Design and Development of Portable Spirometer

M. Udin Harun Al Rasyid, Kemalasari, Muhammad Sulistiyo, Sritrusta Sukaridhoto
Politeknik Elektronika Negeri Surabaya (PENS), Surabaya, Indonesia
{udinharun, kemala}@pens.ac.id, tiyo.lab@gmail.com, dhoto@pens.ac.id

***Abstract*— Spirometer as main device to perfom spirometry test is needed to make clinical diagnosis of Chronic Obstructive Pulmonary Disease (COPD), a limitation airflow disease. Spirometer will produce Forced Vital Capacity (FVC), maximum volume of air that can be exhaled during a forced maneuver and produce Forced Expired Volume in one second (FEV1), volume expired in the first second of maximal expiration after a maximal inspiration as the main factor to diagnosis COPD. Spirometry test generally performed at a health clinic or medical offices but nowdays home spirometry with portable devices is slowly gaining acceptance. But current portable home based spirometers have no coaching, feedback, or quality control mechanisms from physicians to ensure acceptable measurements. This study creates android messaging, javafx desktop and website based information system integrated to portable spirometer made from MPX5100DP sensor to calculate the pressure during FVC, and Arduino nano to keep track and maintaince spirometry test.**

Keywords—* *Spirometer, Portable, Android, Arduino

I. Introduction

Spirometer is main equipment needed by spirometry test, a test commonly used to make clinical diagnosis of Chronic Obstructive Pulmonary Disease (COPD). COPD is a common preventable and treatable disease which characterized by persistent airflow limitations that is usually progressive and associated with an enhanced chronic inflammatory response in the airways and the lung to noxious particles or gases [1].

During spirometry test, a patient forcefully exhales through a spirometer device then spirometer will measure Forced Vital Capacity (FVC), maximum volume of air that can be exhaled during a forced maneuver and Forced Expired Volume in one second (FEV1), volume expired in the first second of maximal expiration after a maximal inspiration. The ratio FEV1 /FVC is between 0.70 and 0.80 in normal adults; a value less than 0.70 indicates airflow limitation and thus of COPD.

Spirometry test generally performed at a health clinic or medical offices using conventional spirometer with a relatively large size and take up much space or with a portable spirometer which is small and easy to use. Portable spirometer also sold freely in the market and can be used regularly at home, so no need to come to the health clinic or health care professional. But this is ineffective when used without the supervision and advice of a physician or by health care professionals because not everyone can read spirogram and follow-up of the test results. Importantly, while office based spirometry is choached by a trained technician, current home spirometers have no coaching, feedback, or quality control mechanisms to ensure acceptable measurements.

There have been several studies devoted to developing portable monitors for ehealth care. Al Rasyid et al. [2-3] proposed portable mobile monitoring system for muscle strain Electromyogram (EMG) and Electrocardiogram (ECG) sensors. The result of EMG and ECG sensor can analyzed by a doctor from distance. Larson at al. [4] proposed SpiroSmart which using a microphone to measure lung function on a mobile phone. The user forcefully exhale at the screen of the phone, The phone's microphone records the exhalation and sends the audio data to a server, which calculates the exhaled flow rate by estimating models of the user's vocal tract and the reverberation of sound around the user's head. SpiroSmart result 5.1% error from common measures of lung function. This SpiroSmart provide flow rates and graphs similar to clinical spirometer, built-in choaching and feedback, data uploading and data evaluation.

Fekr et al. [5] proposed portable real-time platform for human respiratory tracking system. The system uses accelerometer sensor to monitor the respiratory rate and tidal volume for patient with breathing problems or sleep disorders. The experiment results show that the error respiration rate calculation with proposed system using accelerometer is very closed compared to spirometer.

II. System Design

The general overview of the system design process is shown in figure 1. Figure 1 shows how the whole system work. First patient will inhale as hard as possible and then exhale it as hard and as fast as possible through E-Spiro device. As the maneuver happen, E-Spiro device then calculate the pressure and convert it to volume. Data volume then send to patient android smarphone (E-Spiro App) through bluetooth connection. Both Flow-Volume and Volume-Time graph will draw at smartphone screen following the maneuver. When maneuver finished, application will validate the result to meet acceptable and reporducible maneuver.

Every single session spirometry test patient will ask to do maneuver until at least 3 acceptable and reproducible maneuver produced. Validated maneuver and other information such us date of test, patient test position, patient height then saved to patient smartphone.

