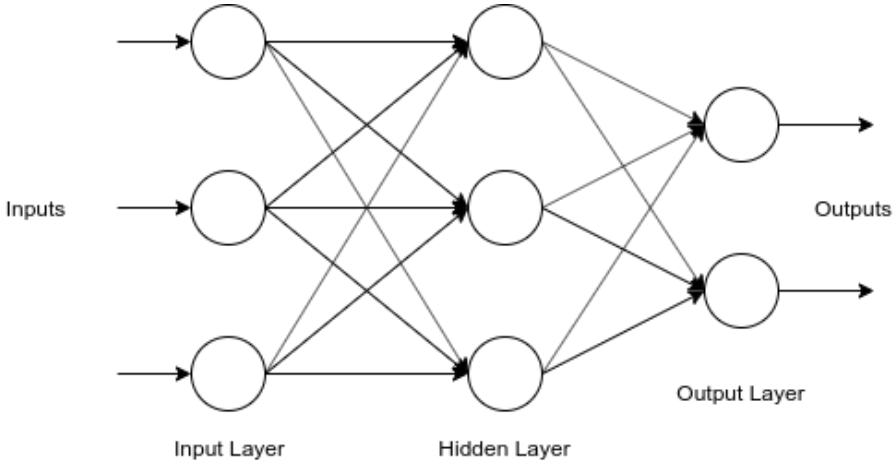

Figure 3.5: Fully / Densely Connected Layer

Simple CNN model network image classification has the architecture of [INPUT - CONV LAYER - RELU - POOL - FC]. The most common CNN follows the pattern:

INPUT -> [[CONV -> RELU] *N -> POOL?] *M -> [FC -> RELU] *K -> FC

where

* represents the repetition,

POOL? Represents the optional pooling layer and

K, M, N are the constant value that is >= 0(K, N values is usually <= 3).

3.2. DATA COLLECTION

The proposed hand gesture recognition system is focused to recognize the static gesture, to train the system, and to classify gestures the dataset is required. For training ASL data-set from National Center for Sign Language and Gesture Resources (NCSLGR) is used that is available at *http://www.bu.edu/asllrp/ncslgr.html.*

4. IMPLEMENTATION AND EXPERIMENTS

4.1. HARDWARE AND SOFTWARE

The proposed system uses Raspberry Pi, a camera module, and a workstation computer. The system is programmed in python language with version 3 and multiple libraries like Open CV, NumPy, Matplotlib, TensorFlow, and Keras are used for data processing, model building, and testing. Raspberry Pi is configured with Raspbian OS that supports python 3+.

4.2. TRAINING AND GENERATING CONVOLUTIONAL MODEL

CNN is used as an artificial neural network to train the system with the dataset of ASL. The dataset consists of a variation of the same gesture which will train the system to get more accuracy with variations of the same gesture. This helps to recognize gestures in various conditions. The features of each image are extracted and stored for future use in the image classification process.

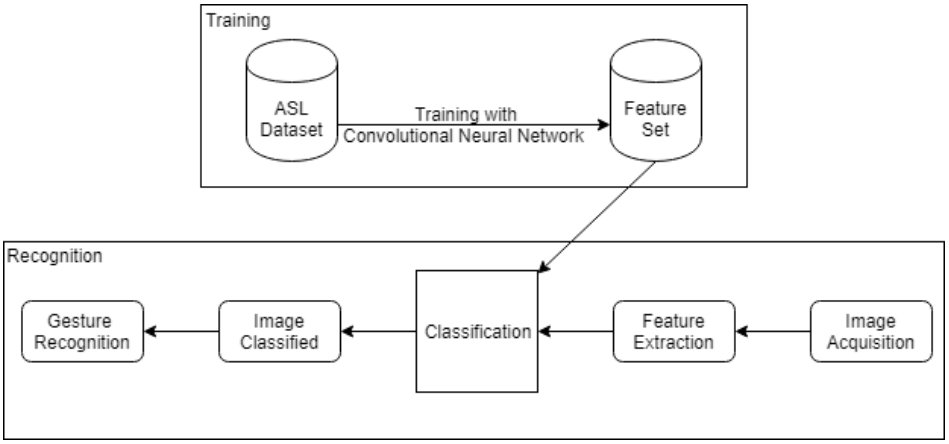

Figure4.1: Training and Image Classification steps

The model was trained with features extracted for 25 iterations/epoch with ReLU and SoftMax activation functions. ReLU activation function is used for non-linear activation function and is the most used activation function. The main task of the ReLU activation function is to eliminate the negative input and make it 0 and does not change the positive input value.

$$f(x) = max(0, x) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (iii)$$

The SoftMax activation function is used to turn the input numbers to the probability to be in a certain class which ranges from 0 to 1.

$$\sigma(z)_j = \frac{e^{z_j}}{\sum_{k=1}^{K} e^{z_k}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (iv)$$

where, z is the vector of input to the output layer and j indexes the output units, so j = 1, 2, …, K.

4.3. FEATURES OF THE PROPOSED SYSTEM

The features of the proposed **Hand Gesture Recognition System** are: -

1. The proposed system is built using the python3 programming language which makes the system operating system independent i.e. the system can run on any operating system that can run the python 3 and the required libraries Keras, TensorFlow, NumPy, Pandas, Matplotlib and OpenCV.
2. The proposed system can recognize the simple static gesture of the ASL alphabets.
3. The proposed system is modular and can be easily updated or upgraded.

4.4. TESTING AND EVALUATION

The model is trained and tested for accuracy and loss. The model has tested with the characters dataset of the ASL and was evaluated during the process of training. Figure 4.2 shows the results.

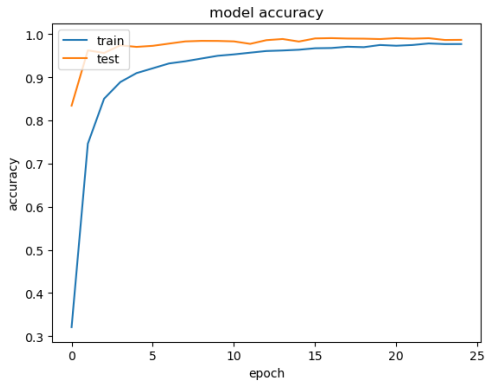

Figure 4.2(a): Model Accuracy

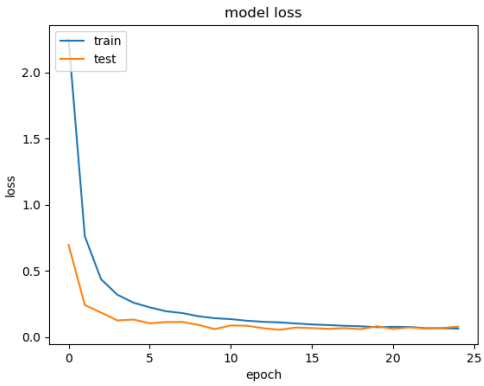

Figure 4.2(b): Model Loss

The model was also tested in a real-life environment in indoor settings. Figure 4.3 shows the outcome with the predicted text.

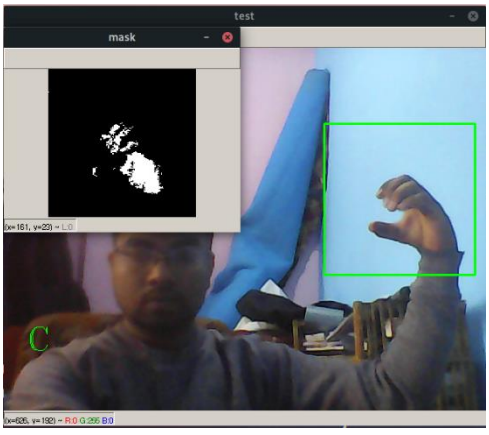

Figure 4.3(a): ASL character C detection

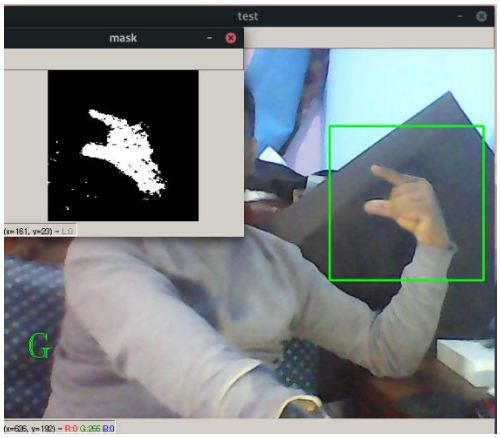

Figure 4.3(b): ASL character G detection

4.5 RESULTS

The proposed Hand Gesture Recognition System uses ASL alphabets gesture datasets to train the model. The dataset is divided into two sets one is training and the other is testing sets. Each set contains a threshold image of each character from A to Z which is 26 characters. The training set contains the training image of 1750 and a testing set contains 250 images.

Table 4.1: Training Accuracy and Loss Result of multiple Algorithm

Model	**Average Accuracy**	**Average Loss**
CNN	98%	2%
SVM	92%	8%
HECS	97%	3%
CaffeNet	88%	12%
SAE-PCA	93%	7%

Comparing multiple neural networks, table 4.1 shows the training accuracy and the loss of the particular model. CNN model shows a high level of training accuracy and low loss which states CNN to be the best model for image classification on the dataset.

Testing of the system with real-life gesture input in two different lighting conditions one with bright lighting conditions and with the single-colored background and other with the normal lighting condition was also conducted. For both configurations, the number of inputs was 10 different gestures.

Table 4.2: Testing System in good lightning condition

S.N.	Sample	Result
1	M	Not Recognized
2	E	Not Recognized
3	I	Recognized
4	H	Recognized
5	G	Recognized
6	S	Not Recognized
7	Y	Recognized
8	L	Recognized
9	C	Recognized
10	V	Recognized
Accuracy		70%

Table 4.3: Testing System in average lightning condition

S.N.	Sample	Result
1	M	Not Recognized
2	E	Not Recognized
3	I	Not Recognized
4	H	Recognized
5	G	Not Recognized
6	S	Not Recognized
7	Y	Recognized
8	L	Recognized
9	C	Recognized
10	V	Recognized
Accuracy		50%

For real-life environment testing, the accuracy rate was higher for the environment with good light. The system was able to classify 70% of gesture whereas while the object was not exposed to normal lightning condition the system was able to classify the gesture with an accuracy of 50% only.

5. CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

An American Sign Language recognition system using the Convolution Neural Network for Raspberry Pi was developed using the implementing CNN model. It was able to recognize the simple static ASL gestures with accuracy above 96% and classify real-world environment images with accuracy above 70% in good lighting conditions. This result was possible due to the fact, CNN being very effective in reducing the parameters without losing the quality of models. Besides that CNN was developed especially keeping images into considerations. Also comparing to other popular neural networks, CNN follows a hierarchical model which works on building a network and finally provides the fully connected layer which makes the CNN contain many layers for feature extraction due to which it is more efficient for image classification. As specified on research gap, much research were held to be solve the problem of hand gesture recognition or human computer interaction where most of them required the external input device for better accuracy where the purposed system eliminated the requirement of the external input device. Besides that, comparitivly the purposed system did not required high computational power as the purposed system ran on top of the raspberry pi 3.

5.2 RECOMMENDATIONS

The system can be enhanced to work more accurately and extra features like dynamic gesture recognition can be added in further future. As for more accuracy, the system requires good lightning conditions which can be enhanced by using calibration methods. The system can also be enhanced by adding up features to add more datasets.

As for the future, the system recently can recognize the ASL character only and can be enhanced to recognize the digits and the dynamic gesture too. The system particularly requires good lighting condition to recognize the gesture and can be enhanced by using a depth-sensing camera which helps and allows to recognize the 3D gesture and the motion gesture.

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SPEECH RECOGNITION IN AUTOMATED HOME LIGHTING SYSTEM

Sk Abu Baker Siddik*[1]

[1] Faculty of Engineering, Science and Technology, Nilai University
No 1, Persiaran University, Putra Nilai, 71800 Nilai, Negeri Sembilan

ABSTRACT

Computers and mobile phones are frequently used to perceive information such as sound, picture, vibration and temperature. Among these, information through voice play a vital role especially in Voice User Interface. Emerging technologies enable remote control in home appliances using voice command. Some of the widely used and efficient technologies of speech recognition are ANFIS (Adaptive Neuro-Fuzzy Interference System), Zigbee and Bluetooth wireless communication system. Among them, ANFIS has a very complicated and huge system to operate signal processing in Smart Home. On the other hand, Zigbee and Bluetooth are both considered as short range wireless communication systems to identify speech command signals. From these two, Zigbee always needs to remain online and internet signals are not directly compatible with mainstream computers. However, the Bluetooth system does not need the internet and is directly compatible with any mainstream computer through wireless communication system. However, the Bluetooth system has a higher bandwidth than the Zigbee system to process signals. Past studies show that speech recognition is one of the more popular research areas since the accuracy of speech recognition is still affected by noisy environment. Hence, this research was conducted to recognize voice command in a noisy home environment to control home appliances using Bluetooth based platform. In addition, this project also applies the Bluetooth phone as a client and Arduino UNO microcontroller as a server to avoid redundant noise and to improve performance. The results showed that the proposed methodology has improved the speech command recognition in controlling home appliances.

Keywords: Home appliances, Bluetooth wireless communication system, Arduino UNO microcontroller, Speech command

INTRODUCTION

At present, speech recognition technologies are developing in the area of Smart Home environment. The reason of these standardized automation system are to provide comfort to the people, especially those people who are physically disabled and elderly people. With regard to comfort, the control elements of building automation can be adapted to the SH user's requirements (Pies 2018), (Slanina 2018).

In home automation area one of the possible facilitation is speech control. This speech control presents a great advantage for a certain group of people, which in particular includes seniors and disabled persons. By using voice or speech commands, for instance, people can simply switch the light on and off. On the other hand, Smart Home appliances speech control system has its drawbacks. Normally, every room in the house object has its own acoustics which essentially distorts the spoken command. There can be different type of noise may occurs in different room, which substantially reduce the success rate of recognition of the spoken commands (Vanus et al., 2018). One of the important problems in speech recognition is background noise of the speech command.

The aim of this proposed system is to build an ideal companion for someone to be at home. This system is a computer and phone based system that can accept voice as well as direct commands and process them. The system provides switching any LED (Light-Emitting Diode) lighting device ON or OFF. The system will reduce or avoid extra unnecessary background noise such music, voice and other sounds while the actual command is given to the system for turning on or off the light.

PROBLEM STATEMENT

Nowadays, in Speech control Smart Home automation, the extra background sound or ambient noise of the surroundings affects the efficiency of speech recognition. The interfering background sound contains noise which make problem to the system for understanding the speech command and the difficulty arises in speech recognition. Thus, the system became exhausting to listen and understand the speech in noise. Speech command issues by the human become harder by the system to pick up. This is a problem for persons who are, for health reasons, unable to manually handle the controller for e.g. the lighting.

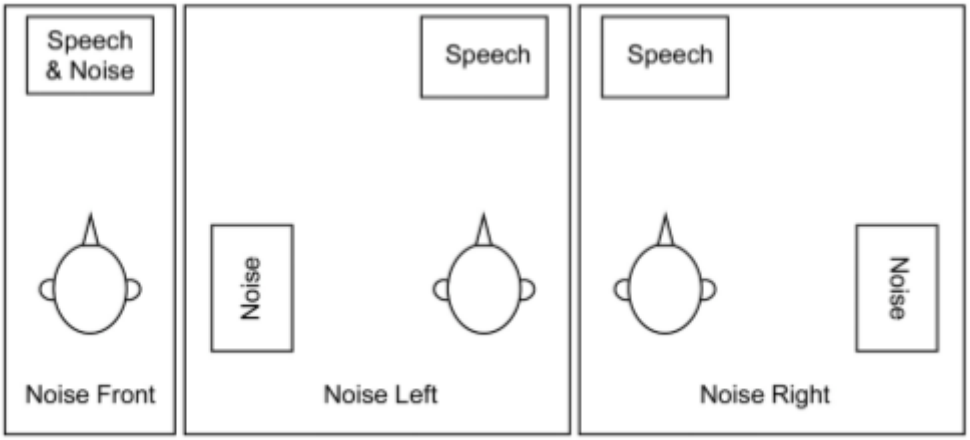


Figure 4: Sound-field condition of Speech and noise.

In figure 1 the Noise Front is showing the result of speech and noise issues together. The Noise Left is showing the clear picture that the noise issues from the left-bottom side of the room and the Noise Right is showing the clear picture that the noise issues from the left-bottom side of the room. So, the noise can be issued from any side or point of the room that may create problem to recognize the voice command. (Vanus et al., 2018)

Table 1: Table shows different types of homes, rooms and noise conditions in the Smart Home area.

Home	Room	Noise conditions
Home 1: House	Room 1: Living room	• Someone reading the newspaper. • Music played on a loudspeaker. • Someone shaking a box of pencils.
	Room 2: Dining room	• Someone playing with a toy. • Someone using a bell. • Someone putting plate on table.
	Room 3: Kitchen	• Someone playing with cutlery. • Someone shaking a jar of seeds. • Beeps played by a microwave.
Home 2: Flat	Room 1: Living room	• Someone reading a book. • Music played on a loudspeaker. • Someone using an indoor bike.
	Room 2: Kitchen	• Someone using a manual roller shutter. • Someone washing the dishes. • Someone opening and closing the oven door.
	Room 3: Bedroom	• Someone opening and closing the storage cupboard door. • Someone pressing the keys of a laptop. • Someone watching TV with sound.

At table 1 the home has two categories such as House and Flat. The House has three different rooms consider as Living room, Dining room and kitchen. On the other hand the Flat also has three rooms seems as Living room, Kitchen and Bed room. At the right side of the table the Noise condition is showing ‘how the noise can be created in to the rooms’ and cause trouble to get the actual voice command given by the users. (Vanus et al., 2018)
In conclusion, the proposed method is focused on solving the problem of command understanding and produces best the result in noisy environment.

OBJECTIVES

There is still gap on home automation system that can be implemented by the latest current technologies. The objectives need to be clarified before improve the system and application so that it can give proper guidance and directions. This project focuses on the following objectives -

- To able to take speech command for turning on or off the light in speech recognition home system.
- To reduce the background noise that captures on the speech command.

SCOPE

The proposed method is intended to reduce the noise from the noisy environment while giving command ‘turn on’ and ‘turn off’ to the system. The proposed system that captures voice command and all background noise then understand the speech and noise. After that the system calculates and filter the given speech command noise with the application sound’s noise reduction method. Finally, the system able to turn on or off the light by matching stored command and captured.

