Comparison of Classifier Performance in Android Based Lung Sound Analyzer

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***Abstract* - The shortage of health professional is one of the huge concerns in the Philippines, especially in the remote areas. Majority of Filipinos only rely on the public health center that has 4.6% doctors out of 66,000 in total. With this problem, the proponents think of a way to help by developing a machine that will automatically analyze the patient's lung sound - Normal, Rales or Wheezing Sound - and give the best result as possible. To get this best accuracy, the proponents did a study on what is the best classifier in the Automation of Auscultation. This is the summary of the classifier's training accuracy, with 85% for Convolutional Neural Network as the highest, compare to Support Vector Machine with 54% and K-Nearest Neighbor with 72%. For the training datasets, the Testing accuracy results are 83%, 76% and 82% for SVM, KNN and CNN respectively. The best classifier will be used for the final model and will be implemented in an android mobile with a user-friendly interface, simple but straightforward interface. The implementation on the Android phone provides mobility and ease in bringing and using the device.**

Keywords – Lung Sounds, Sound Processing, Android, KNN, SVM, CNN

I. INTRODUCTION

The most common and important medical instrument used is a stethoscope, it is used for general examinations in any check-ups but specially it is used in checking if there's an indication that the patient has in respiratory distress. Auscultation is important for doctors, especially physicians, in determining the patient's health and recommendations for further tests. Although auscultation is non-invasive, improper hearings might lead to improper treatments and diagnosis, it leads to improper medication and tests that is all just a waste of money. As the increase of demand in the medicine field increases the number of new practitioners is directly proportional, training of new physicians is inevitable. With the varying of their sound perception. With the usage of this kind of device, new medical practitioners will have an aid for accurately diagnose the sound the patient's lungs produced and can decide for a correct diagnosis and provide treatment and referral, this device can also be use as the patient's self-monitoring of their own lungs sound while undergoing the treatment. Additionally, this device can be used in places that has a scarcity in licensed medical practitioners and only rely on public health workers.

A. Lung Sound

Lung sounds are categorized as normal sounds and adventitious sounds, under adventitious lung sounds are Crackles – Fine (Rales) or Corse, Wheeze, Stridor, Pleural Rub, and Rhonchi. This study focuses in determining the normal lung sounds and two abnormal lung sound – which is the Fine Crackles (Rales) and Wheeze. Rales is the sound occurs if the small sacks in the lungs has fluid and there's a movement in the lungs while you are breathing it can indicate that the patient is suffering in pneumonia or heart failure. Wheeze occurs when the bronchial tubes are narrowed or inflamed, the patient with wheezing sound might be suffering from an allergy or asthma or worst, having a Chronic Obstructive Pulmonary Disease.

B. Gathered Data

The lungs sound data used for the training was gathered from the people ages 5 years old and above. The majority of these sounds are gathered from students in Technological University and AMA College, resulting for gathering more normal sounds than adventitious lungs sounds. For the testing of the device accuracy, the gathered lungs sound from a barangay in Malabon and the data from the deployment is used. The gathered data was classified first by the Head Doctor of a Public Health Center in Las Pinas City before feeding it to the training of the machine.

II. METHODOLOGY

The methodology used is a mixed of hardware and software development, the hardware part is composed of the part of the sound gathering of the device and the other external designs for the stand and casing. Major part of this study is in software development, the pre-processing of the sound, the training of the device and the design of the Graphical User Interface for Mobile.

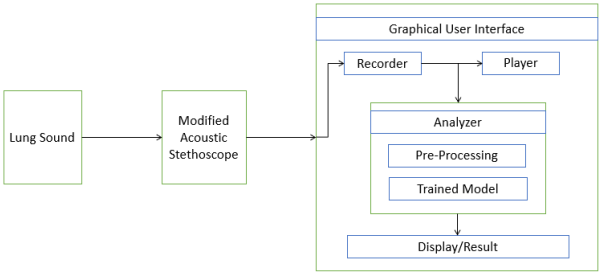

Fig. 1. Block Diagram of the Study

A. *Hardware Development*

For the development of the hardware part, the proponents used the Classic III/II of Littman Stethoscope as the lung sound gathering device and an electret microphone to record the lung sound connected to the mobile phone using a 3.5mm audio jack, a sound card for the jack's compatibility and an USB-OTG for the connection on the phone shown in Figure 2.

