Performance Analysis of Real Time Image Processing for Lightning Event Using Cython and Python Programming Languages

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Abstract. Due to the uncommon and unpredictable phenomenon, lightning event become one of the challenging research topics for the scientist. The main thing that most capturing their attention is the lightning detection method which can improve the public safety by pinpointing the location of the lightning event and sending out the warning notification. Currently, there are lots of researcher proceed with the study related with the relationship between the pattern of the lightning and the electromagnetic signal received. During the research process, they would like to capture a clear lightning image from the cloud to proceed with the study of characteristic of the pattern of the lightning and electromagnetic field. The most common method for the researcher to detect and capture the lightning image is using the high-speed camera with a flash sensor. But this method is extremely expensive and has its own limitation on mobility part. Therefore, this paper is to develop and evaluate the suitable algorithm and programming language onto Raspberry Pi platform and act as an upgraded choice to replace high speed camera with affordable cost, high mobility but less accuracy compares to high speed camera.

1. Introduction

Lightning is an uncommon and unpredictable phenomenon that happened in real life. Due to the sudden electrical discharge in a very short duration, it occurred for a very quick and short time [1]. Because of that, it is so hard for the people to get a clean shoot for a complete and perfect strike of lightning and analysis how it grows [2].

Commonly, people will use Digital Single-lens Reflex (DSLR) camera which have better International Organization for Standardization (ISO) setting to capture the appearance of lightning that only occur in short duration [3]. However, most of the DSLR camera does not have any Central Processing Unit (CPU) to do real time processing. Besides, this method is extremely high cost for researcher.

Therefore, this paper is to study and evaluate the suitable algorithms of image processing for lightning detection. Besides, all the algorithms will be coded by using two programming languages which are Python and Cython programming language. All the final data for the frame per seconds and the processing delay between two programming language will be analysed. Besides, the frames per second based on the different programming libraries also will be analysed. The pattern of the lightning image will be compared to the electromagnetic signal that received by lightning sensor installed at our lab.

2. Methodology

A. Real Time Image Processing

The main reason to proceed this real time image processing is to detect and capture the lightning image that appear on the camera lens. Before the pre-image processing process, there are several things that need to be defined and cleared out such as the save file location, the detection method, internal camera setting and capturing speed. For this process, OpenCV library and PiCamera library is applied by using Python programming language [4].

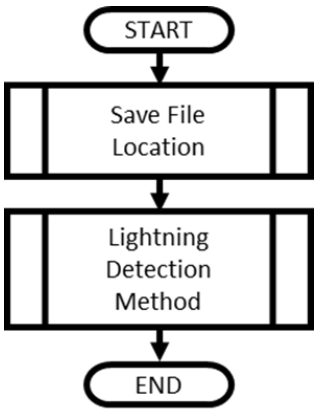


Figure 1. Flow chart for lightning detection system

Figure 1 shows the overall flow chart for the real time lightning detection system. This real time lightning detection system only focus on two main functions which are save file location function and lightning detection method function.

B. Save File Location

Before start capturing the lightning image that detected by the real time image processing system, save file location must be defined. Save file location is used to store the capturing results. Therefore, inside the system must create a new directory for the save file location automatically. In this process, the operation system itself must check whether the file had already existed in the directory. If the folder does not exist, operation system must create another new directory folder automatically. If the folder exists, it proceeds with next function.

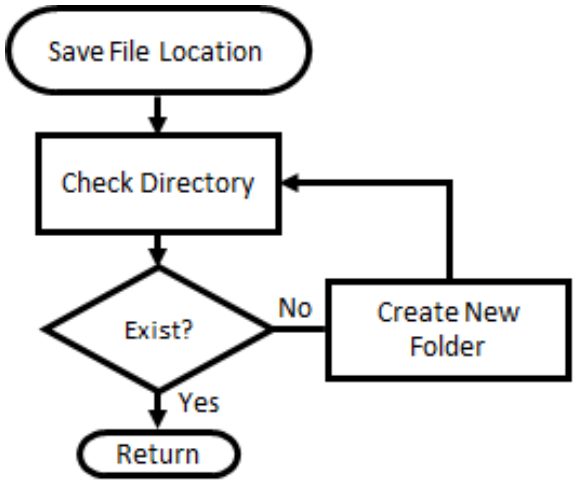


Figure 2. Flow chart for save file location function

C. Lightning Detection Method

For lightning detection method function, it used the pixel value to recognize lightning event. Once the pixel value exceeds more than the threshold value will be recognized as lightning event. After detecting the exceeding pixel value, this real time image processing system will start capturing image until the pixel value is less than the threshold value [5]. Those capturing image will be storing at the folder directory.