METHODOLOGY

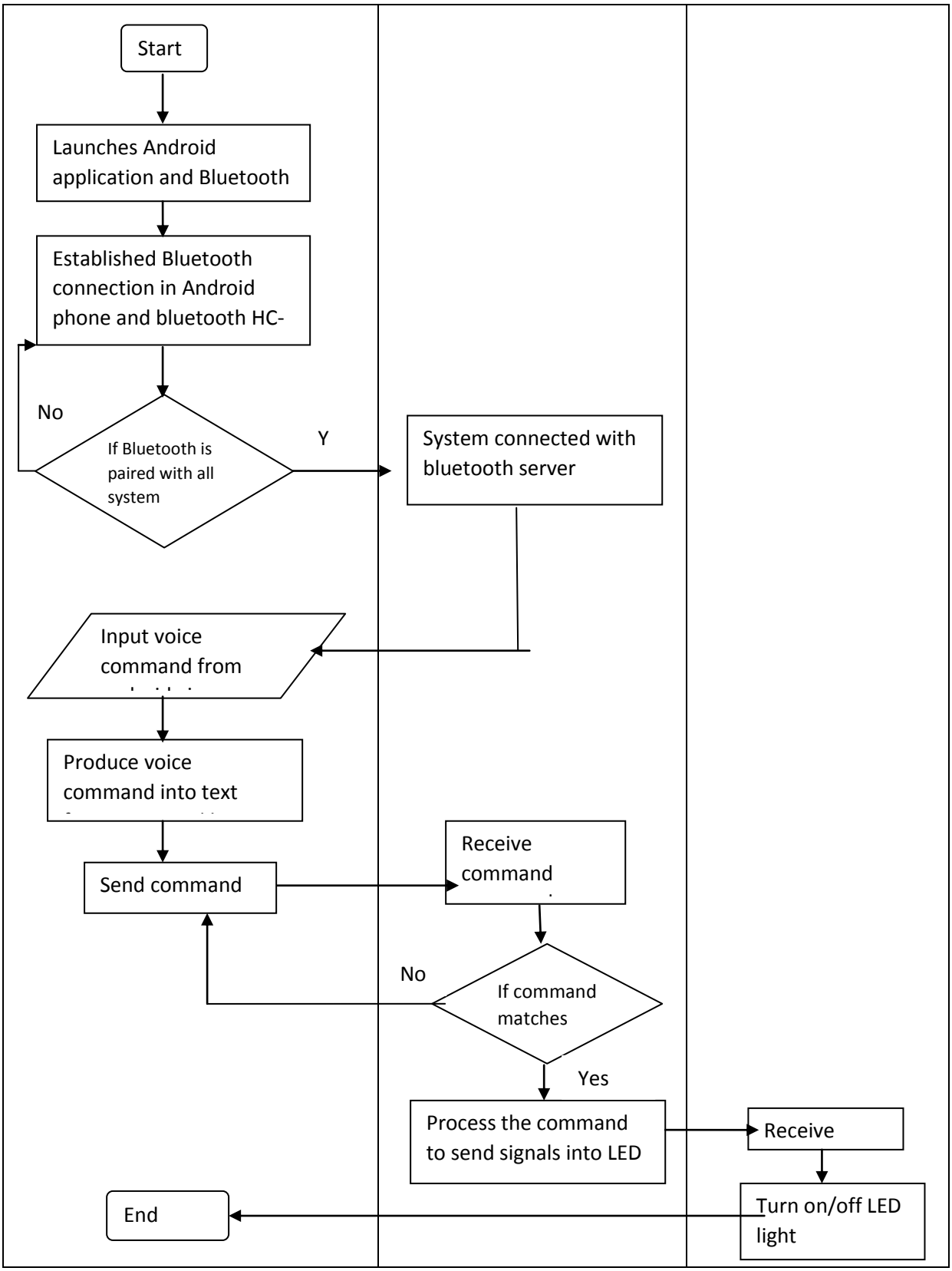


Figure 2: Flowchart for Voice Recognition Smart Home Automation system. This chart is showing the whole operational framework of user, the system and home appliances such as LED light.

The first step to process overall system is the user should launch the Android Application such as Android Phone Speech Command application which helps the user to connect the phone with HC-05 module Bluetooth device. The HC-05 module must have to connect with the Bread Board which wired with the Arduino Uno device. However, the Arduino UNO needs to be programmed with the Arduino IDE. Once the bluetooth connection establishes between Android phone and Module, the Android phone will consider as Client and the Bluetooth module and Arduino system will consider as server. The user must have to give command through the phone using record button.

Then, the android phone application has the Voice Recognition method to recognize the voice command and other sound or noises. Later, the method should avoid or reduce the noise from the command and bring out the actual command. This method algorithm helps to convert the actual command into the form text command. While the method gets the test command, phone bluetooth transfer that digital command into the Arduino board. The Board receives the command by using bluetooth module HC-05. The android phone client always gives the command and Arduino server system detects the command and produce command into signal.

Last, the programmed Arduino UNO board processes the digital command and converts it to analog signal. The Arduino programmed algorithm method helps to match the text command into the system. After that, the system sends the actual signal into the appliances. If the appliances received the right signal then the LED light become on or off.

HARDWARE REQUIREMENTS:

The following hardware components are required to fulfill this project-

- HC-05 Bluetooth Module
- Arduino UNO microcontroller
- USB cable.
- 7 connecting wires
- 2 LED lights (green and yellow)
- 1 Prototyping board (bread board to power supply)
- 1 smart phone (with Bluetooth)

- 1 Personal Computer (PC)

SOFTWARE REQUIREMENTS:

- MIT App Inventor (to create android app)
- Arduino IDE 1.8.9
- MATLAB

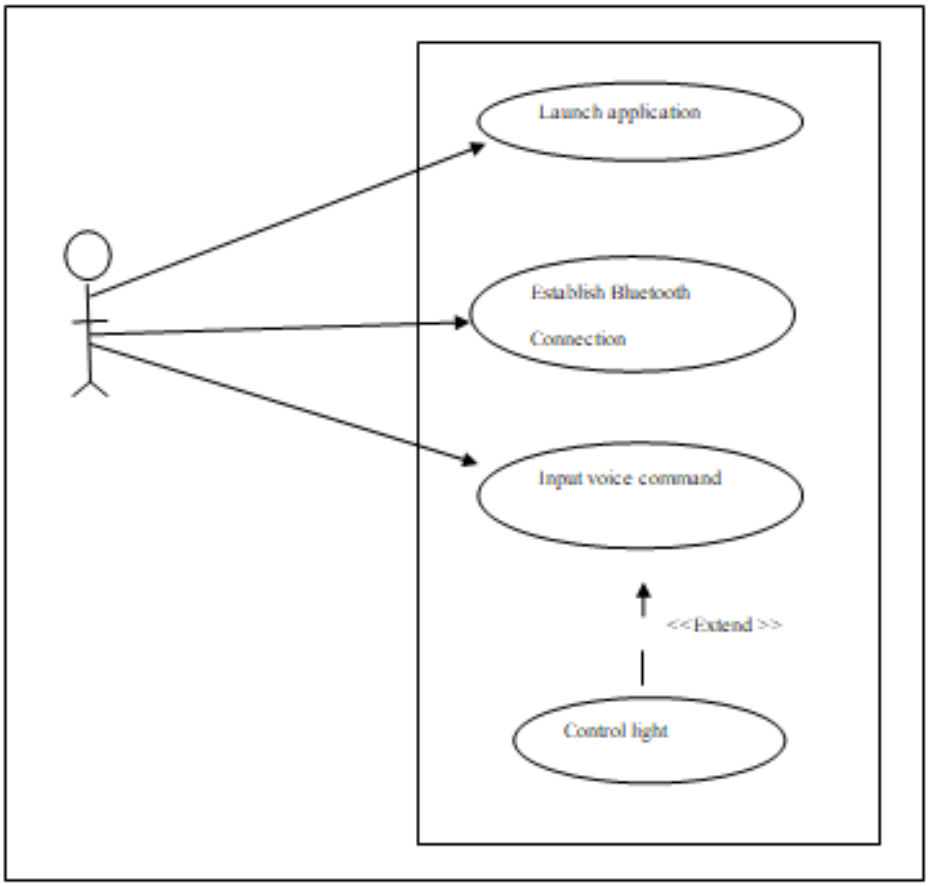


Figure 3: Use Case Diagram for home automation system.

In this project, user acts as a primary actor to launch android application. Then the user has to establish the bluetooth connection and input voice command using speech recognition. Then, the command can control the light on or off using that voice command.

TESTING

The following table is showing the testing of Voice command within the Android mobile app and Arduino Uno System.

No.	Bluetooth connection between Android and HC-05 module	Input voice command in android app (assumption)	Convert Voice command to text command in android app	Text command received by the Arduino serial monitor
1.	Connection establish	Voice command has given “turn on Green”	“turn on Green”	“turn on Green”
2.	Connection establish	Voice command has given “turn off green”	“turn off green”	“turn off green”

Table 2: Test table of the Voice recognition home automation system

RESULTS AND DISCUSSION

To operate the system methods, the user must have to give command into the Android Application by launching it.

(a) (b) (c)

Figure 4: (a) Bluetooth device it not connected. (b) Have to select HC–05 module by clicking bluetooth button. (c) Once the module is selected the app come back to home page with the message bluetooth is connected.

After that, the user should give voice command to recognize it by the speech recognizer method and transfer it to the server system through bluetooth. The table is showing the results of proposed system-

No.	Bluetooth connection between Android and HC-05 module	Input voice command in android app (assumption)	Convert Voice command to text command in android app	Text command received by the Arduino serial monitor	Expected results	Actual results	Comments
1.	Connection establish	Voice command has given "turn on Green"	"turn on Green"	"turn on Green"	Green LED Light on	The system turn on the Green LED light	Light becomes on because System recognizes it and change the light state.
2.	Connection establish	Voice command has given "turn off green"	"turn off green"	"turn off green"	Green LED Light off	The system turn off the Green LED light	Light becomes off because System recognizes it and change the light state.

Table 3: Result for the Voice recognition home automation system.

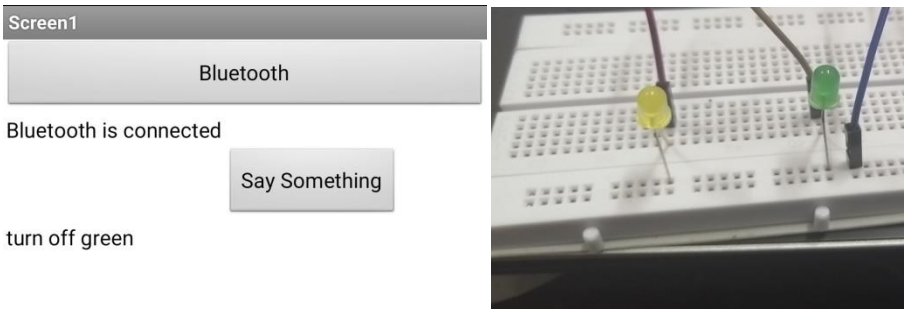
CHECKING GREEN LED LIGHT:

While the user gives the voice command “turns on Green” after pressing “Say Something” button from the application, the system recognize the speech and turns on the green LED light.

(a) (b)

Figure 5: (a) Getting the voice command to turn on green light. (b) After recognizing the command the system gets the signal and turns the green light on.

If the user says “turn off green” then the system turns off the light.



(a) (b)

Figure 6: (a) Getting the voice command to turn off green light. (b) After recognizing the command the system gets the signal and turns the green light off.

MATLAB RESULT:

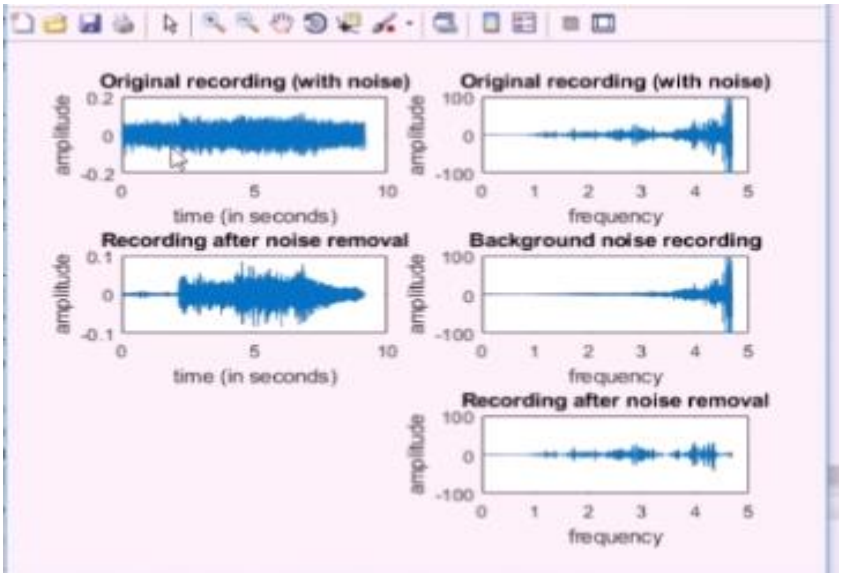
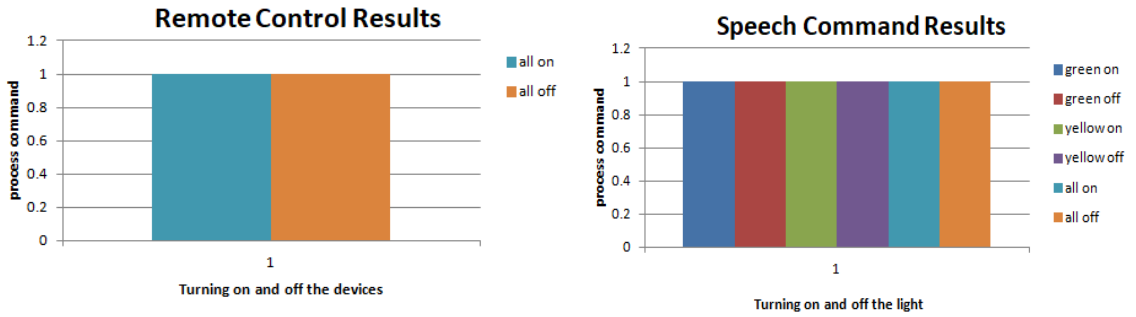


Figure 7: Checking noise reduction

The MATLAB able to check the noise from the original voice command and it create a new command file by reducing the noise in time and frequency.

GRAPH



(a) (b)

Figure 5: (a) Existing method result. (b) Proposed method result.

According to the result the author finds out that the existing method gives command of all devices on and directly it on the all devices but the system is consider as remote control system. So, the system always depends on the press button from the remote control. On the other side the proposed method has developed the system into a speech recognition system

where the results is showing that the user is giving speech command into the android application individual light and all light and the system act as command and produce the result based the command. The main comparison of both methods result is speech recognition method is able to turn on the light instead of remote control which saves human labor and consider the system smart automation.

DISCUSSIONS

The overall system is working very well. The bluetooth based current Smart Home has the remote control system but the proposed system has developed the system using speech recognition method. It has improved the system's performance and producing the best result. The MATLAB has managed to check the noise reduction.

After analyzing the system software and Components, the author has found out that the expenses of Home Automation component are costly in some technology. There Cons and Pros are different. For better understanding there is a comparison between Bluetooth and Zigbee has made.

COMPARISON BETWEEN ZIGBEE AND BLUETOOTH AUTOMATION:

There is a lot in common between Zigbee and Bluetooth, like both operating in the same frequency band of 2.4 GHz and belonging to the same wireless private area network (IEEE 802.15). But even if this is the case, they are not exactly competing technologies. Also, there is a multitude of differences between the two wireless technologies for 'personal area networks' both application and technical.

Such as Bluetooth range is around 10 meters whereas Zigbee can cover around 10 to 100 meters. The complexity of Zigbee in device and application impact is low on the other hand Bluetooth has high complexity on device and application. Zigbee can operate with very low power, it means Zigbee consume very low battery and Bluetooth also consume medium battery. The battery life of Bluetooth is medium. Zigbee has 128 AES plus application layer security whereas Bluetooth has 64 and128 bit encryption. Most of the case Zigbee application used in industrial control and monitoring sensor networks, building automation, home control

and automation, toys and games. Bluetooth has wireless connectivity between devices such as mobile phones, PDA, laptops, headsets, digital cameras etcetera. Zigbee modulation technique spreading with direct sequence spread spectrum (DSSS) and Bluetooth has done this with Frequency hopping spread spectrum (FHSS). Zigbee protocol stack size is 28 Kbyte and Bluetooth protocol stack size is 250 Kbyte. Zigbee battery is not rechargeable (one reason batteries will last up to 10 years and Bluetooth batteries are intended for frequent recharging. The data rate of Zigbee is 250 Kbit per second and Bluetooth data rate is 1Mbit per second which is more than Zigbee data rate. Zigbee application used for monitoring and control and Bluetooth application just need cable replacement. The typical network join time of Zigbee is 30 milliseconds and in Bluetooth it takes 3 seconds. In Zigbee system can use 64k devices for network whereas Bluetooth system can use only 7 devices. Bluetooth was designed for low power consumption with short range communications. The Zigbee system managed by Zigbee alliance and Bluetooth managed by SIG (Special interest group). In Bluetooth their primary focuses on enables user mobility and eliminates the need for cables and wires. On the other hand Zigbee focus on more applicable for large scale remote controls and large scale automation purpose. (KAYA, 2019)
The technology is useful when transferring information between two or more devices that are near each other in low bandwidth situations. Bluetooth is commonly used to transfer data with devices or byte data with hand held computers.

The newest version of the protocol, Bluetooth LE, which stands for “low energy,” uses very little power in comparison to Wi-Fi. The developers behind it also recently announced it will be able to form “mesh networks,” a capability that puts it in further competition with Zigbee and Z-Wave. Mesh networking is where a device has the ability to receive a networked signal and also send out the same signal, extending the range of that network. For these reasons, Bluetooth is not only increasingly popular in smart homes, but many smart phone accessory makers are tapping it for their products.

Bluetooth based system has less cost than the Zigbee. The overall costs for the bluetooth based Smart Home Automation system components are showing on the following table.

Component pricing:

Components	Price (Ringgit Malaysia)
1 piece Arduino UNO microcontroller	RM 65
1 piece USB cable	RM 8
1 piece Bluetooth module HC – 05	RM 10
2 pieces LED light	RM 2
7 pieces Copper joining wires	RM 3.5
1 piece Prototyping bread board	RM 10
Total	RM 98.5

Table 4: Component price for bluetooth based home automation system

CONCLUSION

In conclusion, the system is user friendly and effectively low cost for any kind of user. All the time, whole house or home lighting system remains under the user control. The results outputs are totally controlled by the bluetooth wireless communication system technology. This technology helps to communicate one system to another system. The whole Smart Home Automation system using speech recognition has three different types to software and programming to work or communicate with a lot of device and components. Each program and component have utilize in a proper way. This system is able to do the task as mentioned in the result and discussion chapter. It is giving better performance than the previous existing device. This whole system is very helpful for those people who cannot walk elderly and disabled people. This system also can be used for people's luxurious and comfort life they can set up. The goal of the system is to reduce human labor and save time which is achieved.

ACKNOWLEDGEMENTS

First, I would like to express my special thanks of gratitude to my supervisor, Dr Abbas Mehdizadeh for taking me under his supervision. A special thanks to my Head of Department, Ts Harlina Harun who gave me the golden opportunity to work on this wonderful project on the topic Speech Recognition in Automated Home Lighting System. Moreover, I would also like to thank my lecturers, colleagues and friends who helped me a lot in finalizing this project within the limited time frame.

