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TECHNICAL REPORT

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Detection of ionizing radiations using CMOS sensor from consumer camera device

Chapter 1: The γ radiation

Part 1: First light of this early brief results

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Abstract

The availability of low-cost consumer camera device that use standard CMOS sensor technology enabled us to investigate the possibility of using such device to detect ionizing radiations. A CMOS with active-pixel sensor from a webcam with built-in electronics was evaluated in this early preliminary works for the detection of γ photons from ^{137}Cs source. A computer program was written in Python utilizing the openCV library to record the digitized data from the webcam. The CMOS sensor with a simple system setup was found able to detect the γ photons.

Keywords: CMOS, ionizing radiation, sensor.

1 Introduction

Consumer camera device nowadays are quite inexpensive and easily obtained. Most use the CMOS active pixel sensor (APS) architecture[1] that is made from two-dimensional array of integrated circuit pixels with each pixel contains a photodetector[2]. The photodetector is optimized for detecting photons of visible light based on photoelectric effect. However, this CMOS sensor has also been evaluated and used to detect ionizing radiations most notably cosmic rays[3, 4, 5, 6] as well as from terrestrial sources[7, 8, 9].

In this work, we investigated the likelihood of using off the shelf consumer camera device for radiation detection. An inexpensive spycam camera was selected and purchased for this purpose. This paper shows the implementation of the detector system and the early results acquired.

2 Experimental Work

A mini generic spycam camera (SQ11, China) was used as the detector and tested as is without further physical modification. The γ source used was a $10\ \mu\text{Ci}\ ^{137}\text{Cs}$. The lens of the camera was not removed as γ radiation was assumed to pass through it non attenuated. The properties of the camera was examined using the v4l camera drivers utilities in Linux[10]. The CMOS sensor was found to feature a 480 x 640 pixels frame with frame speed of 1/30 second. The sensor has an 8-bit analog-to-digital (ADC) conversion capability and powered by 5V USB connector.

Python programs were written[11] for control and data acquisition of the sensor. The programs utilize openCV software library[12, 13]. The sensor was operated in monochrome mode to extract the signal without wavelength corrections and the camera lens was covered with aluminum foil so that the CMOS would not be

exposed to visible light but only γ photons as these photons can pass through the foil. Response data were collected both in the absence and presence of γ source. Response measurement to the γ source was performed by placing the source right on top of the lens. One measurement has a recording cycle of 1000 frames with all data of the pixels summed. A measurement correspond to about half a minute exposure.

3 Results and discussion

It is noteworthy to mention that γ photon was detected only with the occurrence of ionizing event right at the midst of the CMOS capturing an image. The thin layer of the CMOS indicates that the probability of any ionizing event is very low as most high energy γ photons may just pass through specifically the active semiconductor depletion region. The total time for one measurement is about 100 seconds giving an approximate electronics dead time of 70 seconds per measurement. Figure 1 shows the spycam camera that was used.



Figure 1: The spycam camera use to detect γ radiation

The observed background or the thermal noise of the CMOS for each pixels have an average value of one for each recorded frame at the time of the experiment. The summation of all data from each recorded frame resulted in average background value of 1000. Reading error occurred occasionally and this can be detected by the python programs. This error manifest as pixel mostly with the maximum integer values of 255. Any recorded frame containing error will not be added

to the summed data for each measurement as it seemed difficult to discriminate between between this error spike and ionization event signal. In the absence of γ source, a measurement with almost flat background signal was obtained. The measurement of background and source are shown in Figures 2 and 3 respectively.