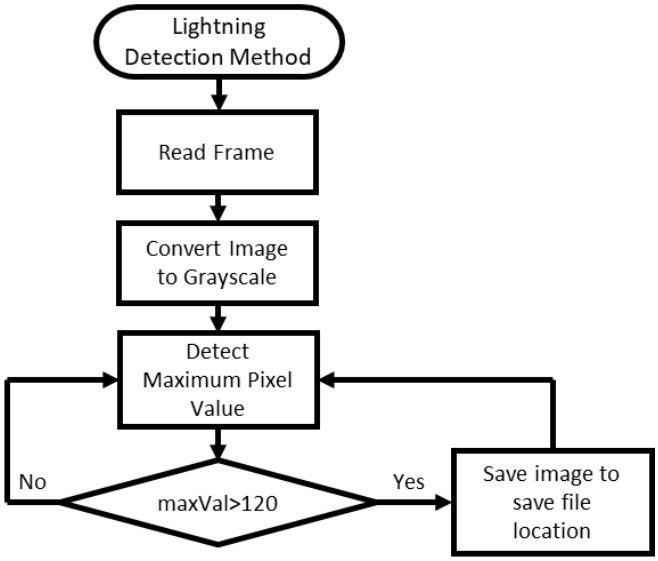


Figure 3. Flow chart for lightning detection method function

Figure 3 shows the flowchart for the lightning detection method for this real time image processing application. This lightning detection method include the conversion of grayscale image and detection for the pixel value [6].

3. Results and analysis

For this paper, the frames per second rate and processing delay are main objectives. Therefore, this paper is comparing the frames per second and processing delay with different perspective such as programming language and programming libraries. But because of the aim of this paper is focusing on lightning event, the structure and pattern of the lightning event also one of the consideration which will be used to compare with the electromagnetic field that capture through the PicoScope software.

A. Analysis of frames per second based on programming language

This paper analyzed the frames per second that based on the programming language that used for the real-time image processing system. There are two differences programming languages that used in this paper which are Python and Cython programming language. By using the same operating system and system flow for this real-time image processing system, compare the number of results based on the saving image files for one second. This testing will take the average number for 15 seconds.

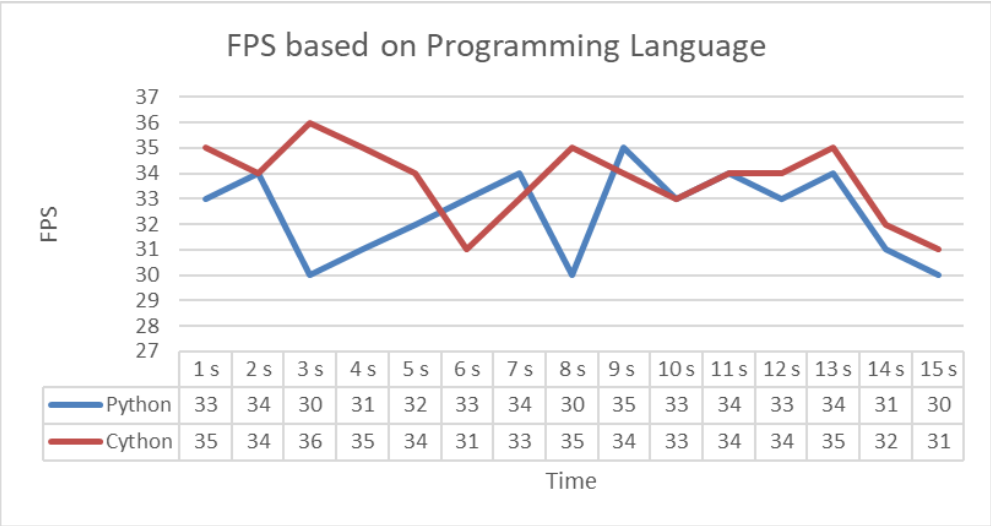
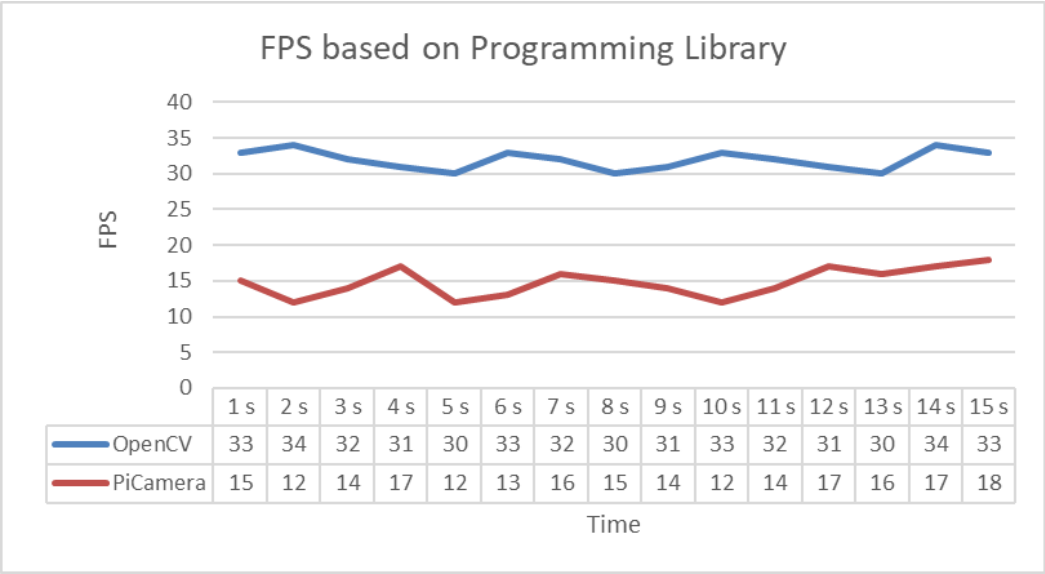