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INTELLIGENT WHEELCHAIR USING HUMAN BRAIN CONTROL SYSTEM AS ASSISTIVE TECHNOLOGY FOR PARAPLEGIC PATIENTS

[1]Muhammad Huzaifa, [2]Dr. Deshinta Arrova Dewi*

[1]Faculty of Information Technology (FIT), INTI International University
[2]Centre for Emerging Technologies in Computing (CETC), INTI International University
Jalan Persiaran Perdana BBN, Putra Nilai, 71800 Nilai, Negeri Sembilan
i17013588@student.newinti.edu.my **,** *deshinta.ad@newinti.edu.my*

ABSTRACT

Estimated more than 5.4 million people in the world are currently suffering and living with some form of paralysis. They are unable to work with full capacity leads to anxiety or depression. Although previous researches had come out with a variety of assistive technologies, this research area still continuously grows and becomes prominent in the medical applications. Our paper intends to explore the possibility to use the human brain control system integrated with a wheelchair to help the paraplegic patient become more interactive with their surroundings and live their life as much as they can. We use a sensor called Electroencephalogram (EEG) embedded in a headset to detect electric pulses in the human brain. Those electric pulses are converted into commands and decisions that are recorded and assigned as movement control keys e.g. left, right, up, and down. We have successfully developed a wheelchair prototype using an EEG sensor with Bluetooth connection to a laptop. Upon four directions movement that we observe using one human brain control, the result shows that turning right and left direction obtain faster execution than reverse and forward direction. This result may vary with a different human brain. We also observe the duration for a thought command sent from EEG to a wheelchair. The result shows that reverse command obtains the least duration compared with others. With this development, we prove that a human brain can control the movement of a wheelchair. This prototype can be customized for paraplegic patients to help their movement. With this assistive technology, a paraplegic patient can be more independent, happy, and confident for a fast recovery.

KEYWORDS: Intelligent Wheelchair, Human Brain Control System, Paraplegic Patients, Assistive Technology

1.0 - INTRODUCTION

1.1 – OVERVIEW

Brain-Computer-Interface (BCI) is referred to a direct link between the Brain and an output electronic device, in which the brain is linked to an EEG (Electroencephalogram) which then sends data to a processing unit and an output interface or object. Hence, replacing the traditional input devices such as a mouse, keyboard, touch interface, or other controllers. BCI applications are created through two different techniques in recent years, Invasive Technique: In this technique, surgery is involved in which electrodes are placed inside the skull to have the most accurate capturing of electrical activity. Non-Invasive Technique: In this technique, electrodes are simply placed over the scalp of the person and able to detect electrical activity. The present research studies in trending, mostly focus on non-invasive BCI. Although it doesn't give the most accurate results but is most convenient to be readily accepted in the current market. (D.J.McFarland, 2016) (Devashree Tripathy, 2014) . This paper aims to explore the possibility of using the human brain to control the movement of an object and benefited the paraplegic patients. The illustration of the BCI is depicted in figure 1. A human brain wave is captured using EEG then analyzed, and recorded with real-time data interpretation. The interpretation is forwarded to the application as inputs and visual feedback as output is directed to the human.

Generally, BCI consists of mainly three sections.

1. An EEG device which detects brain signals in brain waves.
2. The application software which translates and communicates the brainwaves into some recognizable commands and controls.
3. The object or interface being controlled, this could be a cursor on the screen being controlled, a wheelchair, rover, or an avatar in gaming.

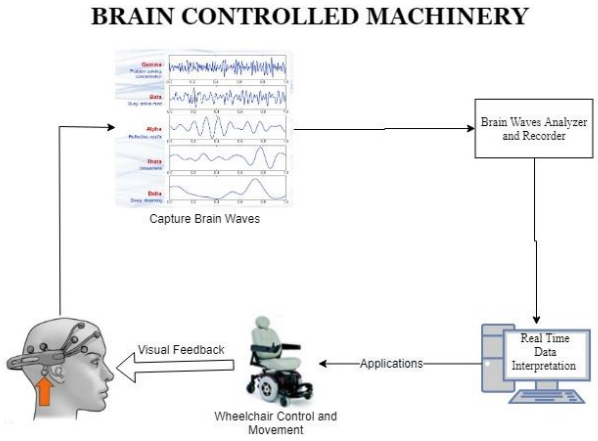


Figure 6:Brain Machine Interface

1.2 - PROBLEM STATEMENT

From data gathered by the World Health Organization Charts, and others a large population of the world struggles with physical challenges for movement and control. This includes patients with paralysis, severe spinal cord injury, and other physically challenged individuals. In such a scenario, people suffering become more restless and feel more hopeless in life. These patients are kept with the utmost care and precautions. They are unable to give feedback or response to any stimuli, pain, or pleasure. The only way to know is said to be the gut feeling of the caretaker; the tears of joy could be interpreted as tears of sadness. (Anon., 2019)

1.3 - PROPOSED SOLUTION

Most research and development sections in corporations and universities are working on the development and deployment of BCI for humanitarian purposes like brain-controlled wheelchair systems, Brainwave based keyboard, Brainwave based communication devices, using EEG devices to Control robotic limbs (Sam B. Fok, 2011) (Bernhard Graimann, 2010). The solution that we proposed has different than theirs whereby our solution provides control movement to the patients to interact with their environment. The electric pulses of the human brain are captured by EEG and then converted into commands and decisions. These commands are recorded and assigned as movement control keys on the system interface e.g. left, right, up, and down. With this approach, our solution does not entirely enable the patients to express themselves but also gives them control via their brain activity. This allows them to be more mobile and have a sense of an optimistic life hence a hope of recovery.

2.0 - METHODOLOGY

2.1 - DEVELOPMENT METHODOLOGY

We use Rapid Application Development (RAD) as our development methodology. The reason to choose this methodology is to find any issue in an earlier stage and resolve it quickly. RAD methodology consists of analysis and design, prototyping (develop, demonstrate, refine), testing, and deployment of the product. The analysis and design as the first step refer to system requirement specification as a result of data collection in the preliminary study. Questionnaires and surveys as part of data collection were conducted towards paraplegic patient's relatives and non-relevant people. Apart from that, we also collect responses via Interviews with medical caretakers, such as nurses, neurologists, general physicians, and from a recovered paralysis patient. The next stage is system analysis and design. In this stage, we execute data based on the requirement and we come out with several diagrams like use cases and rich pictures to identify processes involved in the prototype development. Afterward, the relevant operating system, API, hardware, and software are selected and integrated. Several testing requires at this stage to settle the compatibility issues before it goes for operation. Hence, two testing methods are implemented i.e. black box and white box testing. After both testing methods are satisfied, the prototype is deployed. The following figure depicted the overall RAD step adopted in the study.

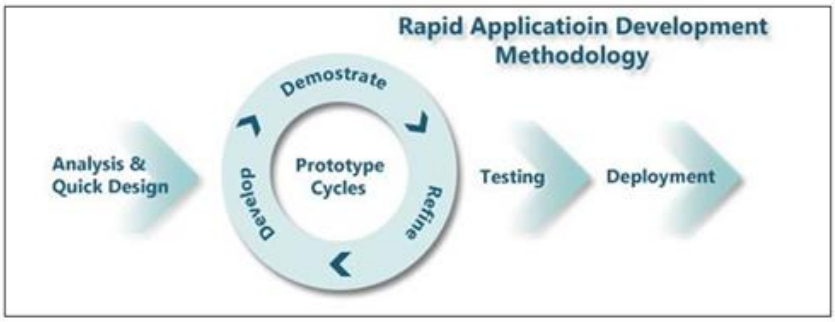


Figure 7: Rapid Application Development

2.2 - SYSTEM ARCHITECTURE

The system proposed as a solution is a rather simpler direct approach o solution with minimalist complication. The EEG headset comes with its API, upon registering account credentials are allocated for usage. Making use of these credentials a connection is made to API, the data collected from the headset is sent to API to be translated in real-time using WebSocket's connection using python and JSON tools and libraries. A live subscription connection is made with the API in a loop to fetch a continuous stream of data. Each stream of data received is processed and regulated into wheelchair movement controls. The following illustration shows the architecture of the system.

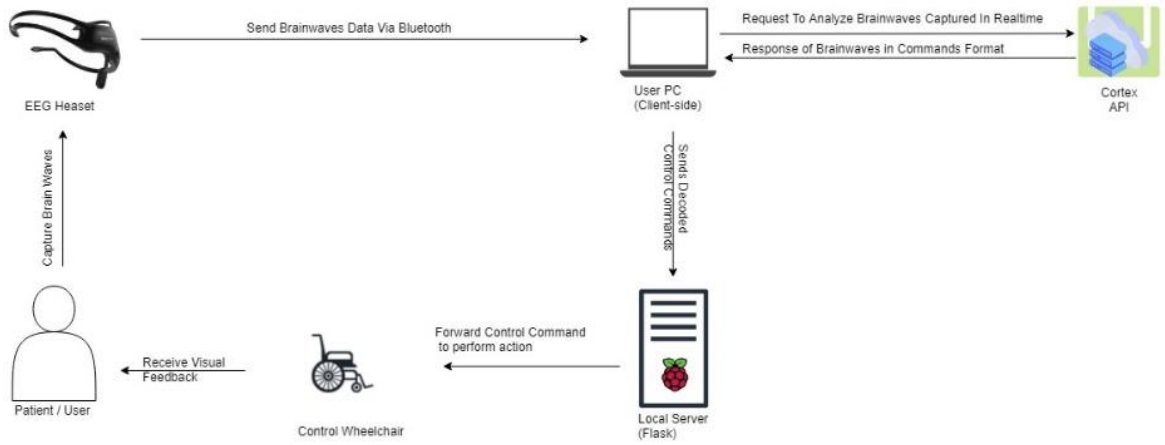


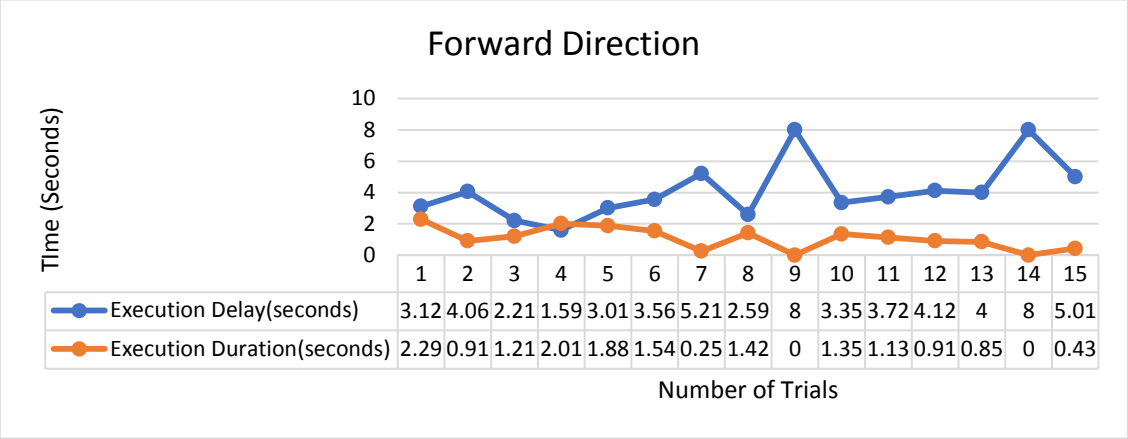
Figure 8: System Architecture

3.0 - RESULT DISCUSSION

The following figure 4 shows our prototype of the intelligent wheelchair that has been successfully developed.

Figure 4: Prototype of Intelligent Wheelchair

After the successful development of the intelligent wheelchair, we observe the wheelchair movement in four different directions. All results are illustrated in figure 5 for the forward direction, figure 6 for the reverse direction, figure 7 for the right direction, and figure 8 for the left direction. The results presented in the graph consist of 15 trials that each wheelchair's movement takes less than 10 seconds. The execution delay refers to the amount takes for sending out the EEG scanner data to the wheelchair whereas the execution duration refers to the amount takes for the wheelchair to move in one direction. We can see that delays may occur up to 8 seconds due to Bluetooth connectivity and resulted in no movements on the wheelchair. When the delay is less than 3 seconds, the wheelchair movement will be smoother and longer. The same trend shows in reverse, right, and left direction. This suggests connectivity can be the main issue in the operation. In terms of speed, we can see that left and right direction can be performed better than forward and reverse. This result may vary depending on human brain activity. Apart from the connectivity, the peaceful state of mind becomes another important factor for the movement of this intelligent wheelchair. More deliberations about the potential cause of delay are discussed in section 3.1.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Execution Delay(seconds)	3.12	4.06	2.21	1.59	3.01	3.56	5.21	2.59	8	3.35	3.72	4.12	4	8	5.01
Execution Duration(seconds)	2.29	0.91	1.21	2.01	1.88	1.54	0.25	1.42	0	1.35	1.13	0.91	0.85	0	0.43

Figure 5: Table Graph of Trials in Forward Direction

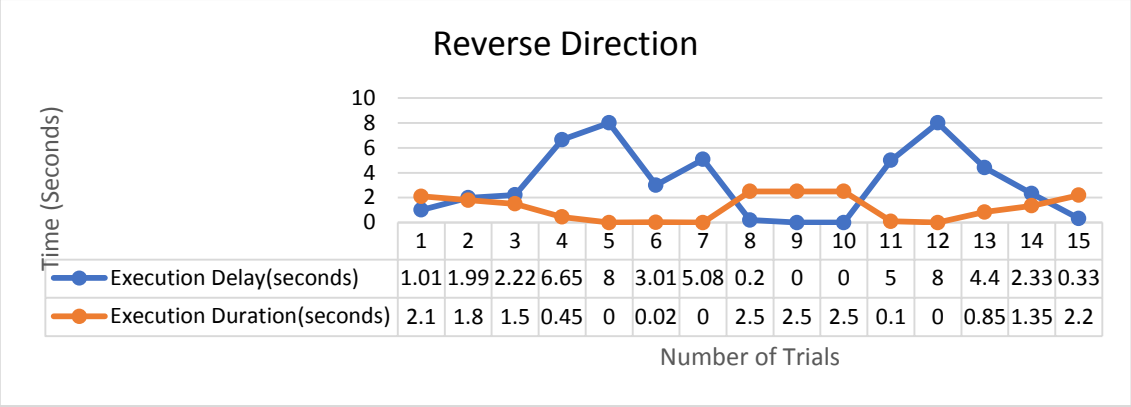


Figure 6: Table Graph of Trials in Reverse Direction

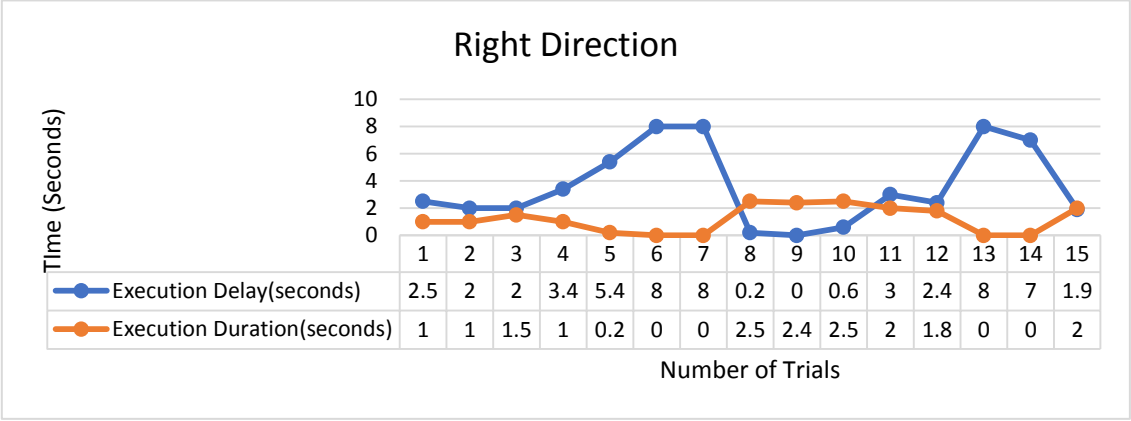


Figure 7: Table Graph of Trials in Right Direction

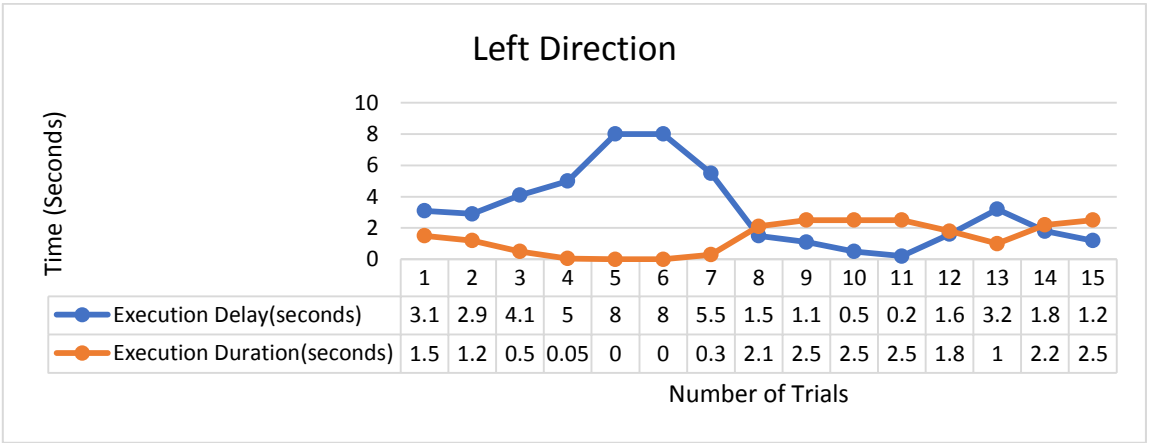


Figure 8: Table Graph of Trials in Left Direction

3.1 POTENTIAL REASONS FOR DELAYS:

1. The foremost reason for a delay is the connectivity delay, the data travels a long way from sensors to PC device via Bluetooth, then from PC device to API via an internet connection, and then way back to the PC device forwarded to the local server, which then commands the motor actions of the wheelchair.
2. Disruption in detecting brainwaves, as the electrodes placed on the head are prone to atmospheric disruptions, such as intense environments with high electrical activity in surroundings such as wireless devices nearby.
3. Bluetooth connectivity is prone to a lot of issues, so sometimes packets of data are lost, or corrupted during transference.
4. Lastly, Human Brain is complicated and there is no measure to identify when a certain thought is generated or not, certain focus and concentration are required, although the API provides a very responsive machine learning algorithm. But the uncertainty of thought generated is high.

4.0 - CONCLUSION

After performing several tests and trials, we confident that the human brain activity can be utilized to control the movement of an object, in this view is the wheelchair. This system has a certain success rate and further can be customized to the need of paraplegic patients. There are gaps and lacks in the system which can be improved further with a better device quality, further evolution in technology with further relevant development codes.

5.0 - ACKNOWLEDGEMENT

We would like to take this opportunity to convey our appreciation to all the members of the Faculty of Information Technology (FIT) and the Center for Emerging Computing Technologies (CETC) for their help and support.