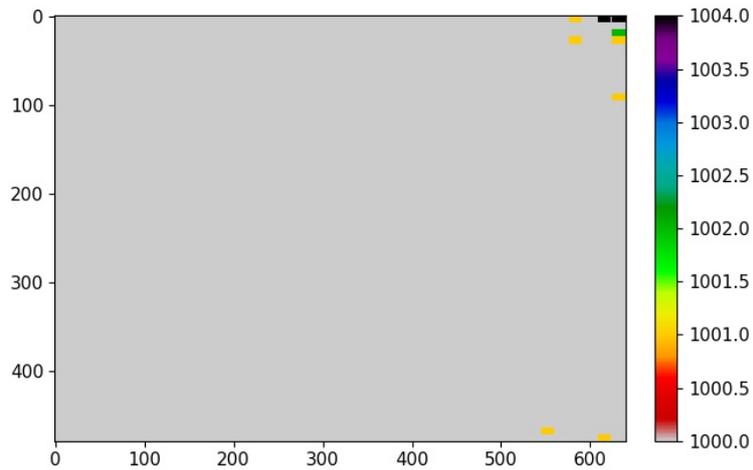


Figure 2: Measurement image of background

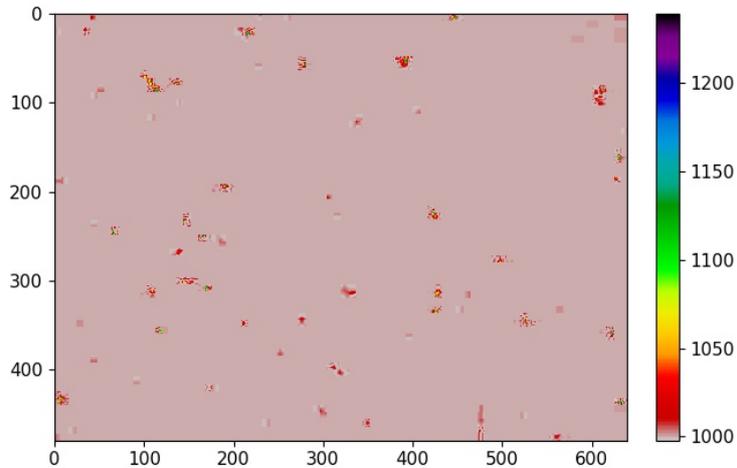


Figure 3: Measurement image of ^{137}Cs source

Figure 2 clearly shows the flatness of the background with only a few cluster of pixels above the value of 1000 with the maximum extra value of only 4. In Figure

3, the flatness of background allows clear distinction between ionizing events and thermal noise. These events are shown by random clusters of higher intensity pixels with maximum value of 1239. The brighter a cluster of pixels, the more charges generated and collected. Some of the clusters might as well resulted from an overlap of multiple ionization events. A few enlarge images of the bright pixel clusters are shown in Figure 4.

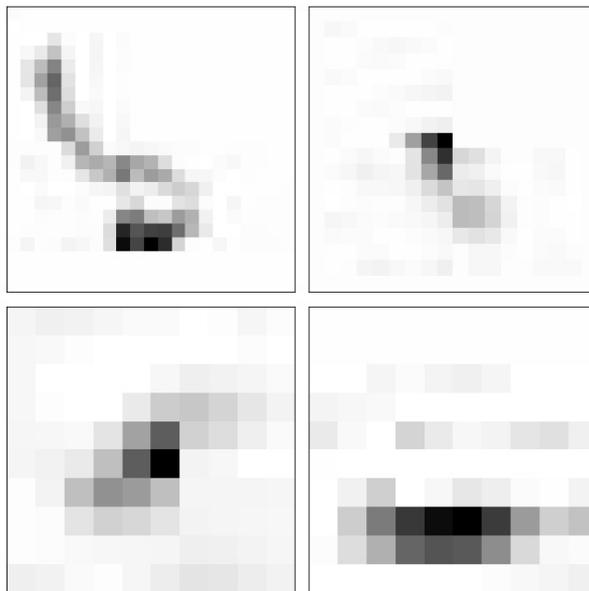


Figure 4: Some enlarge images of ionizing event cluster showing tracking feature of elongated shape

The ^{137}Cs source produces characteristic γ photons with energy of 0.622 MeV. These photons are consider as intermediate energy γ photons and without any attenuation of these photons before ionizing events occurred on the detector as well as the low atomic number elements used in CMOS material, it is reasonable to assume that most of these ionizing events are of Compton scattering type.

Compton scattering usually leaves trace like feature wherein electron recoil eventuate and this electron can ionize further to produce secondary electron, giving image of elongated shape cluster. The CMOS detector therefore provides the opportunity to not only detect but also to classify the ionizing radiation. The total intensity value of pixels in the cluster is proportional to ionizing strength and can be used to estimate the energy of the incident γ photon. An algorithm that can discriminate the features of the pixels cluster perhaps can provide a possible low-resolution spectrometric data.

4 Conclusion

A consumer device camera that used CMOS sensor has been shown able to detect ionizing radiation in particular γ photons and it only requires quite a simple system setup. Ionizing event on the CMOS sensor is evince in the form of cluster of bright pixels providing the possibility of event classification and energy discrimination.

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