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Smartphone-Based Lux Meter with Decision Support System

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***Abstract*—Smartphone application for measuring lighting conditions has been developed, however none of them involving decision support to help user to adjust the lighting condition as needed. This research project, developed a light meter on android device with decision support system. This application has the ability to tell the user whether the lighting condition is good or not according to the room usage, and furthermore the user is expected to be able to save energy on lighting. Since the measurement method did not need high accuracy, the ambient light sensor embedded in the device was used. The result of the research gave adequate measurement and able to give information to the user as needed.**

Keywords—smartphone application; lux meter application; ambient light sensor; decision support system;

I. Introduction

Mobile applications have been rapidly developed in the last decade. Smartphone form factor and low price are some of the consideration for programmers to switch to smartphone application. Smartphones are equipped with light sensor and camera, these features can be used to develop light meter application for many usage. A smartphone application has developed to detect low light bioluminescence, using smartphone camera [1]. An application has also been made using smartphone to measure light intensity by Sarun et.al [2]. Sarun's work also used the built-in camera, and was developed using Java. A recent study was done to compare three methods for light measurement using smartphone light sensor, built-in camera and external light sensor device connected to smartphone. The research concluded that all methods gave adequate accuracy [3].

Many research have been made on the smartphone to measure light intensity, however none of the research involving an information system that could give decision for the user. Smartphone light meter gives a reading of the ambient light, this information/data is useful for people who know how to use the information/data. This research project was made to provide information to smartphone user on the ambient light, when they wanted to have proper lighting. Therefore, a precise sensor reading was not necessary, instead the application could give information whether the ambient light were too high or too low, and could give a suggestion accordingly. To make the produced device simple, the built in Ambient Light Sensor (ALS) in the device was used.

II. Materials and Methods

A research by Gina in 2013, concluded that lighting affect work performance [5]. Other research was also done in a library to calculate the effectiveness of reading environment with lighting conditions, also indicated that lighting situation was one of factor that affect the work [6]. The purpose of the research was designing an application for mobile smartphone to give a measurement on a room lighting condition. Furthermore, based on the reading the application will give information whether the lighting was sufficient, too dark or too bright. Prior to do that, the user had to define what room he was measuring to give correct information. Room with different usage needs different lighting condition. Government regulation no. 38/2012, has determined lighting condition for different purposes, such as housing, hotel, office, education institution and many more [7]. This research took information for housing, although different lighting regulation can be easily put in the database, as follows:

Table 1. Room Type and lighting condition

Room	Max illumination (W/m^2)
Terace	3
Living Room	7
Dining Room	7
Work	7
Bedroom	7
Bathroom	7
Kitchen	7
Garage	3

The scenario for measurement mentioned earlier can be demonstrated in figure 1.

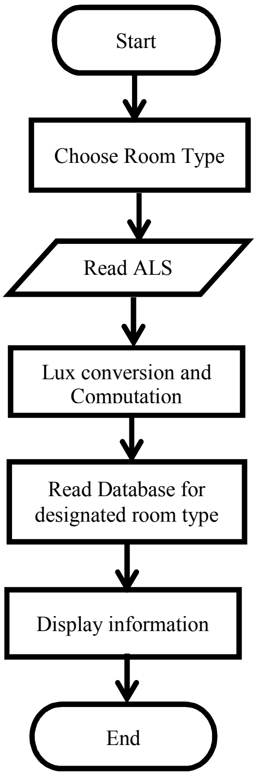

Fig. 1. Application Flowchart

Based on the information provided by the application, the user can take further action, whether to leave it as it is or change the bulb to correct the lighting condition. Furthermore, this action will also give impact on the energy usage.

The project used android v4 based smartphone device for the implementation and the embedded ambient light sensor was used as measurement device. Built in ALS in smartphone gives linear reading and converted to digital output [8], therefore it gave easier way for the calibration procedure.

Calibration must be done for every measurement device. Calibration was meant to convert a measurement done by one device and compared to match the measurement with the standard device. Linear interpolation was done to determine the linear path of measured and converted values, for instance x and y. With two coordinate values (x1, y1) and (x2, y2) the calculation was done with the following equation:

$$\frac{(y-y1)}{(y2-y1)} = \frac{(x-x1)}{(x2-x1)} \quad (1)$$

The x component was taken by using calibrated light meter measurement while y component was taken by smartphone measurement. Therefore, two coordinate values were sampled, one coordinate as low point value, the other as high point value, the linear regretion was used to determine the values in between the two points. The calibration point relied on generic lux meter with factory calibration. Low point measurements were done 30 times and calculated the average, the same procedure was also done for the high point. Figure 2 was calculated using linear interpolation with data taken from lux meter reading 50 lux as low value point and 300 lux as high value point.