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DEVELOPMENT OF SCADA IOT EMBEDDED WINDOWS SYSTEM FOR RESIDENTIAL PHOTOVOLTAIC MONITORING SYSTEM

Shawn Daren Sasitharan[1], Naveeyindren Thangarajah[2]

[1] Department of Mechanical Engineering, Faculty of Engineering and Technology, Tunku Abdul Rahman University College,Kuala Lumpur
[2] Department of Mechanical Engineering, Faculty of Engineering and Technology, Tunku Abdul Rahman University College,Kuala Lumpur

ABSTRACT

The global energy demand has made solar energy the most sought-after green energy source. Installing a photovoltaic system is high in cost and users would want to know important parameters related to the overall performance to know if their system is being utilised optimally. Thus, a simple monitoring system is needed and this project aims to develop a software based monitoring system to tap into an inverter of a particular photovoltaic system to collect relevant data. Three conceptual designs of the monitoring software were prepared and compared against. The best concept design is then chosen via Pugh Matrix. The final design utilises TCP/IP and Microsoft Power BI. TCP/IP is use to establish connection to the inverter and data from the registers of the inverter. The data is stored in a .txt file or a .csv file. From here, the file is loaded into Microsoft Power BI and the results obtained were analysed. A comparison of the developed software with existing monitoring system was made and the new software was shown to be superior. Implementing light and DHT sensors would enable prediction of output of entire panel, tracking of sunlight and measurement of temperature and humidity. These can further enhance the performance of the photovoltaic system.

Keywords: Photovoltaic System, SCADA, Monitoring System

1. INTRODUCTION

In today's technology, there are some renewable energy being implemented all around the world which includes wind energy, hydroelectric, geothermal, biomass and the most popular solar energy. From the environmental perspective, solar energy is considered to be the favourite choice because of the benefits it can provide. Solar energy can operate whenever there is light projected onto the solar panels. This also means that there will be no burning of any kind of substance leaving no harmful gases being released out into the atmosphere (Gibson, 2013). Implementing solar energy also can preserve the environment whereby there will be no destroying of forest to mine for raw materials. In the long run, solar energy can help to combat climate change (Larry, 2015). From the economical point of view, solar energy is a reliable energy source which means that it can support the generation of electricity for a long time (Seth, 2017).

However, a fully functioning residential photovoltaic system is not cheap in today's technological stand. Due to this factor, the information such as efficiency, daily yield, yearly yield, operation time, current and other information is highly important for users. These information are able to determine whether the photovoltaic system is performing at optimum level. In this project, an algorithm will be designed to obtain the data out from the photovoltaic system and project it onto a dashboard to allow residential customer to be able to customize and have a full understanding on the performance of the installed solar panel.

Photovoltaic is a process of direct conversion of light into electricity at the atomic level. When a substance can absorb photon and release electrons, it is known to have photoelectric effect. Electricity is created when these free electrons are captured and supply into a load. The most important part in a solar panel is the photovoltaic cell which is the part that generates electricity. There are mainly two types of solar cells which is monocrystalline and polycrystalline.

When light or photons comes in contact with a solar cell, the electrons are being knocked loose from their atoms. Electrical circuit is formed when there are conductors being attached to the positive and negative side of the cell. For a solar panel to be established, multiple cells are arranged together and if multiple panels are wired together, it becomes a solar array. The

energy created is directly proportional to the panels being deployed which also means that the more solar panels is deployed, the more energy it can generate.

Fig. 1. (a) Solar Cell; b) Solar Panel; c) Solar Array (Graham, 2015)

The electricity produced by the solar panel is in the form of DC current or also known as direct current. However, most of the grid only accepts in AC current or also known as the alternating current. Besides that, the outlet of a typical household is in the form of AC. To perform this operation, an inverter is needed. The primary use of inverter is to convert Direct Current to Alternating Current. Inverter acts like the brain of the entire photovoltaic system. Apart from inverting DC power to AC power, they provide ground fault protection, system stats which includes voltage production, current production, energy production and maximum power point tracking.

The overall operation of a photovoltaic system is depicted in the following illustration.

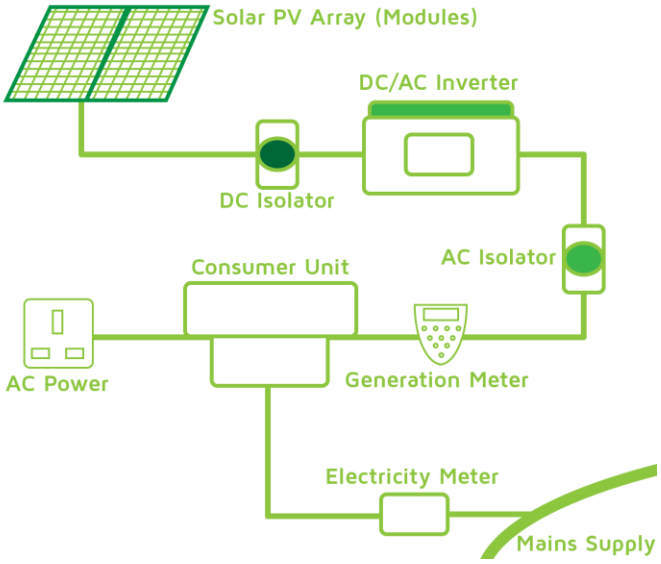

Fig.2. Overall illustration of a photovoltaic system (Ricky, 2016)

Upon installation of a fully functioning photovoltaic system, the inverter will be placed in an isolated environment such as underground, store room or even at the back of the residential house. This makes it tedious to always check the value of the inverter by walking towards it. Besides that, it will be much more convenient to have it check on mobile phone or laptop anytime when the user is in the house. Apart from that, most of the inverter logs the data every 30 minutes. This is not sufficient to see the smallest changes of the solar energy produced by the photovoltaic system. In another words, the inverter data is not sensitive enough. Another thing is that the inverter may not display all the information at the screen of the inverter. This may baffle customer on the performance of the photovoltaic system.

The limitations of the inverter are it is not able to plot a graph and compare to the power generated value. The display may only have the power generation and not the current or voltage. To be able to look at the current and voltage, it is able to determine whether the solar panel is functioning properly. To sum up, the data displayed by a typical inverter has the following limitations:

1. Absence of power, current, voltage generation graph for comparison.
2. Limited data is displayed on the inverter. The inverter only shows the production of power at instance time. It is impossible to track the previous data on the inverter alone.

3. The intervals of the data logged for each inverter varies with one another. A typical inverter logs a data in 10 minutes intervals. By customizing the monitoring system, the user can define the duration of data logging. This allows the monitoring system's data to be more sensitive.
4. The data shown in the current monitoring system does not show the production of power at a specific time.

By implementing a software based monitoring system, this provides cost saving in a long run. A software based monitoring system does not use any hardware, thus eliminating the need of performing maintenance on the hardware. A software based monitoring system eliminates the need of wiring. This configuration is stable compared to wired connections. A single loose of wire or faulty pin will cause the entire monitoring system to fail and troubleshooting takes up ample of time. Hence, this helps the customer to save cost in a long run.

The implementation is fairly easy to use. Run the application code and display the data into a dashboard. This does not need technical skills to operate the monitoring system. A software based monitoring system does not take up any physical space in the residential house therefore the overall appearance is favourable to the residence. A typical inverter logs data at a 10 minutes interval, by implementing this software based monitoring system, it is possible to change the data logging interval into a shorter time. A more sensitive data logging also allows the user or customer to have a better understanding on the performance of the entire photovoltaic system. The software based monitoring system also allows the user to customize the monitoring system based on their preference on what type of data they would like to show on to the dashboard by modifying the code.

2.0 PRIOR RESEARCH

Miss. Apura L & Mr. Madhu N (2016). IoT based Solar Monitoring System. International Journal of Science Technology & Engineering, Volume 3, Issue 2 has done work on retrieving the photovoltaic system's data. In this paper, the author had divide the project into 3 stages which are: Admin, Client and Data Format.

The admin part acts as a server side where the establishment of connection of the client's information on to the webpage will be done. The admin holds the right to allow certain data to be shown to a specific group of people. The client part is where the registered individual will have a certain priority to the information of the photovoltaic system's data. At last is the data format which is the displaying of data onto the web pages. This separation of segments allows to formulate an idea on to creating a photovoltaic monitoring system whereby the admin part will be the bridge of connection to the photovoltaic monitoring system's inverter.

A web-based monitoring system had been conducted by the following research paper which is Renata I.S. Pereiraa, Ivonne M. Duponta, Paulo C.M. Carvalhoa, Sandro C.S. Jucáb (2018). IoT embedded linux system based on Raspberry Pi applied to real-time cloud monitoring of a decentralized photovoltaic plant. Research Gate, has used a Raspberry Pi for their photovoltaic monitoring system. In this project, the author designs a project called IoT embedded linux system based on Raspberry Pi applied to real-time cloud monitoring of a decentralized photovoltaic plant. When the PV module receives light from the sun, the analog sensors detects and sends value to the ADCES. From the ADCES, data is transmitted to the Raspberry Pi. The Raspberry Pi then sends the data to the cloud. Finally the end user retrieve the data via a web monitor.

A similar project was done by Nor Azlan Othman, Muhammad Riduan Zainodin, Norhasnelly Anuar, Nor Salwa Damanhuri (2017). Remote Monitoring System Development via Raspberry- Pi for Small Scale Standalone PV Plant.7th IEEE International Conference on Control System, Computing and Engineering (ICCSCE 2017). In this paper, the design is to develop a low-cost monitoring system by using a Raspberry Pi microcontroller to monitor the performance of small independent solar photovoltaic power generation system. The

monitoring system is able to acquire, store and display solar photovoltaic parameters such as voltage, current and the ambient temperature in real time.

For this project, there will not be any use of hardware or minimal use of hardware. From the two paper above, it will be beneficial to display the data into a web page and if there is any hardware involve, a Raspberry Pi should be sufficient to complete the task. The purpose to be only using a Raspberry Pi is to save the cost at the consumer side. More hardware being involve increases the risk of maintenance. Adding on, the inverter will be able to give out data such as power output directly.

According to R. F. Gusa,I. Dinata, W. Sunanda, T. P. Handayani (2018). Monitoring System for Solar Panel Using Smartphone Based on Microcontroller. 2018 2nd International Conference on Green Energy and Applications, the author of this paper had designed a solar real-time monitoring system for photovoltaic system by using an arduino model Atmega 2560, voltage sensor, current sensor and temperature sensor. The Arduino ATMega 2560 is also connected to the Wifi via WIFI module and it is connected to a smartphone to display the measured values. The measurement of the photovoltaic's current, voltage and power and environment temperature is transmitted through the Blynk, an open ware platform.

A similar project involving sensors and a microcontroller had been done by Ranjit Singh Sarban Singh, Muhammad Izzat Bin Nurdin, Wong Yan Chiew (2019).Raspberry Pi Zero Wireless Monitoring System for Analyzing Solar Photovoltaic Panel. International Journal of Innovative Technology and Exploring Engineering.Volume-8 Issue-8,June 2019.7. In this design, the system continuously records the voltage, current and temperature information of the photovoltaic system. This information is used to determine the photovoltaic performance and the operation of the panels.

Abhishek Parikh, Farah Pathan, Bhavdipsinh Rathod, Sandeep Shah (2015). Solar Panel Condition Monitoring System based on Wireless Sensor Network. International Journal of Science, Engineering and Technology Research. Volume 4, Issue 12. The design from this article describes the hardware and software implementation for fault detection in remote solar panels. A solution has been proposed for this wireless sensor nod which several hardware need to be included such as, voltage sensor, current sensor, light sensor, temperature sensor

and dust sensor and XBeeS2 to implement WSN. Data is constantly being stored and monitored at the central station which is also known as the HUB and data is sent to the server via Ethernet. A graphical user interface (GUI) with Python is written to display the captured data and the data is saved as Excel file.

A different approach of storing data is discussed in Ankit Kekre and Suresh K. Gawre(2017). Solar Photovoltaic Remote Monitoring System Using IOT. International conference on Recent Innovations is Signal Processing and Embedded Systems. This article discussed a low-cost embedded solar PV monitoring system based on IOT. The system will utilize the use of GPRS module and a low cost microcontroller.

For the upcoming project, it is wise to have data stored in the form of csv or text file for tracing back as shown in the paper mentioned above. The data can be stored in the residence's computer and then be retrieved from the same computer to be displayed in the dashboard. By sending data into the internet or server, it can help the resident to monitor on the photovoltaic performance globally. It is also beneficial to include it in the upcoming project as the project feature.

The projects above are all related to Photovoltaic Monitoring System. The method of each project is different but the final result is to obtain the photovoltaic system data in various ways. The projects mentioned above requires hardware which is listed respectively. These method requires extra cost to the project because there is the need to deploy a few hardware. Hardware is susceptible to damage which may be caused from various factor such as high temperature environment, loose connection, degradation of the component with time and circuit damage due to over-current or voltage.

Apart from that, hardware is costly when comparing the firewalls of software and hardware. Each hardware, although the same model cannot operate 100% in similar way. Each hardware will have to be configured accordingly to perform at optimum level. Electronic devices such as Arduino and Raspberry needs to be updated to the current updates. Hardware also takes up physical space and involves wiring. This can be a potential fuss in customer if they are particular on the outlook of their home. Having said so, the wire will dissipate heat and it may be an non conducive environment for the resident.

A fully functioning software based monitoring system can help to save cost in a long run. There is no maintenance needed on the hardware. A software based monitoring system is also portable and can be accessed any part of the residence's residential area.

In the paper of Bok-Jin Youm, Jaehyun Park (2015). TCP/IP Protocol Over IEEE-1394 Network For Real Time Control Application.16th Triennial World Congress Prague Czech Republic has done work on testing the feasibility of transmission control protocol (TCP). In this paper, the author compared the field buses used in the past with a more advance protocol, TCP. From the paper, the author carries out experiment to test the real-time data that is being collected from a device.

The experiment involved a bulk of data being retrieved. As a conclusion of the experiment, the author states that TCP/IP is a stable protocol when dealing with bulk of data being transmitted in. The TCP will look for the IP address of the device and try to establish a connection to the device. After a connection has been established between the host and the slave, the retrieving of data takes place. The data is broken down into packets by the TCP and then it is travelled from the slave to a router over the internet according to the specified IP address. Finally at the host, the packets are reassembled, stored and read.

In the paper of Henri Tokolaa, Christoph Grögerb, Eeva Järvenpääc, Esko Niemi (2016). Designing manufacturing dashboard on the basis of a key performance indicator survey, 49th CIRP Conference on Manufacturing Systems has done research on developing a presentable dashboard. The author states that the current dashboard lacks a systematic presentation content. They conducted surveys to determine the key element to be included into a dashboard.

From the paper, the findings are as follows:

1. Most of the respondent prefers a mobile dashboard and on tablets.
2. Real time data is preferred from a dashboard. This means that when a data comes in, the dashboard should display accordingly.
3. It is tedious to develop a dashboard from scratch. This can be overcome by using a third party software.

Sandrina Vilarinho, Isabel Lopes, Sérgio Sousa (2017) designed procedure to develop dashboards aimed at improving the performance of productive equipment and processes.

There are 2 key aspects from their findings which are:

1. Simplicity
2. Comprehensiveness

Simplicity is defined as how the data is being shown in the dashboard. The ability to understand the performance of a particular aspect in a system. Comprehensiveness is defined as the number of relevant data to be displayed to have an overall understanding of the entire system. There are a few format that a dashboard can retrieved and be read. Format such as Excel and text file is the optimum file format for a dashboard.

.

3.0 METHODOLOGY

Fig. 3. depicts the general flow of the project.

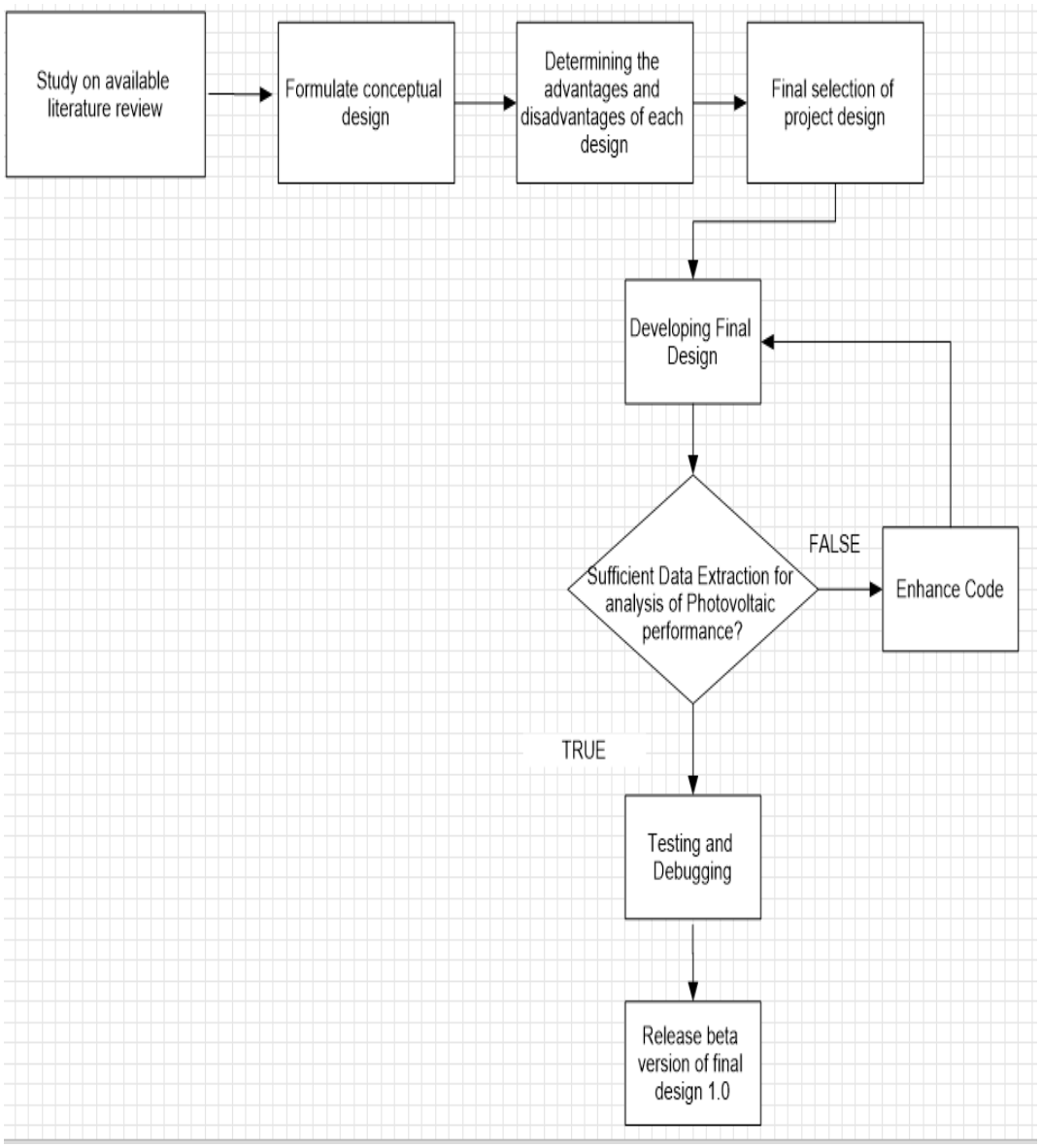

Fig. 3 Overall Flow Chart of the project

3.1 PRODUCT DESIGN SPECIFICATION

The objective of this project is to formulate an overall fully functioning photovoltaic monitoring system. There are a few aspects to be included to help the design to be a better monitoring system. Being a monitoring system, user should be able to understand the performance of the system. The final outcome should contain the aspects that are listed below:

Table 1 Product Design Specification

Aspect	Specification
Performance	● Able to operate at any instance of time. ● Able to obtain data from the photovoltaic monitoring system
Safety	● As the monitoring system will be deployed in a residential house, the monitoring system should be safe for anyone who is operating it. For example, a child operating the monitoring system.
Feature	Include the following data: i. Time and Date ii. Instance Power Produce iii. Total Yield iv. Daily Yield v. Condition of the photovoltaic monitoring system vi. Power vs Time graph
Appearance	● Able to fit into a house. Hardware and wiring will result in messiness and may be a sore to the resident's eye. ● Dashboard appearance must be neat, interesting and be able to comprehend at first glance.
Life Cycle	● In the point of view of a user, the life cycle of the monitoring system must be as long as possible. This is because replacing a hardware or maintenance requires additional cost.
Space	● Should not take up a lot of space in the house.
Cost	● Low cost and minimal maintenance.