Figure 4. Graph of frames per seconds based on programming language

Based on the Figure 4 showed, the average number of the frames per second for the Python programming language is 32.47 frames. However, for the Cython programming language, the average number of frames per second is 33.73 frames. It is only slightly different between those two programming languages. This is because of the library that used in this paper is OpenCV library which is the library that very similar with C programming language. Therefore, we believe that OpenCV brings the benefits of faster processing speed when we used it as the system library.

B. Analysis of frames per second based on programming library using Python programming language

This paper also analyzes on the effect of the programming language on the results of the system based on the frames per second status. In this paper, two different libraries are used to analyze the different between their processing speeds. This real-time image processing system used Python as the programming language and apply each program library. By using the same operating system and system flow for this real-time image processing system, compare the number of results based on the saving image files for one second. This testing will take the average number for 15 seconds.



	1 s	2 s	3 s	4 s	5 s	6 s	7 s	8 s	9 s	10 s	11 s	12 s	13 s	14 s	15 s
OpenCV	33	34	32	31	30	33	32	30	31	33	32	31	30	34	33
PiCamera	15	12	14	17	12	13	16	15	14	12	14	17	16	17	18

Figure 5. Graph of the frames per seconds based on programming library

C. Analysis of the relationship of electromagnetic field with pattern of lightning event

Due to the lightning event itself is a high-current electrostatic discharge, every negative cloud to ground lightning strike will begin with a downward discharge which also known as leader stroke. When the leader gets closer to the ground, the tips of the leader will generate a strong electric field by connecting the upward discharge from the ground and then immediately followed the return stroke. Therefore, this paper captured the lightning event image with the real-time timestamp on it, the result of the lightning image can be identified which characteristic of the lightning by comparing with the pattern or structure of the lightning.

Figure 6. Overview of electric field that generated from Picoscope

Figure 6 shows that the overview for the electrical field that capture from Picoscope software. Based on the waveform from the graph, it can explain more details on the structure of the lightning event by knowing when the step leader and the return stroke is occurred. By further analysis the electrical field waveform from the Picoscope, this waveform can be used to synchronize with the lightning image that capture and do the analysis based on the exact time value. Figure 7 shows the first return stroke that zoom in from the overview of the electrical field that Picoscope captured.