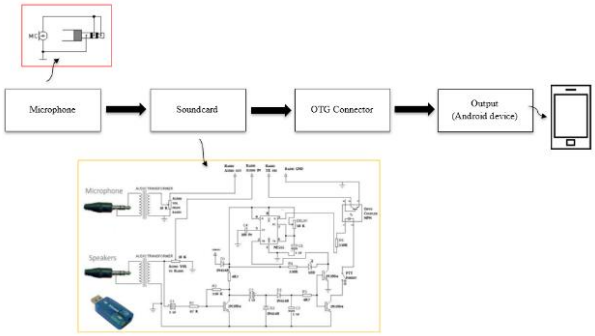

Fig. 2. Hardware Block Diagram and Schematic connection

(a) (b)

Fig. 3. (a) Stand of the Device. (b) Final Actual Design of the Stethiscope

Shown on Figure 3.a is the stand of the mobile phone for the fixed position of the device and in Figure 3.b is the final look of the stethoscope used for the lung sound gathering.

B. *Software Development*

The major part of this study is composed of the software development, wherein even the pre-processing part is done without a microcontroller but just in the coding in both in the Python model and in the Android programming. The software development is composed of the pre-processing, the training and getting the model and the design of the Graphical User Interface.

1. *Pre-processing*

The processing of the sound is made for lessening the environmental noise in the gathered sound. Majority of the other studies used the ideal lungs sound from paid online libraries but in this study, a pure manual recording is used resulting for the non-evitable noise. The pre-processing part aims to eliminate the sound that is far different from the lung sound, the heart beat sound and the environmental noises.

2. *Training Algorithm*

The set of programs used for this part were done using the Python Language coded in the Wing IDE 6.0 as the coding platform. Wing IDE 6.0 is the platform used for the feature extraction and training of the machine For the connection of the model to the mobile, the Android Native Development Kit is used provided by the Tensorflow library written in C++ available in the Tensorflow website. Tensorflow is the free library used especially for machine learning in android.

3. *Graphical User Interface*

Android Studio 3.2 was the platform used for the User Interface making of the device. Android Studio is a freeware made by Google coded in Java Language.

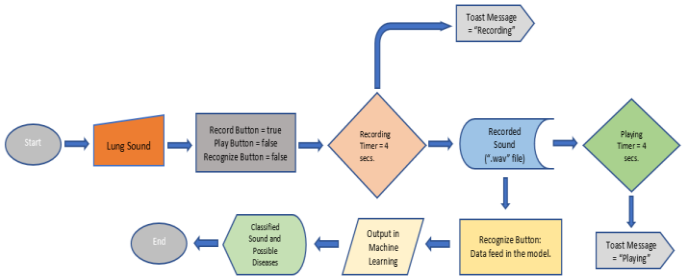

Fig. 4. Flowchart of the Android Application

III. RESULTS AND DISCUSSION

A. *Pre-processing*

The lungs sound file in the dataset is composed of one cycled recorded lung sound with duration of 4 seconds and sampled in 44 100 Hz the required sampling rate for mp3 files. For the focused abnormal sounds – Rales and Wheeze – the range of their frequencies are in 600 Hz to 2000 Hz, hence using

a bandpass filter to get this specific frequency is needed and filtering our other sound that is not related to the lung sound.