4.0 DESIGN

This concept design is to develop a fully software based monitoring system. The code will be written and be compiled in Microsoft Visual Studio 2017/19. The compiled code will produce an application file where upon activation, the program will initiate. The code will then collect data from the targeted inverter to collect the photovoltaic system's data. In the code, the data is then stored in a .csv or a .txt file for documentation purpose. These data is then projected onto a dashboard. The dashboard is built by using Microsoft Power BI or HTML.

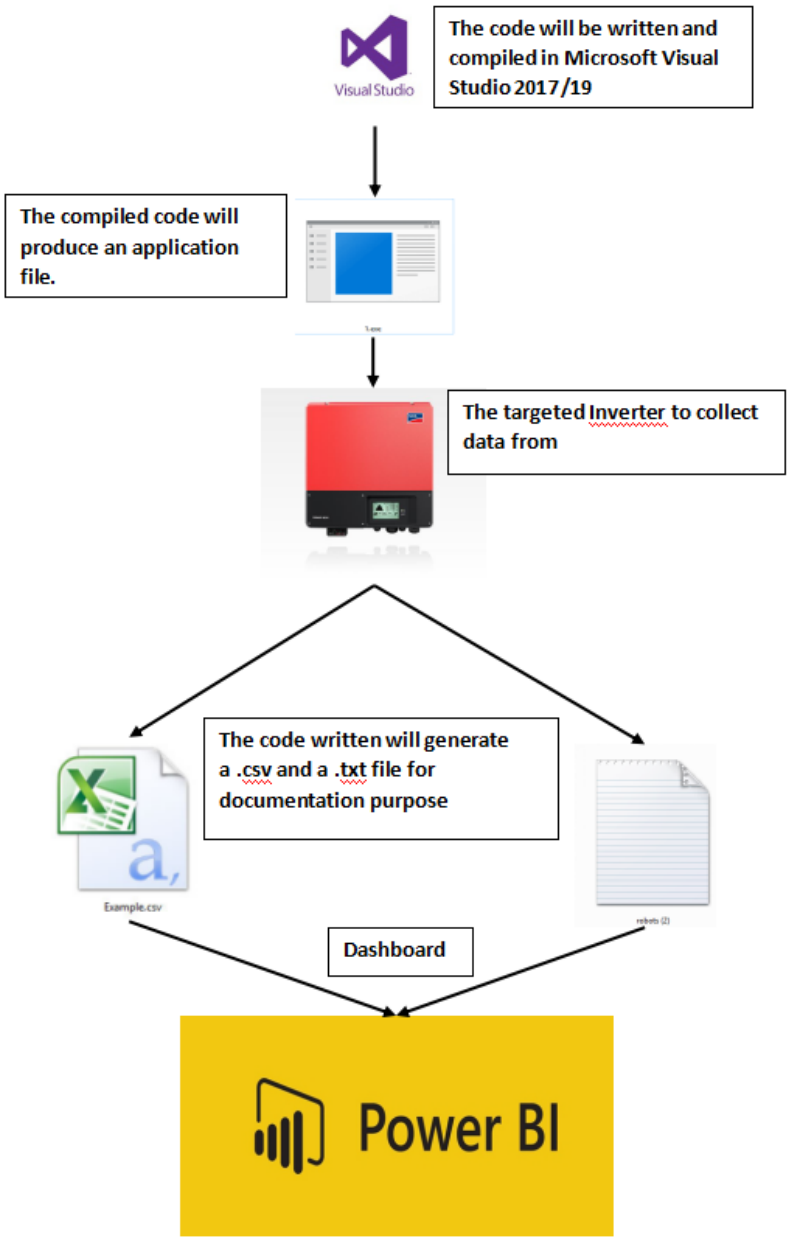

Fig. 4. Project Flow of Selected Design

4.1 MERITS

This design is a software based monitoring system. There will be no hardware involved in this design thus there will be no maintenance of hardware involved as hardware wear and tear is eliminated. Hence, the cost will be kept at a minimum for the customer. Moreover, a fully software based monitoring system will be appealing to the resident's house and it is relatively safer as there is no wiring involved therefore. The risk of electrocution is minimal. The most

important feature is to have the monitoring system to be able to operate at any instance. This design is able to operate at any instance regardless of the environment or power outage.

To have a software based monitoring system, the execution is straightforward. To execute, deploy the software onto a personal computer and launch the .exe file. The .exe file will prompt a command window to collect the desired data. The datasheet of registers containing data is obtained from the manufacturer.

The desired data will then be stored into the file specified in the configuration file. The file type can be stored in various format. For the purpose of this project, a .txt and .csv file is used. To display the data, Microsoft Power BI has been used. Microsoft Power BI is a freeware that has the capability to project data in statistical format such as graphs, tabulated data, charts and many other formats. Microsoft Power BI also allows the user to track a data easily. For example, the user may click at a specific time, all the information related to the time will be highlighted. Thus, Microsoft Power BI is a suitable software for dashboard.

5.0 EXECUTION

The process of the coding can be broken down into:

1. Configuration setting. Establishing connection to inverter.

- The initial step is to specify the IP address of the inverter and the historical data file path. The code in Appendix.1 will retrieve the IP address and the file path according to the .txt file above.
- The first step is to connect to the desired inverter. The following code written in Appendix.2 will establish a connection between the host (Personal Computer) to the slave (Inverter). Each inverter has its own IP address. The IP address is written in the configuration file beforehand. The code will retrieve the IP address of the inverter in the configuration setting. If there is no inverter's IP address, the code will display out " Could not connect to " the respective IP address. If connection is successfully established, the code will proceed on to the next step which is to collect the desired data.

2. Collect the desired data from their respective registers.

Transmission Control Protocol (TCP)

- In this attempt, TCP service is being used. A TCP class provides a gateway for connecting, transmitting and obtaining data over the internet in synchronous mode. The TCP protocol forms a connection to a targeted device or slave. To perform a TCP service, the address of the network device hosting must be known and the IP address of the targeted device must be available. An inverter has 2 kinds of IP addresses which are:
    i. Static IP address
    ii. Dynamic IP address

The concept of a Transmission Control Protocol can be explained as a Host (Personal Computer) and a Slave (Inverter). The host will obtain the IP address of the slave and the connection will be established. The reason of using a Transmission Control Protocol because it is an open protocol meaning the protocol is free of charge. Transmission Control Protocol is able to distinguish between devices over the internet by using the IP address. The most important benefit is that it is less prone to network interruption.

- The datasheet of the inverter's register is obtained from the manufacturer. In this project a 2MPPT photovoltaic system is being used and therefore there will be 2 DC Current, 2 DC Voltage and 2 DC Power, the code written in Appendix.3, Appendix,4, Appendix.5, Appendix.6, Appendix.7 and Appendix.8 is to collect the following data:
    1. Local Time.
    2. Inverter serial number
    3. DC Current 1, DC Voltage 1, DC Power 1
    4. DC Current 2, DC Voltage 2, DC Power 2
    5. Current Total Yield
    6. Current Total Power
    7. Daily Power
    8. Inverter Condition

3. Store the data into a location specified in the code.

- In Appendix.9, the historical file is saved as .txt and a .csv file. This is because the dashboard in the later part will be able to read this type of format and display the data in a systematical order.

4. Data logging interval.

- The technique used for data logging is by running the entire code and 'sleep'. The function code is by using Thread.Sleep(). Thread.Sleep() is to pause or make the program on hold before the next cycle.
- In Appendix.10, the program will run and complete the first round and it is then in the state of 'sleep' for the specified time period. After 5 minutes, the program runs another time and collect the data for that instance and the program goes to sleep. This method uses less power and it is straightforward.

5.1 FLOW CHART

Overall Program Flow:

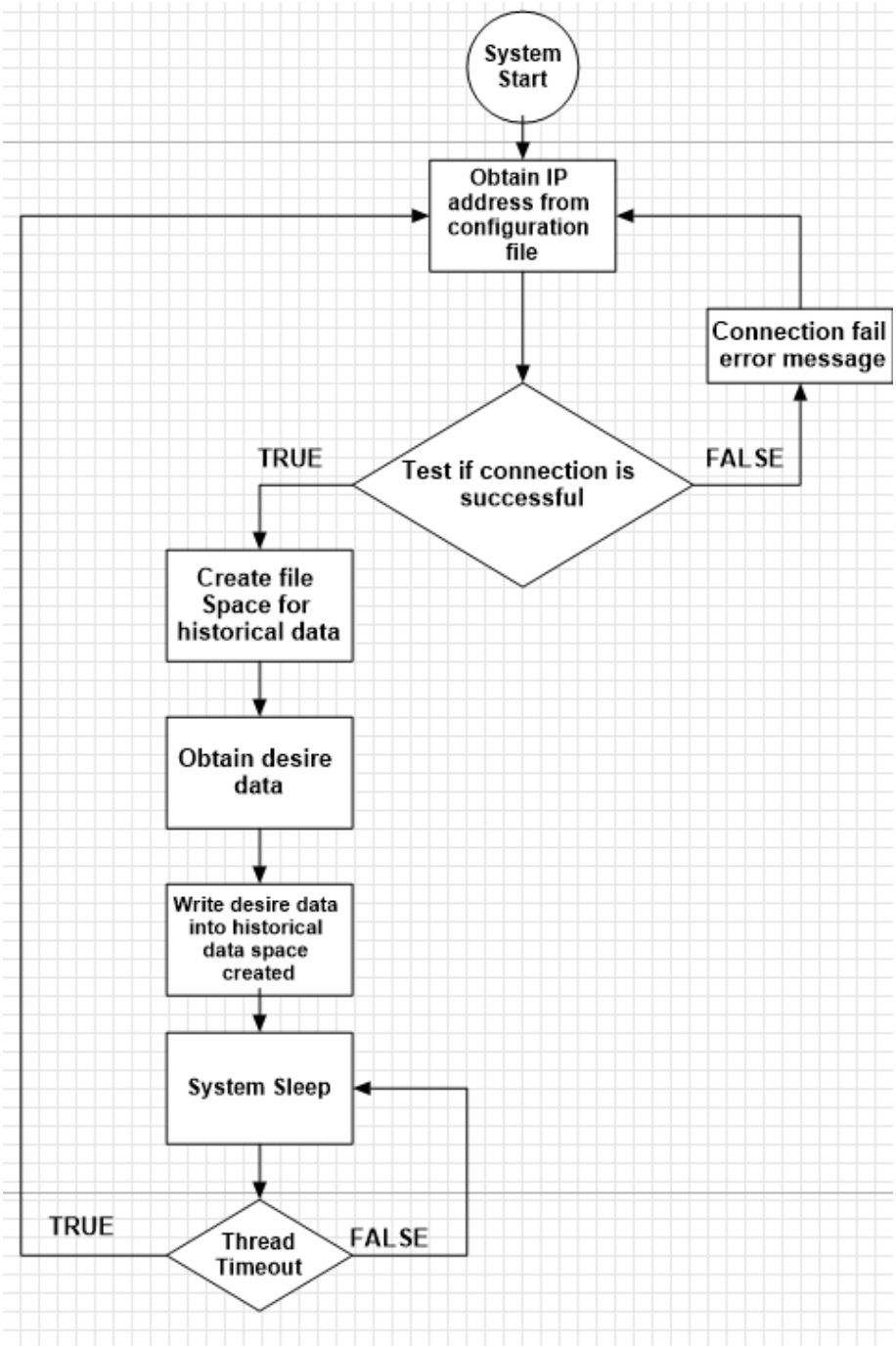

Fig. 5. Overall Program Flow

6.0 RESULTS AND ANALYSIS

To test the results of the developed monitoring system, the data from the manufacturer's monitoring system is being use to compare with. In the process of development, a Sunny Boy SB4000TL-21 inverter has been used and to test the feasibility of the developed monitoring system.

The data being retrieved is the daily yield, total yield, inverter condition, voltage produced, current produced, power produced, power graph, voltage graph and current graph. The data logging interval is set as 5 minutes. The manufacturer's monitoring system logs data every 30minutes while the developed monitoring system is 6 times more sensitive than it. The results are as follows:

Daily Results:

