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Pandu Pribadi, Yudhiakto Pramudya, Muchlas, and Okimustava

The IoT Implementation on the Night Sky Brightness Measurement in Banjar using the Sky Quality Meter

Pandu Pribadi[1,a)], Yudhiakto Pramudya[1,2,b)*] Muchlas[2], Okimustava[2]

[1]*Prodi Magister Pendidikan Fisika, Universitas Ahmad Dahlan. Jalan Pramuka 42, Sidikan, Umbulharjo, Yogyakarta 55161, Indonesia*

[2] *Pusat StudiAstronomi, Universitas Ahmad Dahlan, Jalan Gondosuli 1, Semaki, Umbulharjo, Yogyakarta 55165, Indonesia*

[a)]pandupribadi2384@gmail.com
[b)*]yudhiakto.pramudya@pfis.uad.ac.id

Abstract. There are number of factors that must be considered for observing the celestial bodies. One of them is the night sky brightness (NSB). The Sky Quality Meter (SQM) is employed to measure the night sky brightness. The device can be controlled by implementing a control system based on Internet Of Thing (IoT) to assist the data acquisition. The hardware is Raspberry pi as an interface and SQM-LU as a sensor. PySQM was employed as the multi-platform software designed to read, store, and plot data from SQM-LU. There are two types of data. They are the text data and graphical data. Both data can be accessed through the internet network. Hence, the Night Sky Brightness data acquisition can be made remotely through the internet network. The system was evaluated in Banjar, Jawa Barat, Indonesia. The system was able to control the SQM and transmit data to the data storage. The sky brightness level in Banjar is 20.1 mag/arcsec^2. It is considered as a low light pollution area. The IoT based system is capable performing the Night Sky Brightness measurement in Banjar and as an important aspect to analyze the light pollution in a particular area.

INTRODUCTION

Number of factors must be considered on astronomical observation. One of them is the Night Sky Brightness (NSB). The NSB is very influential on views, especially during the night time. The NSB value can be obtained by two approaches. The first approach is a direct measurement using a photometer instrument such as Sky Quality Meter (SQM). The second approach is a calculation using mathematical formulas. SQM serves to determine the brightness of the night sky in units of magnitude per square arcsecond (mpas) [1]. The NSB value can be influenced by several factors. They are the zodiacal light, the integrated light from galaxies, the integrated starlight from our galaxy, the light of aurora, and the twilight emission lines [2].

SQM has been used for many purposes such as light pollution and prayer time determination. The light pollution measurement using SQM has been done in Japan. The measurement was also combined with the measurement of electricity consumption and light pollution guidelines. The light pollution reach higher degree near heavily populated area [3]. This situation creates problem on astronomy since about one-tenth of the Word population have difficulties to observe the stars and constellations [4]. Hence, the campaign on light pollution reduction has been done in number of cities in the world. During the Earth Hour campaign time, the NSB value become better than the regular time [5]. Besides astronomy, the environment is also affected by the light pollution. The bright sky can alter the behaviour of insects, birds, and bats [6]. Based on those facts, monitoring the sky quality by using SQM is important. SQM is also operated to determine the time for Islamic pray [7][8]. However, the analysis of moon light

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effect to the SQM need to be considered [9]. The sun declination may also affected the measurement of the twilight [10]. SQM is also used to measured the changing of sky brightness during lunar eclipse [11] and solar eclipse [12].

The NSB value is also have relationship with the temperature and humidity, although the mechanism about how those parameters influenced the NSB still need to be studied further [13]. In general, observation of celestial bodies is one of the activities that are often done outdoors and takes time always to monitor the results of remarks made. Because of this, it needs an Internet of Thing (IoT) system that can be accessed from anywhere through the internet network. The measurement system of temperature and humidity on SQM has been developed [14]. Hence, we are going to develop a system with internet-based things of measuring the NSB of Banjar which is located in between 07° 19'- 07° 26' south latitude and 108° 26 '- 108° 40' east longitude.

THEORETICAL STUDIES

Internet of Things

Internet of Things (IoT) is a new paradigm that provides a large number of tools to connect to the internet network to access information. Everyday, many objects are transformed into the smart objects that can sense, interpret, and react to the environment, such as the combination of internet and technology that give rise to Radio-Frequency Identification (RFID). In other words, IoT makes an object has an identity so that it can identify other purpose and make it easier for humans to interact with these objects [14]. IoT is a compulsory concept to publish the benefits of continuing internet connectivity. Such capabilities as data sharing, remote control, and so on, including also in objects in the real world. For example, foodstuffs, electronics, collectibles, any equipment, including living things that are all connected to local and global networks through a built-in and always-on sensor [15].

Raspberry Pi

Raspberry Pi is an electronic board with the size of a credit card that has a computer-like function. If it is connected to a monitor, keyboard, mouse, and computer network, it can scold it to write documents, play games, even make it as a web server. The components of the Raspberry Pi can be seen in figure 1. Raspberry Pi requires the operating system (eg, OS: windows, Linux, mac, Unix) running from SD card on Raspberrry. It is different from microcontroller board which we use without Operating System (OS). The common OS are Linux distro Raspbian. The OS is stored on SD card. The OS boot processing can only be done from SD card [16].