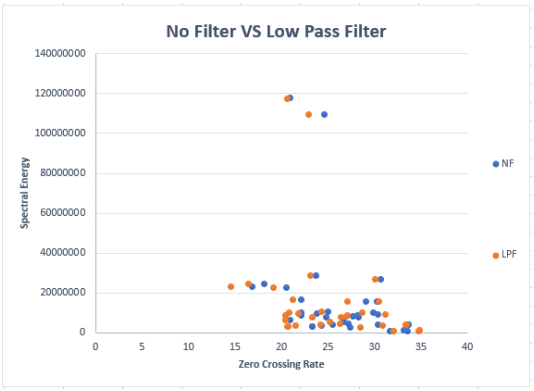

Fig. 5. Scattered Plot of Low Pass Filtering

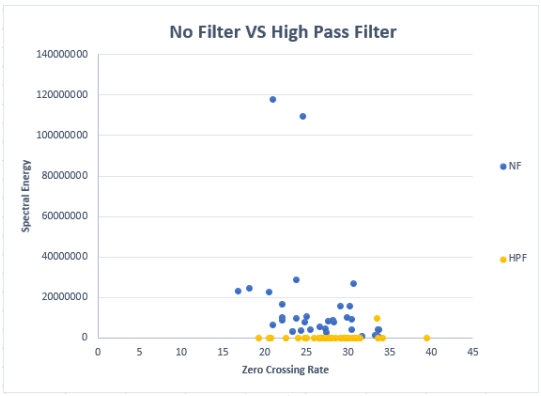

Fig. 6. Scattered Plot of High Pass Filtering

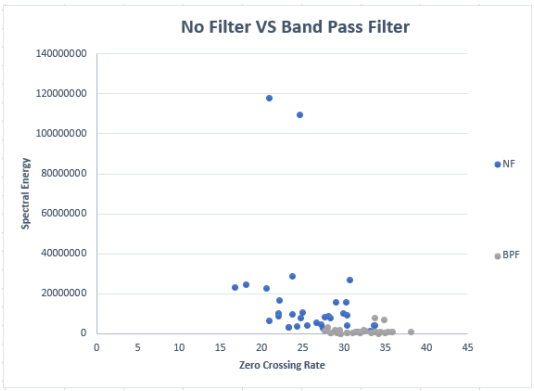

Fig. 7. Scattered Plot of Band Pass Filtering

Comparing the scattered plots, the proponents chose the suitable filter by how compressed data in the plot is. Zero Crossing Rate determines the rate at which the signal changes from positive to negative, this determines the number of the signal's frequency. The decrease in Zero Crossing Rate proves that the signal is filtered. As Gronnesby (2014) indicated, lesser noise sound has a highest Zero Crossing Rate. Having that band pass filter has more compressed and highest ZCR therefore Band Pass Filter is suitable filter for the pre-processing part of the study.

B. Best Classifier / Training Algorithm

In determining the best classifier, this study considers the results in the testing accuracy, precision, recall and F1 score. Since this study is in the field of Biomedical and aiming to be an aid of the doctors, highest accuracy of classifier was needed, and the precision of its reading must be considered. The classifiers to be compared are: Convolutional Neural Network, Support Vector Machine and the K-Nearest Neighbor. The data set is the same all throughout to compare the results of each classifier.

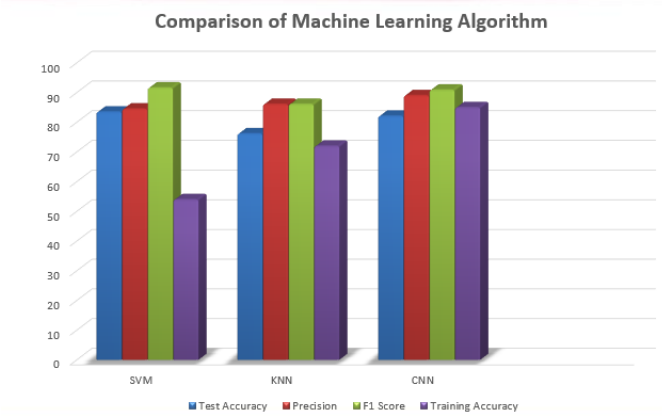

Fig. 9. Comparison of Machine Learning Algorithm

In the determination of what is the best classifier, the algorithms are tested using the test datasets. The graph shows their differences in Accuracy, Precision and F1 score. Additionally, the Training Accuracy is also presented on the graph. Although SVM have the highest accuracy in testing, it's classification in the training datasets are all Normal lungs sounds due to the class imbalance, it happens that majority of the lung sounds in the data sets are normal, resulting to the higher testing accuracy for SVM. Eliminating SVM, between the two models, Convolutional Neural Network has the highest Accuracy, Precision, Training Accuracy and F1 Score.

C. Graphical User Interface

The android application was designed in Android Studio and written in both Java Language and XTML for the design. The User Interface has and easy to navigate design containing buttons for the recording of the lungs sound, the button for the playback of the recorded sound and the recognition button for the classification of the lungs sound. There is also a text view where in the resulted classification and the possible disease will be displayed. In the handy mobile, there is a visualizer for the recording and playing sound for additional design of the application and a button for the about the project for the summary of what the study is all about.

Fig. 10. Actual Design of the Lung Sound Analyzer Application

IV. CONCLUSION

In conclusion, the Automated Lung Sound Analyzer was able to provide a reliable result with the training accuracy of 85% using the Convolutional Neural Network compared to the other classifiers with much lower accuracy of 54% and 72% for the SVM and KNN respectively. The testing accuracy for the Convolutional Neural Network is 82%, Precision of 89% and F1 score of 91%. Comparing the results for the comparison, CNN is the best classifier for the Lung Sound Analyzer and has a good compatibility with the Machine Learning in an Android. The device has an easy to navigate mobile user interface with buttons to record the lung sound, playback the recorded audio and recognition that has the model that will determine the status of the patient's lung sound and indicates the possible sickness in the average process speed of 15 seconds. The possible diseases displayed under each lung sounds are researched and validated by the doctor. Those possible disease are all fixed in each sound, more medical tests are needed to be diagnosed in either of those ailments. The Lung Sound Analyzer will be a good help as an aid for the patients in the remote areas that lacks doctors in doing the basic test such as the automation of auscultation, it is also a great help for the new medical practitioners who are a bit confused in the differentiating these lung sounds, this can be used for their training of mastering the different lung sounds The Automated Lung Sound Analyzer is also portable and can be installed in any android devices, and the hardware parts are all available in the market

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