GeigerCam: Measuring Radioactivity with Webcams

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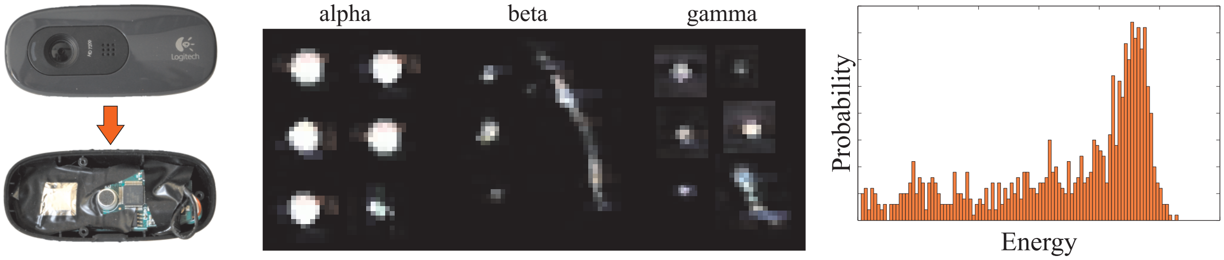

(a) (b) (c)

Figure 1: *With a modified off-the-shelf HD webcam (a) we record impacts of various kinds of nuclear radiation (b) and obtain a measure of the energy spectrum of the source. (c) shows the characteristic spectrum of the α emitter Americium-241.*

1 Abstract

Measuring radioactivity is almost exclusively a professional task in the realms of science, industry and defense, but recent events spur the interest in low-cost consumer detection devices. We show that by using image processing techniques, a current, only slightly modified, off-the-shelf HD webcam can be used to measure α, β as well as γ radiation. In contrast to dedicated measurement devices such as Geiger counters, our framework can classify the type of radiation and can differentiate between various kinds of radioactive materials. By optically insulating the camera's imaging sensor, recordings at extreme exposure and gain values are possible, and the partly very faint signals caused by the particle impacts are separated from the thermal and device background noise and analyzed in real-time.

2 Introduction

The measurement of ionizing radiation has a long history with many academic and commercial applications in nuclear safety, defense, medicine, biology, material sciences, amongst others. Even entry-level devices start in the \$200-300 price range, which is too expensive for casual applications or mass deployment. While Geiger counters have a higher sensitivity than our approach, they lack the capability to differentiate different types of radioactivity or to measure the radiation's energy, features which require significantly more expensive equipment and constraints our framework does not suffer from. The rapid development in image sensor technology and their mass applications resulted in very cheap megapixel sensors, with a physical pixel size of 2-3 μm. Due to the resulting high sensitivity it is possible to record even low energy nuclear radiation with consumer HD webcams, with their sensor only shielded against visible light. Our approach results in a simple device that can be operated on any computer and costs only \$20-30, the price of the webcam and the modification.

3 Our Approach

One of the main challenges in using a webcam (in our case a *Logitech C270*) to produce reliable measurements of ionizing radiation is the separation of the particle impact signal from the optical, thermal and device background noise without excessively damping of the signal. To achieve this, we remove both the lens and the IR filter, which would otherwise absorb all alpha particles and beta particles to a large degree. The fully exposed sensor is then sealed with an $8\mu m$ thin aluminum foil, removing any optical influences and replacing the IR filter. The camera is set to the longest exposure time possible and to a very high gain to detect even faint signals. During measurements, GPU assisted real-time image processing of the direct video feed is used to treat the remaining noise by tracking the noise spectrum per pixel, incorporating not only spatial but also temporal variations due to temperature changes and spontaneous emissions. A confidence value per pixel based on event probabilities is calculated to identify potentially hit pixels. Finally, we use morphological clustering to group pixels into particle impact events and analyze their energies.

We measured the emissions of a broad sample of radioactive substances. As α emitters, we chose ^{241}Am, ^{238}Pu, ^{239}Pu and ^{233}U, β emitters measured are ^{14}C, ^{36}Cl, ^{90}Sr^{90}Y. γ emitters are ^{60}Co, ^{137}Cs and Plutonium-Beryllium ($PuBe$) as a neutron source. Furthermore, we measured naturally available radioactive sources Thorium (^{232}Th), pitchblende (^{238}U) and tritium (^{3}H).

4 Results and Future Work

Preliminary measurements show reliable detection rates for α and β radiation and their energies. Compared to a professional very sensitive radiation detector, a *Berthold LB 124 Scintillator*, we achieve a relative count rate for α particles of $1.10 \times 10^{-2} \pm 0.17$. The β detection rate can be measured with high precision (error $< 5\%$) but depends on the material measured. This indicates that the sensitivity of the sensor varies with the radiation's energy. Reliable γ detection requires higher radiation levels than β due to the smaller effective cross section. We were not able to detect neutrons, despite a significant emission rate of the PuBe source.

For more robust results, the efficiency of different sensors and intra-model differences need to be explored. Furthermore, an exact energy calibration allows the identification of radioactive materials, both natural and synthetic. We see the final applications of a cheap radioactivity sensor both in high-level radiation environments where inevitable sensor destruction would incur negligible costs, and as consumer hardware, either as a do-it-yourself modification kit or as a mass-produced consumer product.

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