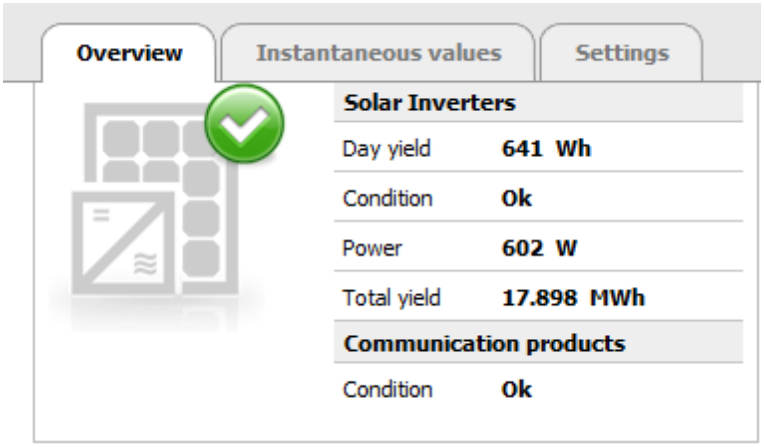

Fig. 6. Manufacturer Monitoring System 25/4/2019

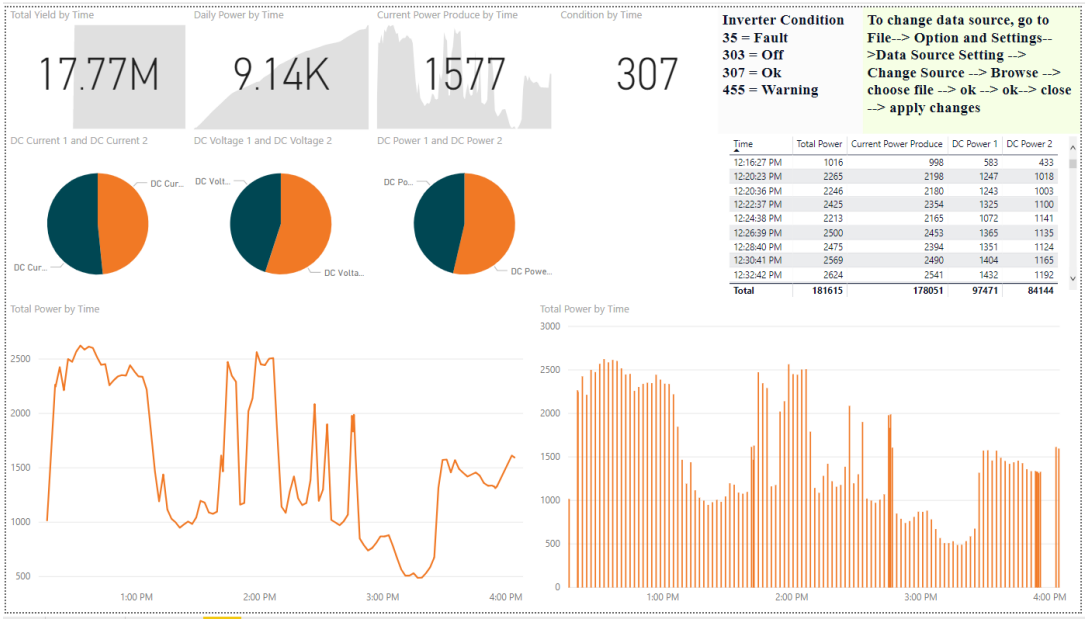

Fig. 7. Developed SCADA Main Page 25/4/2019

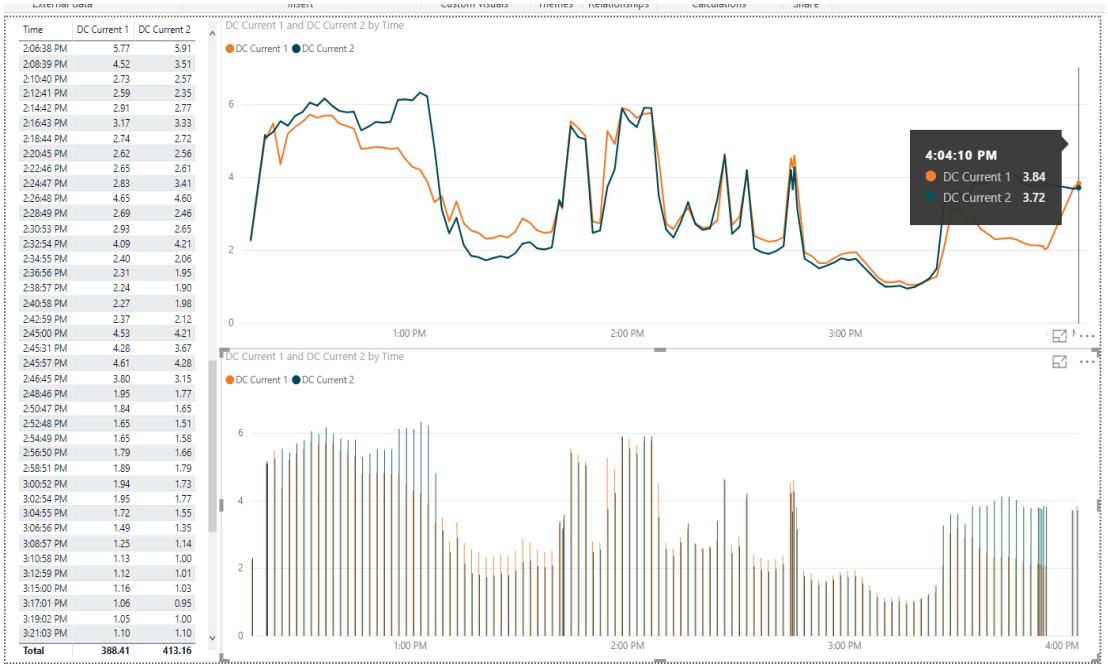

Fig. 8. Developed SCADA Current 25/4/2019

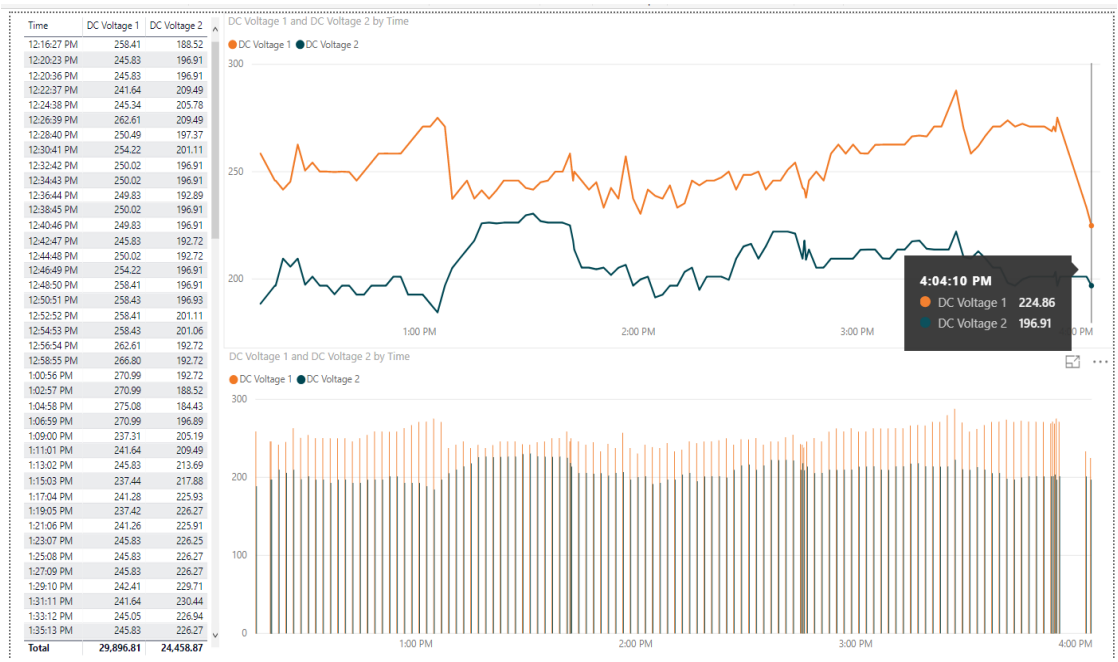

Fig. 9. Developed SCADA Voltage 25/4/2019

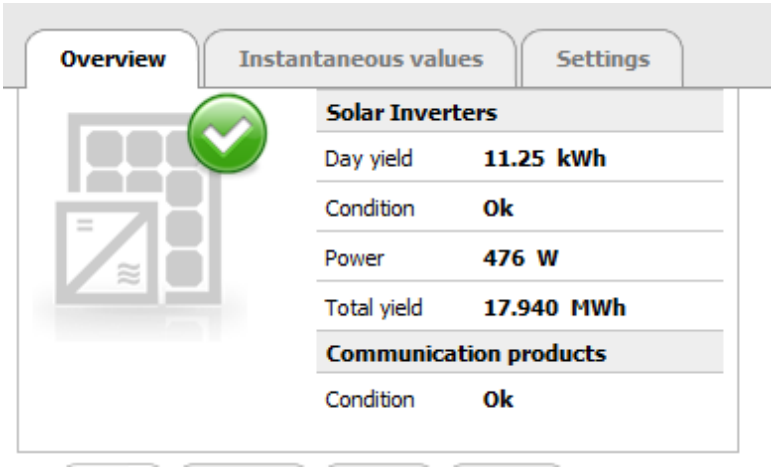

Fig. 10. Manufacturer Monitoring System 7/5/2019

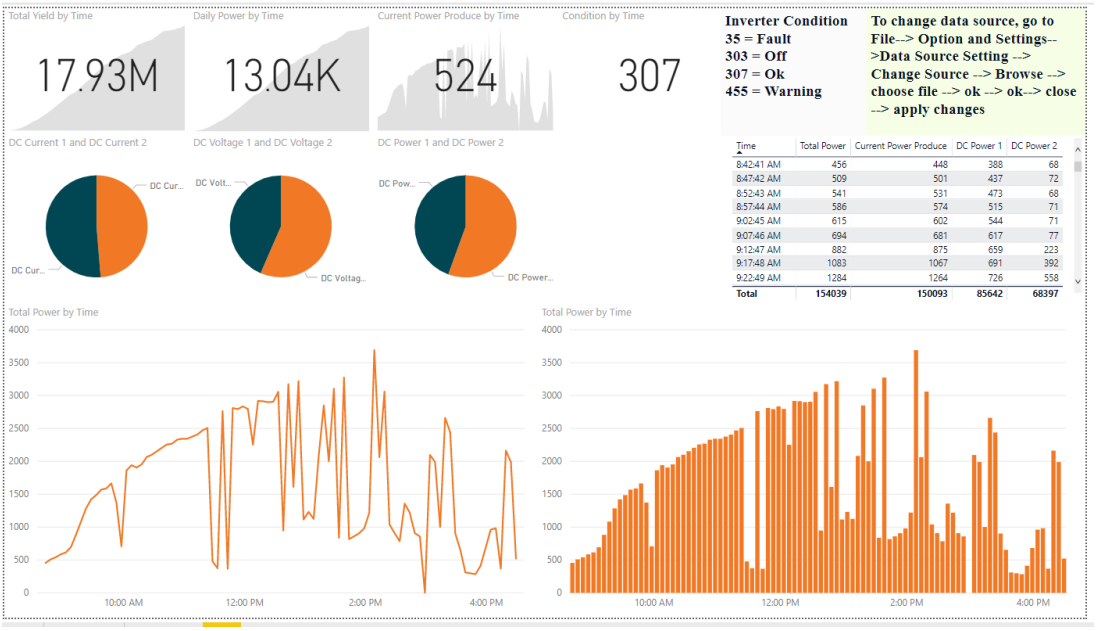

Fig. 11. Developed SCADA Main Page 7/5/2019

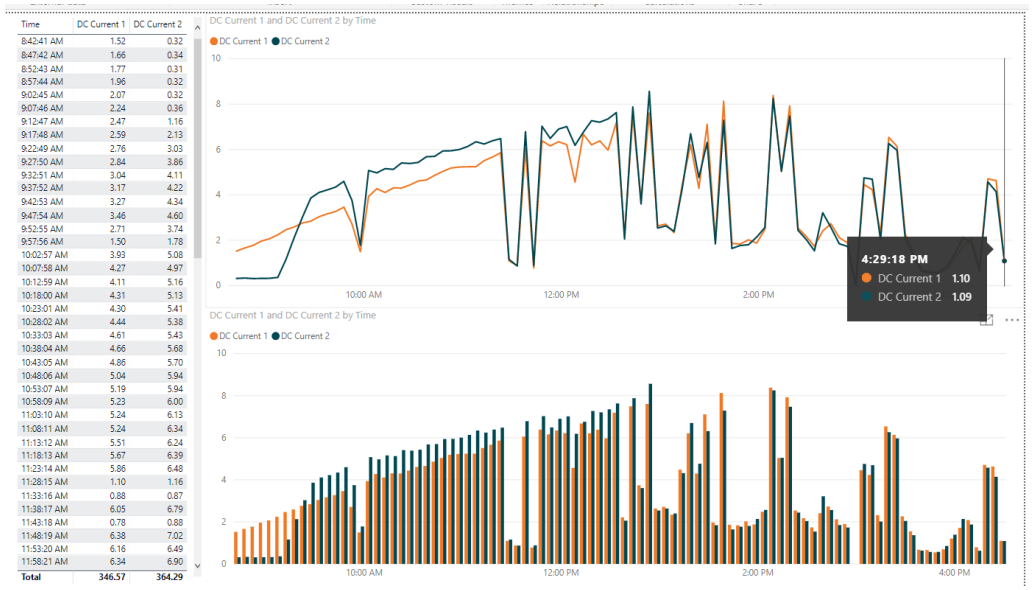

Fig. 12. Developed SCADA Current 7/5/2019

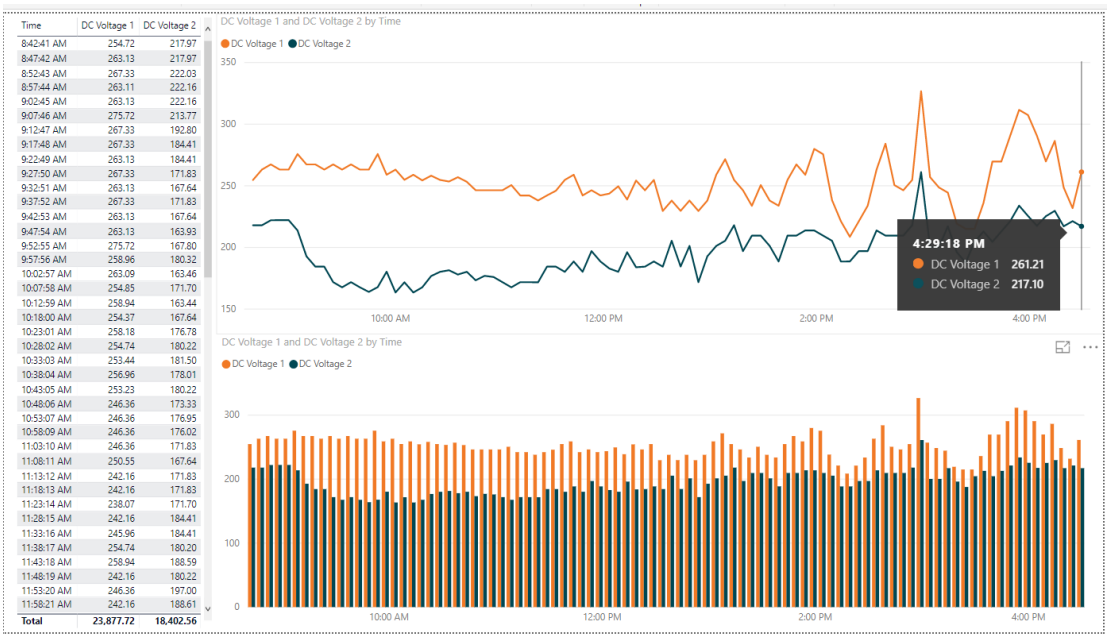

Fig. 13. Developed SCADA Voltage 7/5/2019

From the figures above, the data of 25/4/2019 and 7/5/2019 is displayed. Figure 6 and Figure 10 is the data from the manufacturer's software while Figure 7, Figure 8, Figure 9, Figure 11, Figure 12 and Figure 13 is the data obtain by the developed software in this project. In Figure 6 and Figure 7, the values of the obtained data differs because the logging time of the inverter is different. The logging time for the manufacturer's software is every 30 minutes interval. The logging time for the developed software is 5 minutes interval. The data of the developed software has higher sensitivity and the data obtained is more precise. From the manufacturer's software, there is an absence of current and voltage values and graph. The value of current and voltage is important to determine whether the power produced is accurate and it is easier for debugging purpose either the panel has degraded or the DC wiring lines are faulty. The current and voltage graphs are displayed in Figure 8, Figure 9, Figure 12 and Figure 13.

ANALYSIS:

The value of Day Yield, Power and Total Yield of manufacturer monitoring system and the developed SCADA are being compared. As shown in the result, the value differs slightly. This is because the data logging time is different. SMA Explorer logs data in 30 minutes interval which makes it less sensitive. The developed SCADA is able to log data at any

desired interval. In this comparison, the developed SCADA logs data in 5 minutes interval. SMA Explorer lacks the current and voltage produced while the developed SCADA has additional information such as voltage produced, current produced and the graphs for generated voltage, current and power. The values of voltage and current is essential to determine the faulty areas of a solar panel if any. Adding on, the developed SCADA is able to display the data in a graphical method and a tabulated method. This allows user to identify the exact value at that instance of time.

Table 3 Comparison of manufacturer monitoring system and developed SCADA

SMA Explorer	**Aspects**	**Developed SCADA**
✔	Daily Yield	✔
✔	Total Yield	✔
✔	Current Power Produced	✔
✔	Inverter Condition	✔
✔	Power Graph	✔
X	DC Current	✔
X	DC Voltage	✔
X	Tabulated form	✔
X	DC Current Graph	✔
X	DC Voltage Graph	✔
X	Higher Sensitivity (Shorter Data Logging Interval)	✔

From the table above, the common data that the developed monitoring system and the manufacturer's monitoring system is the daily yield, total yield, current power produced, inverter condition and power graph. The data mentioned above is the bare minimum data that is needed to be displayed on the monitoring system. However, this is not very friendly when it comes to debugging. For instance, just by having the power graph would not show whether the power production is undervalue or working in optimum level. Therefore, by having the voltage and current, debugging can be done by multiplying and determine whether the panels are working fine. If the power produced is not sufficient, it can mean that the cables needs to be maintained. Apart from that, the panels may have some bus-bar being disconnected. Adding on to this, by having a tabulated data, the data at any instance can be tracked. For instance, suppose during the solar noon at a clear sky, the power production should be at its peak. To track, a tabulated data can ease this when it comes to operation and maintenance. A higher sensitivity data logging can also help in operation and maintenance. By having a higher sensitivity data logging interval, the data can be more precise.

7.0 CONCLUSION AND FUTURE WORK

This monitoring system will be able to perform significant task such as ensuring the optimum performance of the photovoltaic system at all times. The user is able to see whether the inverter is in the perfect condition by the inverter code signal. By looking at the code, the user is able to determine whether there is a need to perform maintenance on the inverter or the solar panels. By the development of this monitoring system, user is able to customize the monitoring system to have their own preference on the data being displayed.

A proper dashboard must have the two criteria which are simplicity and comprehensiveness., the relevant data needed for the monitoring system is total yield, daily yield, current power, condition of inverter, tabulated data, dc current, voltage and power, time of power produced.

In future, it is possible to create a website to retrieve the data from the computer and display it. It is possible to retrieve the data from the inverter and store it at a location on the personal computer. The data stored is the historical data from the inverter. By using SSRS - SQL or HTML, it is possible to retrieve the data from the location of the PC and display it on

a website. Apart from that, by having a website, the user can monitor their photovoltaic system at any instance. In this project, the inverter and the personal computer must be connected to the same network.

Apart from that, a light intensity sensor can be installed on a panel to obtain the sunlight's irradiance at that instance. By having the intensity data, power output of the entire panel can be predicted. The data transmitted out from the light intensity sensor can be use for tracking sunlight. This can help improving the efficiency of the overall photovoltaic system. Adding on to that, a DHT sensor can be installed onto a photovoltaic panel to measure the temperature and humidity. Once these values are obtained, it is possible to perform calculation to predict the output of the photovoltaic. This can verify whether the panels are performing at optimum level or not. For instance, if the solar panel temperature is at operating range, the panels should be able to output a higher value comparing to if the temperature exceeds the operating range of a panel.

In this project, the data is stored in the user's personal computer. If the user has subscribed to a cloud service, the inverter data can be transferred to the cloud. This can free up space on the user's personal computer. As the data will be taken on a daily basis, the cumulative data will be massive. The stored data can then be retrieved by using a third party software such as Microsoft Power BI or a website. This allows the user to monitor their photovoltaic system anytime and anywhere.

ACKNOWLEDGEMENTS

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Appendix

```
#Inverter IP address
IP:192.168.1.170


#HISTORY_DIR:.\HistoryFiles
HISTORY_DIR:C:\Users\This-PC\Desktop\Photovoltaic Monitoring
System_Master\MyApp\MyApp_1\MyApp_1\bin\Historical Data
```

Appendix.1

```
for (; ; )
{
    foreach (IpInformation ipInfo in IP_Information)
    {
        using (TcpClient client = new TcpClient())
        {
            try
            {
              //Establish connection to inverter
               Console.WriteLine("\nConnecting to " + ipInfo.IP_Address);
               IAsyncResult ar = client.BeginConnect(ipInfo.IP_Address, ipInfo.IP_Port, null, null);
               WaitHandle wh = ar.AsyncWaitHandle;
               try
               {
                   if (!ar.AsyncWaitHandle.WaitOne(TimeSpan.FromSeconds(ipTimeout), false))
                   {
                       client.Close();
                       throw new TimeoutException("Could not connect to " + ipInfo.IP_Address);
                   }
               }
               finally
               {
                   wh.Close();
               }
```

Appendix.2

```
// Get inverter serial number.

const ushort SERIAL_NUMBER_ADR = 30005;
const ushort SERIAL_NUMBER_REGISTER_COUNT = 2;
// Read SMA serial number registers (U32)
ushort[] serialNumberInfo = master.ReadHoldingRegisters(ipInfo.UnitID, SERIAL_NUMBER_ADR, SERIAL_NUMBER_REGISTER_COUNT);
// Extract fields from U32
UInt32 serialNumber = ((UInt32)serialNumberInfo[0] << 16) | (UInt32)serialNumberInfo[1];
line += "," + serialNumber;
```

Appendix.3

```
    // Extract fields from DC 1 Current S32 (FIX3)
    if (DC1Info[0] == 32768)
        DC1Info[0] = 0;
    if (DC1Info[2] == 32768)
        DC1Info[2] = 0;
    if (DC1Info[4] == 32768)
        DC1Info[4] = 0;

    double DC1_Current = (double)(Int32)(((UInt32)DC1Info[0] << 16) | (UInt32)DC1Info[1]) / 1000;
    double DC1_Voltage = (double)(Int32)(((UInt32)DC1Info[2] << 16) | (UInt32)DC1Info[3]) / 100;
    double DC1_Power = (double)(Int32)(((UInt32)DC1Info[4] << 16) | (UInt32)DC1Info[5]);

    line += "," + DC1_Current + "," + DC1_Voltage + "," + DC1_Power;
}
```

Appendix.4

```
    // Extract fields from DC 2 Current S32 (FIX3)
    if (DC2Info[0] == 32768)
        DC2Info[0] = 0;
    if (DC2Info[2] == 32768)
        DC2Info[2] = 0;
    if (DC2Info[4] == 32768)
        DC2Info[4] = 0;
    double DC2_Current = (double)(Int32)(((UInt32)DC2Info[0] << 16) | (UInt32)DC2Info[1]) / 1000;
    double DC2_Voltage = (double)(Int32)(((UInt32)DC2Info[2] << 16) | (UInt32)DC2Info[3]) / 100;
    double DC2_Power = (double)(Int32)(((UInt32)DC2Info[4] << 16) | (UInt32)DC2Info[5]);

    line += "," + DC2_Current + "," + DC2_Voltage + "," + DC2_Power + "," ;

}
```

Appendix.6

```
//Get Total Yield
//kWh
const ushort DC_totalpower_ADR = 30529;
const ushort DC_totalpower_REGISTER_COUNT = 2;
ushort[] DCtotalpowerInfo = master.ReadHoldingRegisters(ipInfo.UnitID, DC_totalpower_ADR, DC_totalpower_REGISTER_COUNT);
if (DCtotalpowerInfo[0] == 32768)
    DCtotalpowerInfo[0] = 0;
double totalyield = (double)(Int32)(((UInt32)DCtotalpowerInfo[0] << 16) | (UInt32)DCtotalpowerInfo[1]);
line += totalyield + ",";

//Get current total power
//kWh
const ushort DC_currentpower_ADR = 30775;
const ushort DC_currentpower_REGISTER_COUNT = 2;
ushort[] DCcurrentpowerInfo = master.ReadHoldingRegisters(ipInfo.UnitID, DC_currentpower_ADR, DC_currentpower_REGISTER_COUNT);
if (DCcurrentpowerInfo[0] == 32768)
    DCcurrentpowerInfo[0] = 0;
double currentyield = (double)(Int32)(((UInt32)DCcurrentpowerInfo[0] << 16) | (UInt32)DCcurrentpowerInfo[1]);
line += currentyield + ",";
```