FIGURE 1. Raspberry Pi

PySQM

PySQM is a multi-platform software designed to read, store and plot data from SQM-LE and SQM-LU unihedron photometers developed by Miguel Nievas and Jaime Zamorano at the Department of Astrophysics and Atmospheric Sciences at the University of Complutense. The first stage of the program tries to connect to the SQM photometer and takes some measurement tests (information, Calibration, and data) to check that the tool is working

for measurement. SQM calibration has been performed to convert into real data in every iteration program. The program will automatically switch the SQM on and off. PySQM program will stored the data in two different files (file.dat and graph).

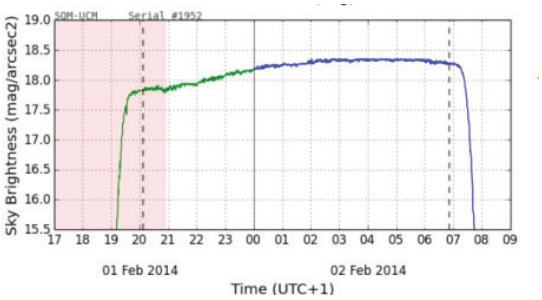


FIGURE 2. Results of data storage from PySQM program (https://guaix.fis.ucm.es/PySQM)

METHODOLOGY OF RESEARCH

The research is development research of measurement instrumentation. The research also included the observation and measurement of the NSB. In this research, the equipment used are Raspberry pi, Monitor, SQM-LU, Notebook, and Internet Network.

Data Retrieval Procedure

SQM, in this study using the type SQM-LU. It is a part that plays a vital role in research that serves as a detector the brightness of the sky. SQM-LU is connected into Raspberry Pi's USB port filling the data obtained by the sky brightness level through the monitor. Raspberry Pi is connected to the server via LAN (local area network) to access sky level brightness data anywhere with internet network. Compiled the circuit by following the sketch in Figure 3.

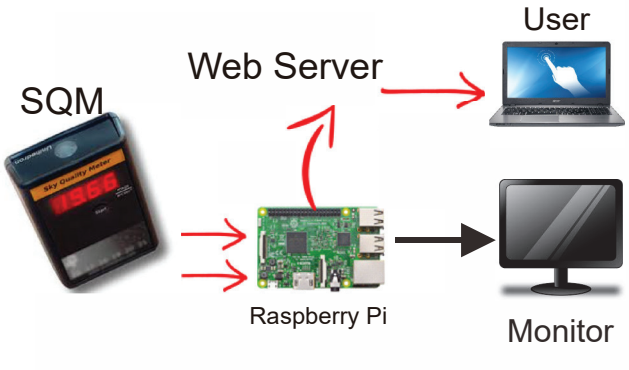
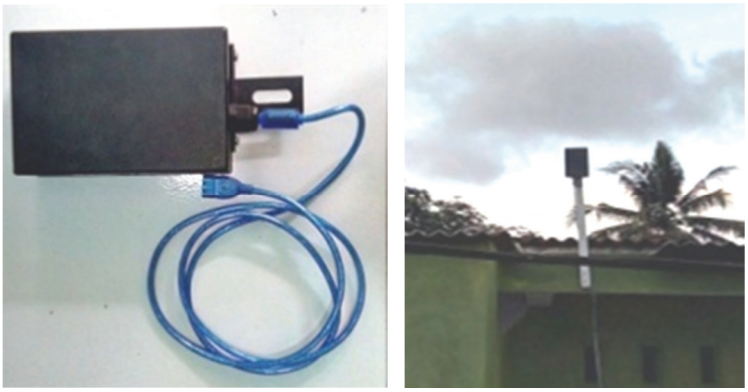


FIGURE 3. The observational set up using IoT

RESULT AND DISCUSSION

The first stage of the research is to design and install SQM-LU hardware to withstand the weather, notably rain conditions like Figure 4. It is important for the device to be protected since it will be installed outdoor for long time. The Indonesia climate is also important to be considered in term of the rain, heat from the sun, and the humidity.



(a) (b)

FIGURE 4. SQM_LU Hardware Design and Installation: (a) Box SQM-LU (b) SQM-LU is installed at the outdoor

The second stage is the configuration the SQM-LU tool with Raspberry Pi which is connected to all its parts. The console of PySQM program that contains the instructions of operation can be seen in Figure 5. It shows the command to detect the Linux Platform and then followed by detecting the location of the device input to the Raspberry Pi. The final command is reading the data from the SQM-LU.