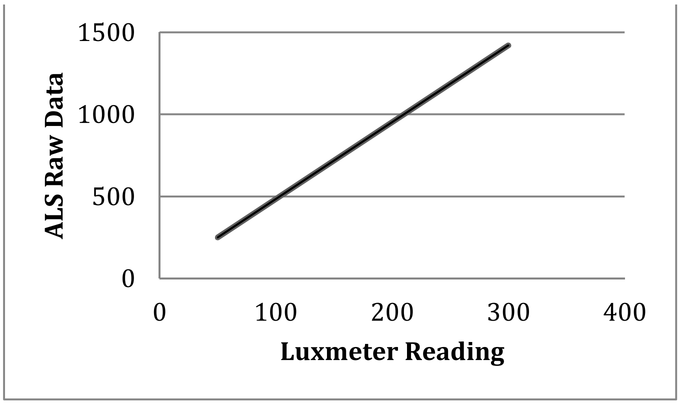

Fig. 2. Calibration Result

The linear equation result was put in the application program, and can be represented as:

$$y = 4.68x + 15.8 \quad (2)$$

III. Result

The application was developed using Android Studio, figure 4 indicated the graphical user interface of the application.

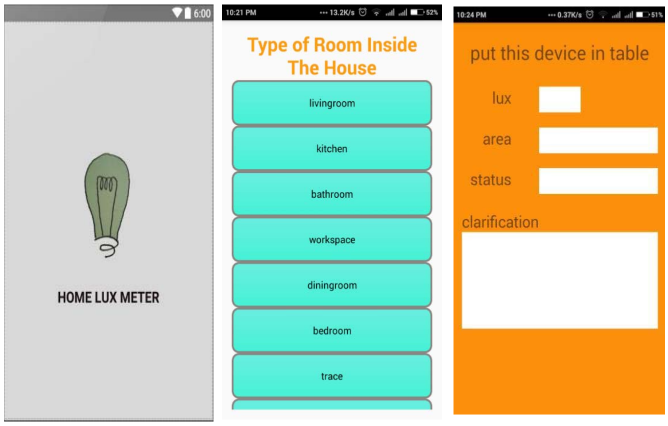

Fig. 3. Graphical User Interface

After calibration, several data point were tested and resulted. Measurement comparison between application and luxmeter demonstrated as follows:

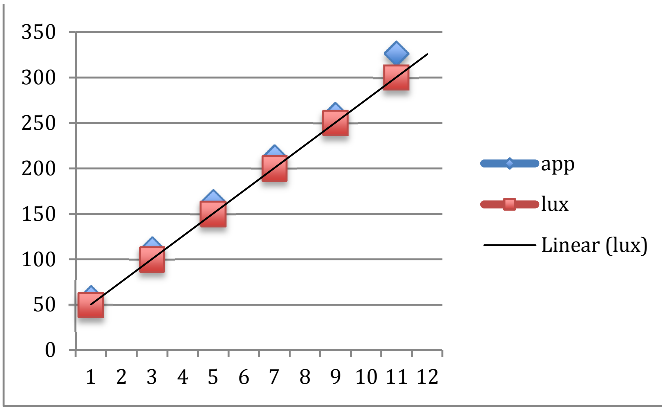

Fig. 4. Measurement Comparison

Table 2 indicated the standard deviation when several data samples.

Table 2. Device reading comparison

No	Lighting (Lux)	App Standard Deviation	Luxmeter Standard Deviation
1	50	0.152	0
2	100	049	0
3	150	0.504	0.504
4	200	0.678	0.629
5	250	0.718	0.629
6	300	0.98	0.794

Most of the problem encountered when measuring the device was the light scatter. ALS in the smartphone did not have filter that prevent reflected light from entering the sensor. While in the lux meter, the sensor was covered with white dome to prevent reflection. This resulted in the high standard deviation in the high lux measurement.

Fig. 5. Measurement test

Tabel 3 below demonstrates the reading of smartphone application in the designated room.

Room Type	lux meter	application	Error	Accuracy
Living Room	30	24.4	5.6	81.34%
Kitchen	14	13.6	0.4	97.15%
Bathroom	16	14.38	1.62	89.88%
Work	12	10.44	1.56	87.00%
Dining Room	10	9.21	0.79	92.10%
Bedroom	7	5.8	1.2	82.86%
Terace	5	5.39	0.39	92.20%
Garage	8	8.89	0.89	88.88%

The following figures demonstrated application result and information when several lighting conditions.

Fig. 6. Measurement for working area, indicating bad lighting conditions, the software advice to change the correct light bulb.

Fig. 7. Measurement for terrace, indicating bad lighting conditions, the software advice to change the correct light bulb.

Application in the device determined several conditions

- Bad lighting condition when the ambient light was lower or higher than the standard conditions according to SNI, the application will recommend to change the light bulb
- Good lighting conditions when the ambient light was the same as the standard conditions according to SNI, the application will not give any recommendation

IV. Conclusion

The research project resulted in several conclusions; application measurement resulted in accuracy between 81.24% to 97.15%. Measurement accuracy was very much affected by calibration method and environment conditions. Application was also able to determine good lighting or bad lighting and give recommendation as expected. Problems encountered during the design was that light scatter would affect the smartphone sensor reading, when compared to luxmeter that had filter to prevent light scatter from entering the sensor. Smartphone design improvement is needed to give beter accuracy on light meter measurement.

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