Appendix.7

```
//Get daily power
//kWh
const ushort DC_dailypower_ADR = 30535;
const ushort DC_dailypower_REGISTER_COUNT = 2;
ushort[] DCdailypowerInfo = master.ReadHoldingRegisters(ipInfo.UnitID, DC_dailypower_ADR, DC_dailypower_REGISTER_COUNT);
if (DCdailypowerInfo[0] == 32768)
    DCdailypowerInfo[0] = 0;
double dailyyield = (double)(Int32)(((UInt32)DCdailypowerInfo[0] << 16) | (UInt32)DCdailypowerInfo[1]);
line += dailyyield + ",";

//Get condition
const ushort DC_condition_ADR = 30201;
const ushort DC_condition_REGISTER_COUNT = 2;
ushort[] DCconditionInfo = master.ReadHoldingRegisters(ipInfo.UnitID, DC_condition_ADR, DC_condition_REGISTER_COUNT);
if (DCconditionInfo[0] == 32768)
    DCconditionInfo[0] = 0;
double condition = (double)(Int32)(((UInt32)DCconditionInfo[0] << 16) | (UInt32)DCconditionInfo[1]);
line += condition + ",";
```

Appendix.8

```
string filePath;
string filePath_1;
filePath = historyDir + "\\SMA-" + timeNow.ToString(FILE_NAME_DATE_PATTERN) + ".txt";
filePath_1= historyDir + "\\SMA-" + timeNow.ToString(FILE_NAME_DATE_PATTERN) + ".csv";
```

```
    line += "\n";
    File.AppendAllText(filePath, line);
    File.AppendAllText(filePath_1, line);
    Console.WriteLine(line);
```

Appendix.9

```
    Thread.Sleep(300000);          //5 minutes interval
    //Thread.Sleep(120000);        //2 minutes interval
    //Thread.Sleep(60000);         //1 minute interval
```

Appendix.10

INVESTIGATION OF HEART ABNORMALITIES USING PHONOCARDIOGRAM SIGNAL

Mohammed Qaid*[1], Vikneswaran Vijeana[1]

[1]BioSIM Research Group,
School of Mechatronic Engineering, University Malaysia Perlis,
Sg. Chuchuh, Arau, Jalan Wang Ulu, 01000 Kangar, Perlis

ABSTRACT

Cardiovascular disease (CVD) is a serious illness that plagues the world. Early detection and prevention help to reduce the mortality rate of CVD. There are many advanced technologies available for the detection of CVD related symptoms; however, these technologies are only available in urban areas. Healthcare facilities in rural areas would only be equipped with basic diagnostic devices, and the primary investigation tool would be the statoscopes. Investigation of heart sound abnormalities by using the phonocardiogram (PCG) signal is the main idea of this project. The main problem of this project is to distinguish between normal, murmur, and extrasystole heart sound. The heart signal must undergo pre-processing, segmentation, feature extraction and classification process. In signal pre-processing, the signal was filtered with an order six Butterworth filter with the 25HZ-900HZ frequency range and zero-phased digital filter to eliminate unwanted signals. Then, the filtered signal was segmented using average Shannon energy. The segmented signal was used in the feature extraction process. Feature extraction was done in time-frequency signal analysis from the segmented signal by using Stockwell transform, also known as S-Transform (ST). Finally, the classification process was done using Ensemble classifier with 68.7 % accuracy. The completed research work will be able to provide initial screening assessments to medical practitioners on whether the heart sound of the patient is normal or murmur and extrasystole, which requires further investigation on underlying causes.

Keywords: Time-frequency analysis, S-transform, Segmentation, Classification

1. INTRODUCTION

Heart sounds arise from the interweaving of complex processes correlated with atria, ventricles contraction, and relaxation, the motion of the valve, and blood flow. These can be detected from the heart through a stethoscope, a tool widely used for testing and diagnostics of clinical care. The practice of determining the acoustic properties of heart sounds and murmurs, including the strength, the rate, period, the amount and consistency of vibrations, is classified as cardiac auscultation.

Phonocardiogram (PCG) is a graphic record in the form of a wave in which you can see the heart sounds obtained with a stethoscope to track and represent visual representation of the sound of the heart during the cardiac period. Phonocardiogram analysis provides valuable cardiac data and can be a useful tool in the treatment of cardiovascular disease(Tong, 2015).

Based on the latest Statistics on Causes of Death in Malaysia released by the Department of Statistics Malaysia (DOSM).The annual total number of death due to ischaemic heart disease in Malaysia from 2010 up to 2018 was significantly increased by the double number. In 2010 the total number of death due to ischaemic was 9,371 and increased up to18,267 in 2018 (*Department of Statistics Malaysia Press Release Statistics on Causes of Death , Malaysia , 2019*, 2019).

The heart sound have different category such as normal, murmur, and extrasystole categories. The normal category is the healthy heart sounds, in other hand the murmur and extrasystole categories are consider as abnormal heart sounds. The murmur sound contain whooshing, roaring, rumbling, or turbulent fluid as a noise in the sound. The extrasystole sound occurs once extra heart sound is existing or heart sound skipped(Chakir et al., 2018).

From the study that done by Z. Tong (2015), wavelet threshold was applied to de-noise the signal. By applying the wavelet threshold, coefficients that represent the signal was kept and noise eliminated. According to A. K. Kumar and G. Saha (2015),the signal undergoes a segmentation process after pre-processing. Segmentation was done by calculating the duration of the cycle. Artifacts contained in the PCG signal will result in the cycle's incorrect estimation duration. Next, The author used the Hilbert Transform energy envelope to calculate the signal energy. In the researched of The Heart Defect Analysis Based on PCG

Signals Using Pattern Recognition Techniques by P. Lubaib and K. V. A. Muneer (2016), The diagnostic system of detector and classifier was used to detect heart disease. Features of the time domain and the frequency domain were used. In time-domain features, mean and variance of segmented signal were obtained while in frequency-domain features (MFCC). The steps to obtain the MFCC are as follows. First, log obtained by each amplitude spectrum was converted to Mel scale. Finally, Discrete Cosine Transforms was computed to obtain MFCC. This data were used in classification processed. These results in classifying the heart sound into normal and abnormal together with abnormal type.

The S-Transform has been proven in to perform better than other time-frequency /scale transforms for heart sounds signal analysis (Bentley & Deng, 2012). In the researched that carried out by (M. Nabih-Ali et al., 2017). Artificial neural network was one of the common methods used in classification. The weight and input multiplication plus neuron bias were summed up. Output elements fire only if the output is positive otherwise, it does not fire. Forty-four features will be classified into two classes, which are normal or abnormal heart sound. The result obtained was 97% accuracy, which showed that it produced good classification accuracy.

2. METHODOLOGY

2.1 Pre-processing

All signals may contain undesirable signals and sound effects that may cause a disturbance. Thus, all signals must be pre-processed first in order to remove the interference before dealing with signal segmentation, extraction of features and classifications.

Once the input signal is not clear and show unstable amplitude, the other stage of procedure will be affected. The entire signal must have a standard scale that able to proceed with all PCG signal given. In case, that disturbance is not removed and existing
in the signal, the accuracy of segmentation stage will be effected. The frequency band will be taken into account in the procedure to see the result of the pre-processing results. Any changes that applied to the signal will be clear in the frequency band.

First, perform pre-processing as the signal may contain undesired sound and artifacts that may corrupt the signal and affect the accuracy of the signal classification. PCG noise may be

either from an internal source (lung sound, peristaltic intestine sound) or from an external source (external background noise), including voltage level intrusion in the human body and breathing vibrations, electromagnetic interference (EMI) and electrical signal disturbance (Mubarak et al., 2018).

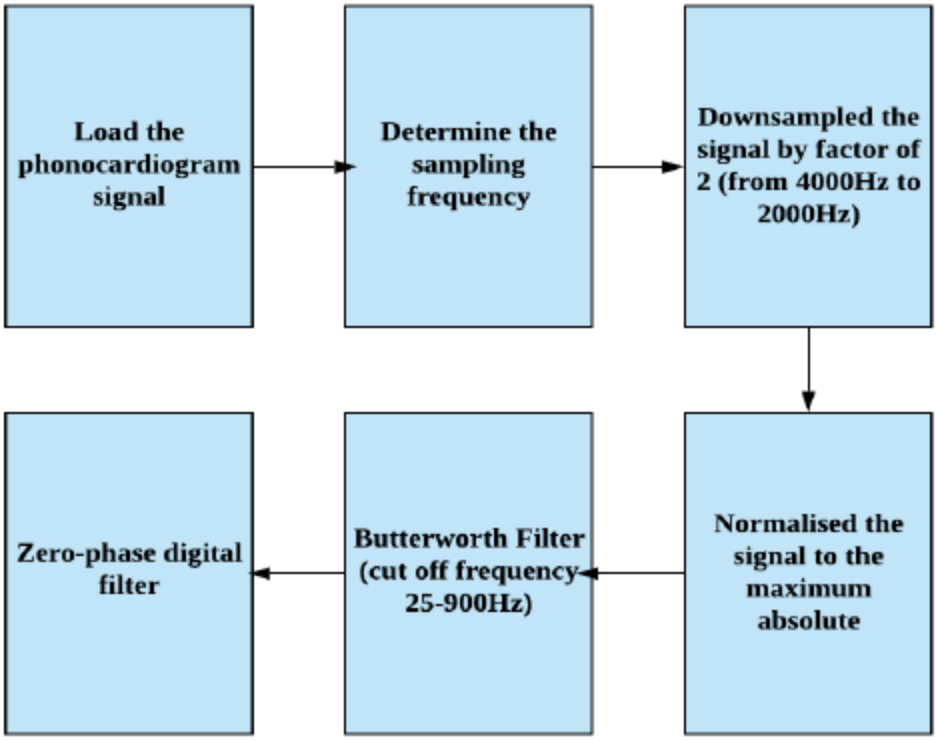

Fig. 1 The summary of the pre-processing steps

The sampling frequency of the signal is 4000Hz, so this sampling frequency cannot proceed. According to the Nyquist Theorem, the sampling rate must be at least 2fmax, or twice the peak analog frequency variable. If the sampling rate is less than 2fmax, some of the higher frequency components of the analog input signal will not be properly reflected in the performance. This unfavourable state is a type of distortion called an alias.
The sample rate of the recording was decreased by factor 2 to 2000 Hz. The downsample was achieved by reducing the signal sampling frequency of the first sample and after every two samples. Downsample was required to avoid redundant sampling of a signal (Chakir et al., 2018).

Then the signal normalized using Equation (2.1). Normalize signal will have the real value in in the range of -1 to 1.

$$\hat{x}_{norm}(i) = \frac{x(i)}{\max_{i \in R} |x(i)|} \quad (2.1)$$

The signals are processed using a 25-900 Hz frequency range band-pass filter from Butterworth. Such frequency ranges were chosen as the PCG signal provided medical details within these frequency ranges (Chakir et al., 2018).

Butterworth filter is a form of the filter designed for signal processing with a maximum flat passband and stopband for the significance response (Antoniou, 2006). The term 'maximum flat', refer to the non-existence of ripples in the signals included in the passband and then having the response to roll off towards zero in the stopband. The response slopes off linearly towards negative infinity when viewed in the logarithmic Bode plot. This filter is fast and easy to be used. This filter passes all of the cut-off frequency signals, but attenuates signals above and below the cut-off frequency (Kim, 2018). These are the main reasons of choosing Butterworth band-pass filter for this project.

Then, the signal is filtered using zero-phase digital filter. After the signal is filtered in a forward direction, the filtered sequence is then reverses and run backs through the filter (Wu et al., 2019). This will result precisely no phase distortion, thus no group delays occur. Besides, zero-phase filter also preserves features in a filtered time waveform exactly where they occur in the original signal. The signal ready to undergo to the next stage, which is segmentation.

2.2 Segmentation

After pre-processing step, the PCG signal will undergo segmentation process. To segment the signal, Average Shannon Energy method applied on PCG signals in this project.

Average Shannon Energy

Average Shannon energy applied to obtain the envelope of the signal. Four different ways can be used to calculate the envelope of the normalized PCG signal. The equations are represented in Equations (2.2), (2.3), (2.4), and (2.5).

$$\text{Shannon energy: } E = -x^2 . log x^2 \quad (2.2)$$

$$\text{Shannon entropy: } E = -|x| . \log |x| \quad (2.3)$$

$$\text{Absolute value: } E = |x| \quad (2.4)$$

$$\text{Absolute value: } E = x^2 \quad (2.5)$$

Based on Fig. 2 indicates that energy (square) buries sounds of low intensity below sounds of high intensity by rising the proportion of high or low intensity. For the advantage of large-amplitude oscillations, Shannon entropy mitigates the low-value noise effect that keeps the envelope too noisy to interpret. All signals are given equal weight by the absolute value. Shannon energy more efficiently accentuates the medium-energy signal and attenuates signals of lower and higher-intensity, which helps to suppress noise (Saini, 2016) therefore, It can be summed up that Shannon energy is better than the other methods of the envelope.

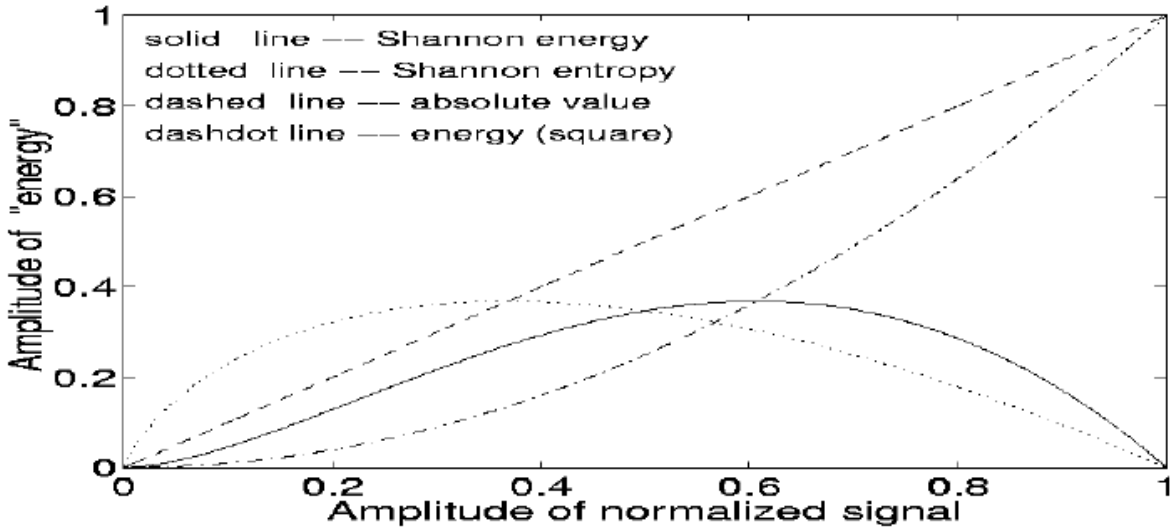

Fig. 2 Comparison of different envelope method (Sahin, 2015)

Average Shannon energy is calculated with 20ms time window with 10ms overlapping. Average Shannon Energy is obtained as Equation (2.6) (Sahin, 2015).

$$E_s = -\frac{1}{N} \cdot \sum_{i=1}^{N} x_{norm}^2(i) \cdot log x_{norm}^2(i) \quad (2.6)$$

Then, average Shannon energy versus time axis is calculated like Equation (2.7) (Saini, 2016) where $Es(t)$, is the average Shannon energy obtained by Equation (2.5), $M(Es(t))$ is mean or the average Shannon energy and $S(Es(t))$ is the standard deviation of the average Shannon energy.

$$P_e(t) = \frac{E_s(t) - M(E_s(t))}{S(E_s(t))} \quad (2.7)$$

After obtaining the envelope of the normalized PCG signal, threshold of the signal is calculated to obtain the peak candidates. The mathematical equation is as in Equation (2.8).

$$thr = 0.5(\max_{t \in R}(t) + \min_{t \in R}(t)) \quad (2.8)$$

The intervals between each adjacent peak candidates are calculated by subtracting each candidate's peaks with its neighbour. The widest interval is pick as diastolic and then alternate. The idea is to select and classify the widest interval as diastolic, then in both directions alternate. This is because diastolic period is always longer than systolic period, hence the longest period must be diastolic (Sahin, 2015). The final step of segmentation is done by segmenting each of the intervals of the signal.

2.3 Feature extraction

Stockwell Transform

At this stage, the method that is relied upon is Stockwell transform, also known as S-Transform (ST), and this process was applied to all periods of systole and diastole as shown in Fig. 3, and then extracted the ST-MATRIX. This process enables us to analyze the information in a period of time and frequency at the same point. In the form of the spectrum we can point out that, the dark color period refers to the lack of frequency as well as resolution and vice versa. Depending on that, we have three important information's which are basically the maximum value of each column in ST-MATRIX, the maximum value of each row in ST-MATRIX and standard deviation value of each row in ST-MATRIX. Using the information's of the three different vectors we can obtain several features such as mean, median, maximum, minimum, standard deviation, skewness, kurtosis, rms, rssq, variance, normal amplitude signal, amplitude factor, difference between maximum and minimum and mean absolute square. In addition, doing the statistics equations to select the best features from the ST-MATRIX, which in turn helps in the classification process for the next stage.

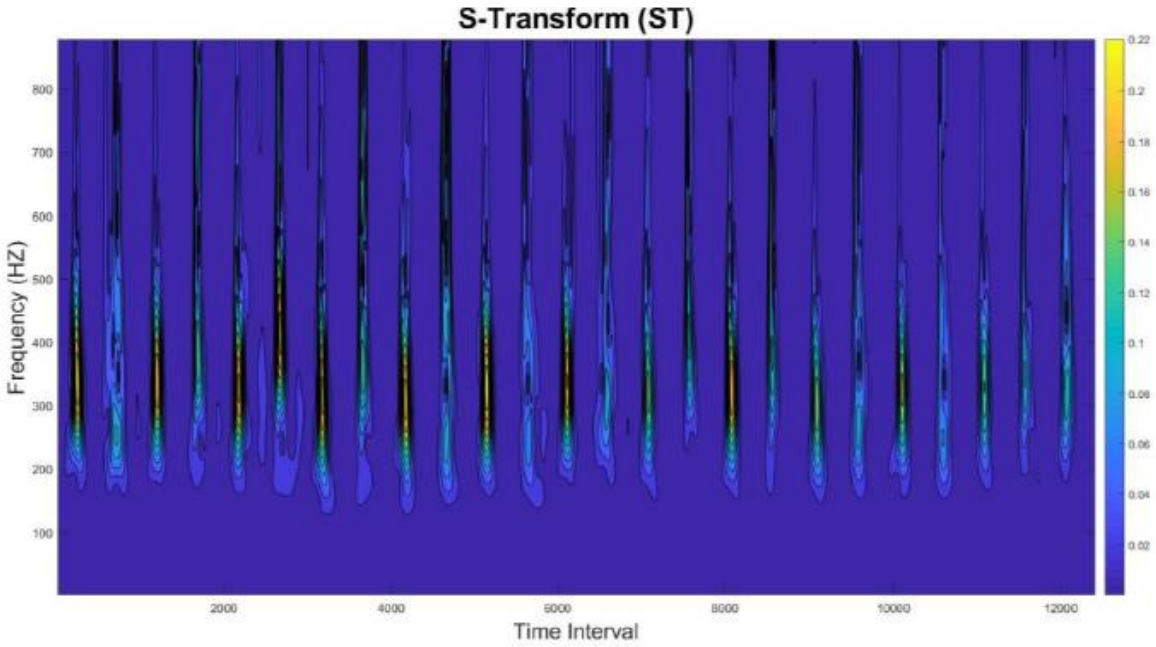

Fig. 3 Stockwell transform of normal heart sound

2.4 Classification

Classification is the final step throughout signal processing. For classification, the features derived from the ST-MATRIX are fed. In these procedures, Ensemble Classifier have used.