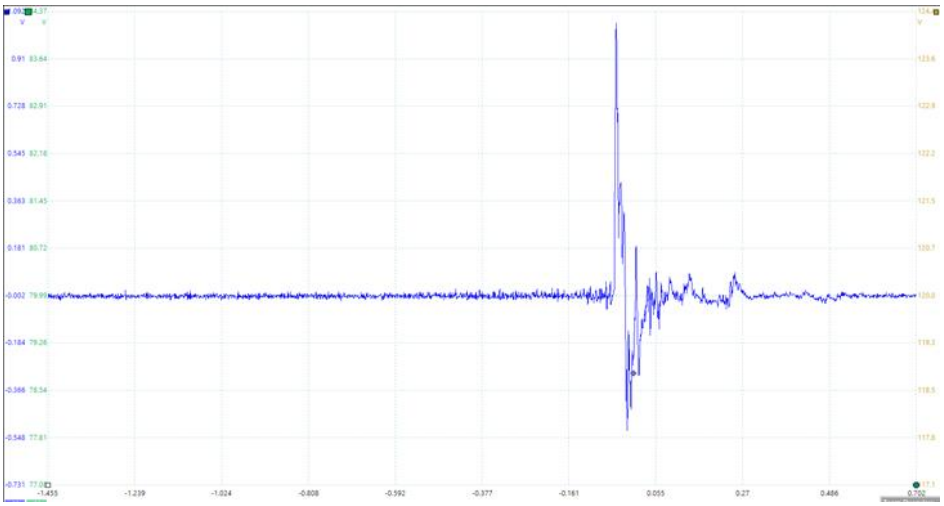


Figure 7. The first return stroke of the lightning event

Comparing the result of the lightning event from Picoscope, the electromagnetic waveform will be comparing with the actual lightning event image by synchronizing timing for both based on their timestamp.

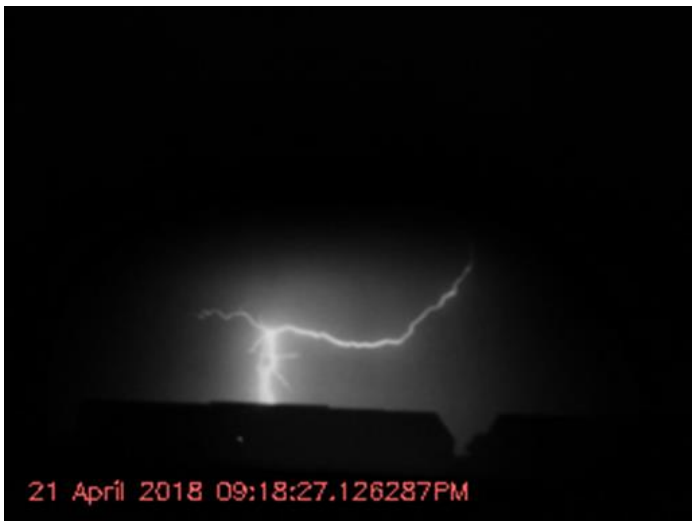


Figure 8. Image of first return stroke of the lightning event

By comparing with the timestamp of the lightning image that captured and the Picoscope results that we captured, we can clearly see that the lightning is in the brightest moment which also known as the return stroke moment. The branches of the lightning are started to branch out.

4. Discussion

This paper is an upgraded version to replace the DSLR camera with more affordable cost, high mobility and further image processing for the output capturing image. Therefore, this paper develops a real time image processing system which can detecting and capturing lightning event itself. Based on the results, Raspberry Pi 3 is a suitable minicomputer that can be use as the real time image processing system.

After analysis all the results, the most suitable programming that uses for this real time image processing system is Python programming language. This is because Python programming language is easier to build a real time image processing system compare to Cython programming language [7]. Based on the experimental results, even though Cython programming language is slightly faster than Python programming language, the limitation of research source for Cython programming language is one of the main reasons that Python programming language is easier to code.

For the programming library, OpenCV library is preferable compared to PiCamera Library. Mainly is because of the processing result for OpenCV library is almost two times faster than PiCamera library based on the experimental results. The reason that OpenCV library is processing faster than PiCamera library is because of OpenCV library is an optimizing C language library which is almost like C language coding [8]. Therefore, the processing time for OpenCV library is faster compare to PiCamera library.

5. Conclusion

Throughout all the research and troubleshoot part, this project has successfully build the real time lightning detection system with the suitable image processing method for analysis the lightning object. After analysis the experimental results, processing delay for the Cython programming language is lesser compare to Python programming language. But this statement must depend on which programming library that used. For OpenCV library, the processing time for both programming languages are almost the same due to OpenCV library is an optimizing C language library. In a conclusion, all the objectives are achieved.

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