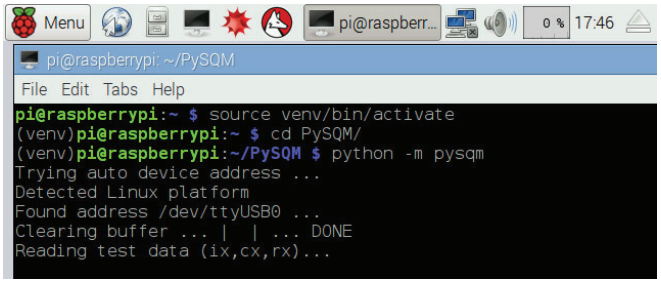


FIGURE 5. PySQM program instructions

To run the PySQM Program, first go to the terminal file on the Raspbian operating system found on Raspberry pi. The next step is running python-m pysqm direction. Hence, it can read sky brightness data from SQM-LU as seen in Figure 6.

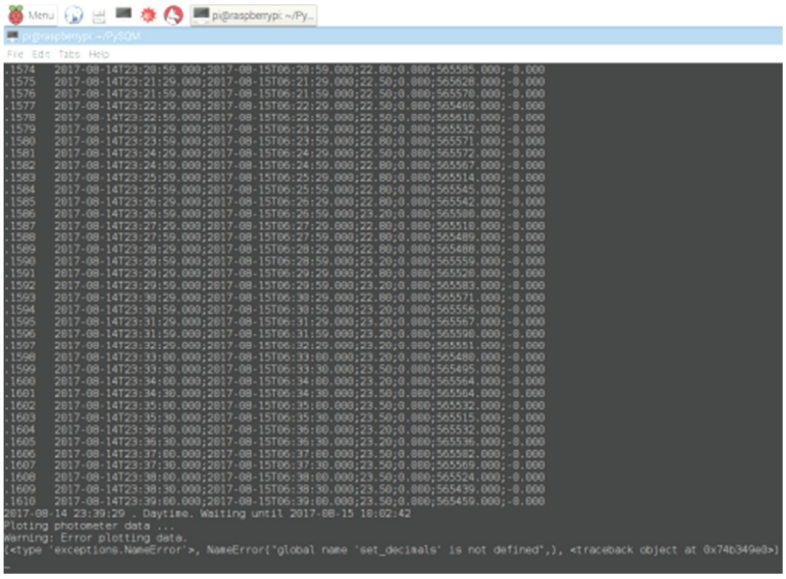
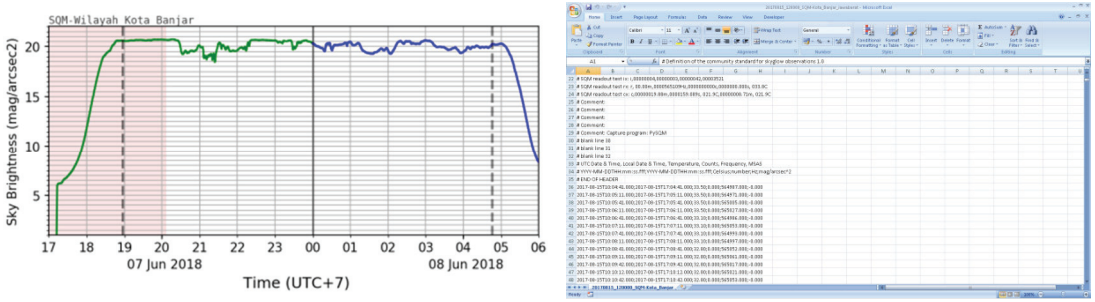


FIGURE 6. Results of SQM Program data PySQM

The results of reading the data in the process by PySQM program with the data taking at 17:00 until 06.00 next day can be seen in Figure 7. The 60 data can be saved in two different file.dat and photographic format.



(a) (b)

FIGURE 7. Results of SQM Program data PySQM file taken on 07-08 June 2018: (a) format photographic data (b) data format.dat.

The data acquisition process will continue as long as the tool (SQM_LU and Raspberry Pi) is in the on condition. The last step is sending data to the web server. Internet network can be accessed by Raspberry Pi so that the data files in the SD card can be uploaded to the web. There are some obstacles when sending this data, such as web server applications that are unable connect to the network. The data transmission flow diagram is shown in Figure 8.

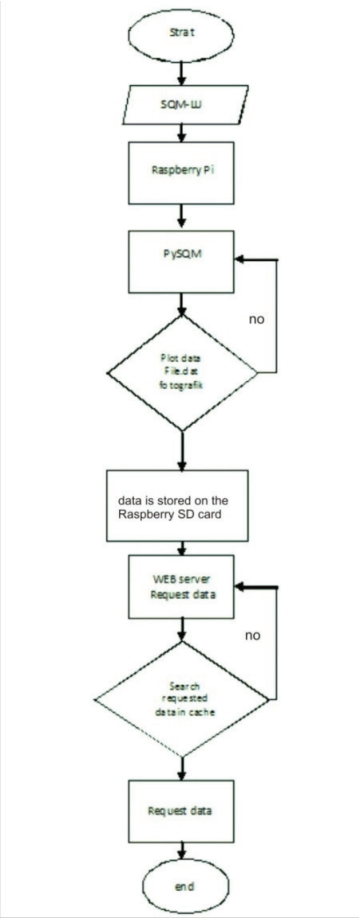


FIGURE 8. Flowchart of the research procedure to obtain the data and send to the web server.

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