Ensemble Classifier

Ensemble learning helps to improve the performance of machine learning by integrating many designs. This method makes it possible to produce better predictive results than a single model. Ensemble models are meta-algorithms incorporating multiple techniques in machine learning into one predictive model to minimize uncertainty (bagging). Improvement of discrimination (boosting) or inference (stacking).

It can be split into two classes composed of sequential set methods and parallel set methods. The purpose for sequential approaches is to manipulate base learners ' dependency. The overall performance can be improved by measuring previously mislabelled cases of higher weight. In the meantime, the main motive of parallel approaches is to maximize autonomy among simple learners as it can be dramatically reduced by averaging the error (Potes, Parvaneh, Rahman, & Conroy, 2016).

3. RESULTS AND DISCUSSION

The algorithm used is able to identify the diastolic and systolic period in the PCG signal. By investigating the spectral information of the phonocardiogram signals, it is possible to extract salient features to differentiate various heart ailments. The proposed system is able to classify the PCG signal into normal, murmur, and extrasystole categories as shown in the Table 1.

Table 1. Classification accuracy

Model No	Normal (%)	Murmur (%)	Extrasystole (%)	Average (%)
1	84.9	72.5	12.4	68.7
2	85.2	72.7	12.8	69
3	86	72.1	10.7	68.7
4	85.3	71.5	13.4	68.7
5	85.3	71.7	11.3	68.4
6	85.8	71.8	11.2	68.6
7	85.8	72.2	12.8	69.1
8	85.2	71.8	11	68.4
9	84.8	72.1	10.8	68.2
10	85.4	72.5	12.2	68.9
Total Average	85.4	72.1	11.9	68.7

As shown in Table 1 that the result of classification of heart sounds into several categories is 68.7 %. Although the low rate to some extent, but the classification ability to classify heart sound as normal is very high rate, which is 85.4 %, but according to the classification between the remaining categories of the heart sounds, which are murmur and extrasystole, it gave a somewhat low percentage, which are 72.1 % and 11.9% respectively. Due to the unhelpful extra features resulting from the lack of statistical analysis of these features, which led to a decrease in the classification rate.

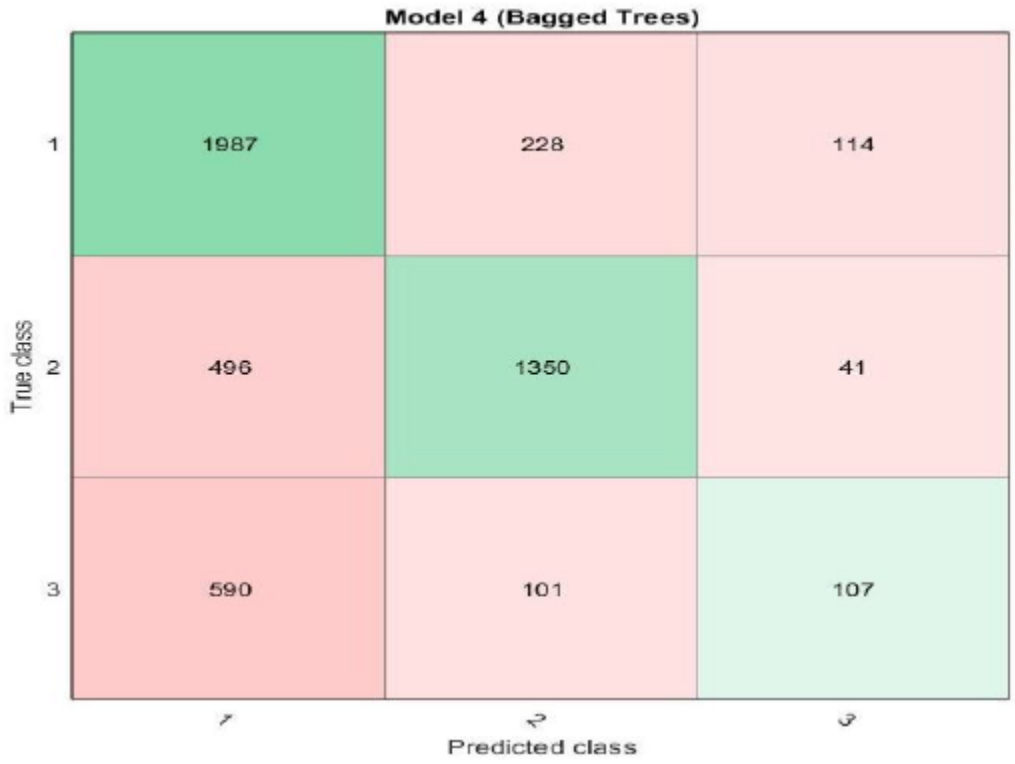

Fig.4 Confusion matrix of ensemble classifier on heart sounds (model 4)

Fig.4 shows the results of ensemble classifier on heart sounds (model 4) for three different classes which are normal as class 1, murmur as class 2, and extrasystole as class 3. It is clear that class 1 shows the highest accuracy in the confusion matrix since 1897 heart sound periods classify as a normal out of 2329 periods. Then the second class shows that the classifier able to classify 1350 periods as murmur out of 1887 periods. The last class which is class three that is shown in the confusion matrix above and it show that the classifier able to classify 107 periods of the heart sound as extrasystole class out of 798 periods. The ensemble classifier achieve a poor result in classification of the 3rd class.

4. CONCLUSION

In conclusion, machine learning able to distinguish between normal, murmur, and extrasystole heart sound by using Ensemble Classifier, the best accuracy that achieved in this work was 69.1%. The effective processing of phonocardiogram signals could provide useful information to understand heart abnormalities. By detecting the murmur and extrasystole heart sounds, it is possible to diagnose related heard abnormalities earlier. Phonocardiogram based heart screening concept is a low cost solution that can be implemented in rural healthcare centers.

Several suggestions may be aimed at improving existing accomplishments in the identification of heart sounds into normal, murmur, and extrasystole. It is possible to study a strategy of reducing unnecessary signals and sound so that the signal is less distracting. For a better recognition, a deep exploration of this field should be made. To improve the results, the number of signal usage should be increased as the larger the data sample, the higher the number of accuracies may increase.

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EARLY INTERVENTION PROGRAM OF GROSS MOTOR DEVELOPMENT FOR AUTISM SPECTRUM DISORDER(ASD) USING AUGMENTED REALITY APPLICATION

Nur Adlina Bt Md Isa[*1], Dr Norasikin Fabil

[1]Universiti Sains IslamMalaysia (USIM)
Bandar Baru Nilai, 71800 Nilai, Negeri Sembilan

ABSTRACT

Augmented reality (AR) is the technology that integrate the computational data information with user's environment in real time. AR has been applied and shown advantages in many areas. Therefore, this research study AR in Autism Spectrum Disorder (ASD) context. ASD children suffer in motor delays in their routine day. The ASD children also difficult to understand and translate teacher's instruction during school session. Furthermore, most of the autism therapy center provide the traditional education tools which is more rigid and not interactive. Thus, the mainly aim of this project is to develop interactive learning application for ASD kids (KidzLearn application) using augmented reality. This is to attract children to focus more during learning session and easily understand what had been taught. This project also has been tested by 10 experts from Kidz Emporium Therapy center towards the user acceptance on the apps (KidzLearn application) Methodology development used for this project is Agile Model. This application is develop using Unity Software to display the 3D models and animation of the character. The security method used is QR Code for ensuring the usage of the application. Since this is application purposely develop for ASD children, QR Code is the best choice used to authenticate user and can handle it with easiest way. Finding for this research are AR learning application are design with combination of animation and audio element which is an edutainment concept . KidzLearn application also have security element which is QR Code and the user acceptance towards this application also been identified.

Keywords: Augmented Reality, Autism Spectrum Disorder, 3D Model, Unity, Agile.

1. INTRODUCTION

Autism Spectrum Disorder (ASD) is a severe developmental disorder that affects children. The disorder affects the brain that can cause retardation of their mind. This neurological disorder will affect the children in terms of communication with peers, socialize with community and imagination level, which that the kids always pretend play. Typically, ASD cannot be recognized during getting birth, parents will see the changes in their baby at age three. Many children with autism tend to self-stimulatory, such as hand-flapping, gloved, swaying or repetitive vocalizations (Nababan et al., 2018). Difficulty in realizing emotional change, lack of empathy with others and difficulty in responding appropriately to a disorder in social interaction for people with autism.

Kidz Learn application for autism kids are developing to solve this problem. First Autism children suffer motor delays in daily life, such as sitting, walking and jumping. Next , Children also have a problem to integrate and understand teacher's instruction. Next based on Autism centre they provide traditional and rigid learning tools for learning session.

Technology becomes demand by years, all level of age used a smartphone in daily days for convenience life. In the learning process, technology is also used to attract children to focus and understand more in their studies such as Frog education one of e-Learning system which focuses on school students. The learning process becomes more interactive and more visual than rigid textbooks. Students also can explore limitlessly and become more creative. As time progress, Augmented Reality (AR) is one of the famous technology in education. AR is an interactive experience of the real world which user can see just real as it superimposed a computer-generated image on user image.

AR creates an improvement in terms of enjoyment, engagement and imaginative skills development and learning in children with autism (Taryadi & Kurniawan, 2016). As AR can help children in imaginative skill so AR application for autism kids are developed to help children to increase their quality of life.

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1.1 OBJECTIVES

This research aims to develop an interactive learning application for Autistic Spectrum Disorder (ASD) kids using Augmented Reality and to fulfil the following objectives:

1. To design and develop an AR application that combines with animation and audio element which is an edutainment concept to help children in memorizing and understanding during the class session for ASD children.
2. To Implement secured QR Code AR application for ASD children.
3. To identify the user acceptance towards the AR application project.

1.2 RESEARCH SCOPE

There are many approaches used by the therapist and specialist to improve autism children in their daily routines. In this research, skills that are applied are focusing on gross motor and pre-learning skill based on early intervention program in Kidz Emporium Therapy Centre. KidzLearn application is develop in Malay language instead of English as requested by Therapist. This Augmented reality for autism application is used to help children in memorizing by superimposed every cue card or action words used by the teacher in 3D at real-time.

This KidzLearn application are tested by 10 experts included 3 therapies, 6 teachers and 1 Head of the Kidz Emporium Therapy center. This testing involved among 10 ASD children around 4-7 years old from the student of the therapy center within 2 weeks.

1.3 METHODOLOGY

This project (KidzLearn application), Agile SDLC Model has been adopted. The algorithm consist of 3 cycles named Agile-1 for QR Code, Agile-2 for Belajar and Agile-3 for Kuiz. Figure 3.2 shows the adaption agile model as the methodology development for this AR application.

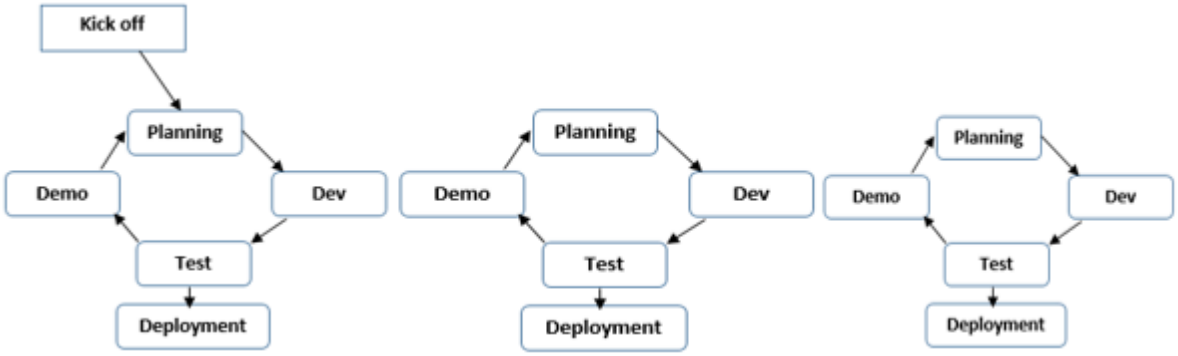

Figure 1: Methodology Development of KidzLearn application
(Adaption: https://bit.ly/2DHWLI6)

Agile Methods focus more on technical excellence and good design. This model divides the system into a partition of incremental builds. These builds are provided in iterations. Typically, each iteration is within one to three weeks. The direct conversation and continuous input are much better as a developer have no guesswork. Every iteration partitions contain various task working simultaneously like planning, requirements analysis, design, coding, unit testing, and acknowledgement testing. At the end phase of development, the system will present to the client and stakeholders.

Each of the agile cycle conducts 3 different phases. The first phase is the QR Code which, the user should authenticate themselves before enjoying the application. Next "Belajar" phase, this phase contains the basic knowledge for the children such as animal name, shape and food. Gross motor skill also implement at this phase, action words used by the children in their daily life are also digitized to become a 3D model with animation and audio. The last phase is "Kuiz dan Pembelajaran". Simple quizzes will be develop and implement to the application.

1.4 USER INTERFACE DESIGN

1. AUTHENTICATION PAGE

When User click 'QR Code' button, the software will move to the next interface, which is Scan QR Code Interface QR Code is printed at one of the flashcards. One QR Code is for few specific flashcards that have been chosen by the Admin. QR Code is used to access the markers usi ng a software named Unity to activate the marker to display 3D Images. User can scan the marker successfully. Without QR, all the markers are not trackable and detected by the AR camera.

Figure 2: Qr Code Page

Figure 3: Scan Qr Code

2. HOME PAGE

Figure 5.12 shows the homepage which contains two functions which are Belajar and Kuiz**.**

Figure 4: Home page of the application

3. MAIN PAGE

This part consist of learning of the object. User will learn the living things and non-living things in the 3D model. User will scan the flashcard and cue cards to generate a 3D model with animation and audio. Chapter categorizes with Bentuk, Haiwan, Makanan and Aktiviti. Aktiviti are more towards gross motor skill, which cover all actions words frequently used by the children in their daily living skill such as wave hand, running, walking, jumping and others. While, Bentuk, Haiwan and Makanan focus towards the environment around the children. The basic knowledge for the children.

Figure 5: Main page of the application.

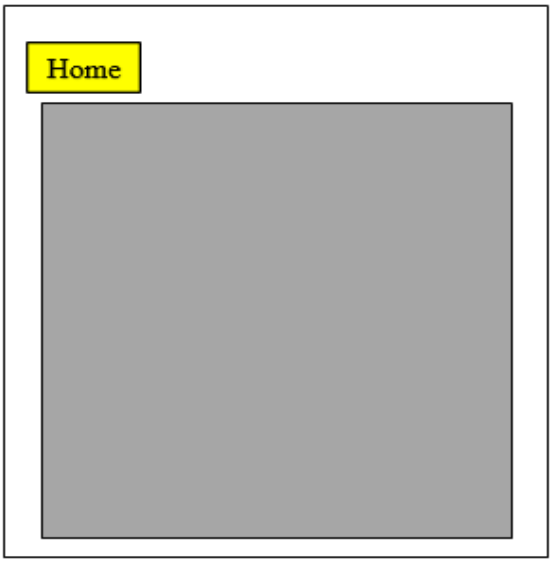

Figure 6: Camera to Scan Flashcard

4. KUIZ

The quiz contains multiple choices questions. Include sound right and wrong answer. The user also can back to a previous question but cannot to the next question until the answer is true.

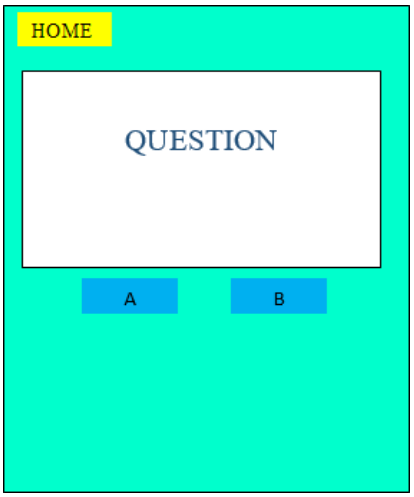

Figure 7: Question interface

1.5 RESULT AND DISCUSSION

In this testing, the end-user will evaluate and verify the whole function of the application. The end-user will evaluate the application whether it is achieved user requirement and objectives of the project or not. The end-users include 3 therapists, 6 teachers and a Head of Kidz Emporium Therapy centre. The questionnaire included an interface part and functionality part. All the users must test the application within 2 weeks and give their feedbacks by fulfilling the questionnaire form. Below shows the questionnaire form that should be fulfilled by the end-users.

The questionnaire consists of 8 question which are closed ended questions. Question 1 to 7 focus to design and development of the applications while question number 8 shows the user acceptance toward the application.

Table 1: User Evaluation Result

Questions	1	2	3	4	5
Is the AR Mobile Apps easy to use?	-	-	3	6	1
The overall design is suitable for Autism children.	-	-	-	6	4
The information and content are organized.	-	-	1	7	2
When the navigation button clicked, does it direct to the correct page?	-	-	-	2	8
Is the picture used in AR clear and understandable by Autism children?	-	1	3	5	1
How satisfied are you with the AR content?	-	-	-	6	6
How do you rate the application in term of user-friendliness and efficiency?	-	-	3	7	-
The application is helpful to inform another center to use this application?.	-	-	1	8	1

Based on the questionnaire, the majority of the respondent agree this application is suitable to use for the ASD children as supported learning to help children in memorizing. Table 1 shows the analysis result from the questionnaires.

Majority of the respondent agree that the overall design of the application is suitable for the ASD children. The information and content also organized well and getting the highest rate for efficiency and friendliness. A majority of the experts suggest to recommend this KidzLearn application to another autism center as it is a very useful application and help ASD children in their education.

1.5 CONCLUSION

In a nutshell, the main idea of developing this KidzLearn application has already been discussed. The main idea comes from user requirement in Kidz Emporium Therapy to have interactive learning for their school. This system also has its strength and limitation. This thesis also requiring basic learning for autism children and a lot of skill before the application and thesis writing being completed.

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