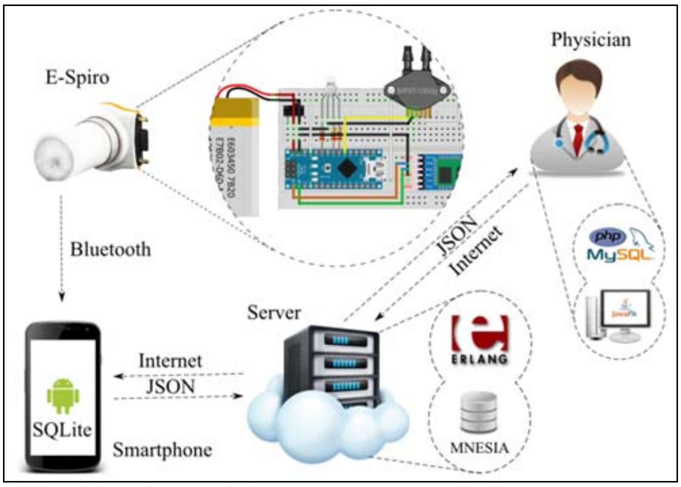

Figure 1. General system design

Detail test result can be seen at history. There patient will serve such us information about his/her FVC (Forced Vital Capacity) maximum volume of air that can be exhaled during a forced manuever, FEV1 (Forced Expired Volume in one second) volume expired in the first second of maximal expiration after a maximal inspiration, ratio of FEV1/FVC to determine is positivie COPD or not, FEV1 predicted value, percentage of patient FEV1 with FEV1 predicted value, Diagnosis, both Flow-Volume graph and Volume-Time graph and spirometry test development graph. That data not only save to patient smartphone but also send to physician / heatlh care professional javafx desktop application who supervise him/her by the time singe session spirometry test finished. physician / heatlh care professional will server same information such patient got. This application also provide messaging function so patient and his/her supervisor can discuss about test result, give feedback each other just like messaging application.

III. Performance Evaluation

The purpose of this test is to determine wheter E-Spiro hardware can read lung volume compared with existing spirometer. Testing tools contains BIOPACK spirometer and Personal Computer. This test is performed by 4 random people who each of them do 5 manuever, one of them is smoker. We calibrate BIOPACK spirometer first. The perform maximal inspiration and maximal ekspiraton towards BIOPACK spirometer mouthpiece. Each people do 5 manuever.

Figure 2 shows saved test result of spirometry test. It shows information about Supervisor, test date, height, position of test, FVC value, FEV1 value, ration between FVC and FEV1, FEV1 prediction value, percentage value of real FEV1 and FEV1 predicted, diagnosis and COPD level.

This test result also save and send to doctor after test finished. Below is one of screenshot of E-Spiro spirometery test result on patient smartphone and doctor desktop app.

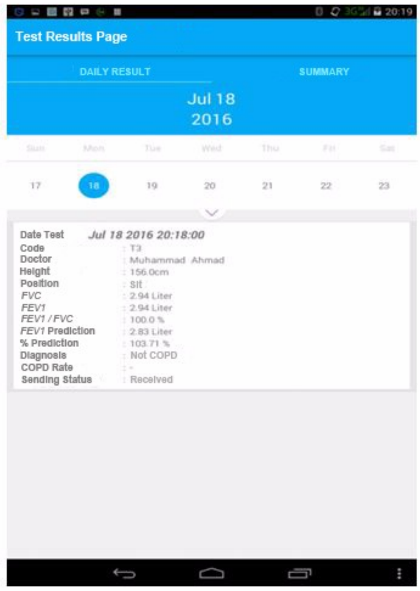

Figure 2. Mobile monitoring result

IV. Conclusion

Portable spirometer should not only give ability to perform spirometry test but also should give ability to share data/test result with physician to keep track and maintain the test. One of the idea is to create messaging based system integrated to spirometer device like E-Spiro and erlang as web server. Erlang choosen becouse from the research in this paper it meet the avaibility and reliability.

Acknowledgement

This research was supported in part by Ministry of Research, Technology and Higher Education of Indonesia, under *Penelitian Terapan Unggulan Perguruan Tinggi* (PTUPT), Grant No. 0045/E3/LL/2018.

References

[1] E. Andreeva, M. Pokhaznikova, A. Lebedev, I. Moiseeva, O. Kuznetsova, J-M. Degryse, "Spirometry is not enough to diagnose COPD in epidemiological studies: a follow-up study", Nature Journal Primary Care Respiratory Medicine, 2017.

[2] M.U.H. Al Rasyid, D. Prasetyo, I.U. Nadhori, A.H. Alasiry, "Mobile monitoring of muscular strain sensor based on Wireless Body Area Network", International Electronics Symposium (IES), 2015.

[3] M.U.H. Al Rasyid, A.A. Pranata, B-H. Lee, F.A. Saputra, A. Sudarsono, "Portable electrocardiogram sensor monitoring system based on Body Area Network", IEEE International Conference on Consumer Electronics-Taiwan (ICCE-TW), 2016.

[4] E.C. Larson, M. Goel, G. Boriello, S. Heltshe, M. Rosenfeld, S.N. Patel, "SpiroSmart: using a microphone to measure lung function on a mobile phone", Proceedings of ACM Conference on Ubiquitous Computing, pp. 280-289, 2012.

[5] A.R. Fekr, K. Radecka, Z. Zilic, "Tidal volume variability and respiration rate estimation using a wearable accelerometer sensor", International Conference on Wireless Mobile Communication and Healthcare (Mobihealth), 2014.