Radiation Detection with the Camera of Consumer Mobile Devices

Igor Borovikov, Guennadi Narychkine

The 17 Annual CASIS Workshop 2013
HPC Innovation Center, Livermore Valley Open Campus
May 22, 2013

Abstract

The CCD or CMOS matrix of consumer mobile device can detect quanta of ionizing radiation. The signal can be extracted from the camera dark frames i.e. when the lens is covered with an opaque shield. Simple thresholding techniques combined with custom filtering allow to separate background noise from the events generated by the sufficiently energetic ionizing radiation. We discuss an iOS app trueGeiger [2], released by the authors in 2011, its calibration, limitations and possible area of applications.

<u>The Goal</u>: provide a reasonable estimate of radiation levels in the case of emergency.

<u>The Method</u>: separation of the signal generated on CMOS/CCD by ionizing radiation from the background noise while shielding camera from visible light.

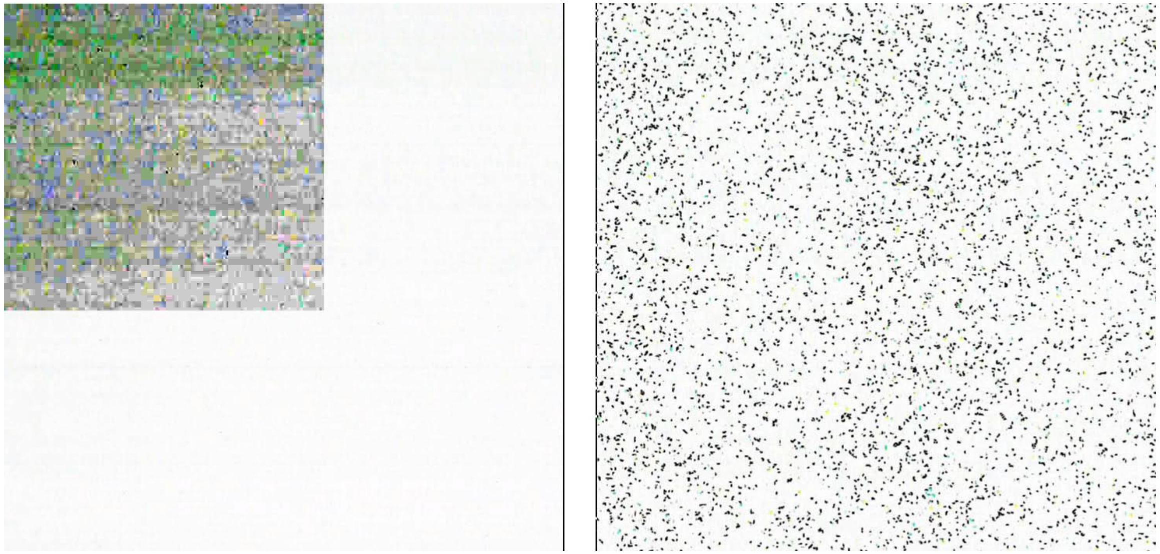
Tested with paper stickers.

Avery® Removable Round Color-Coding Labels, 3/4" Diameter, Black

The Challenges:

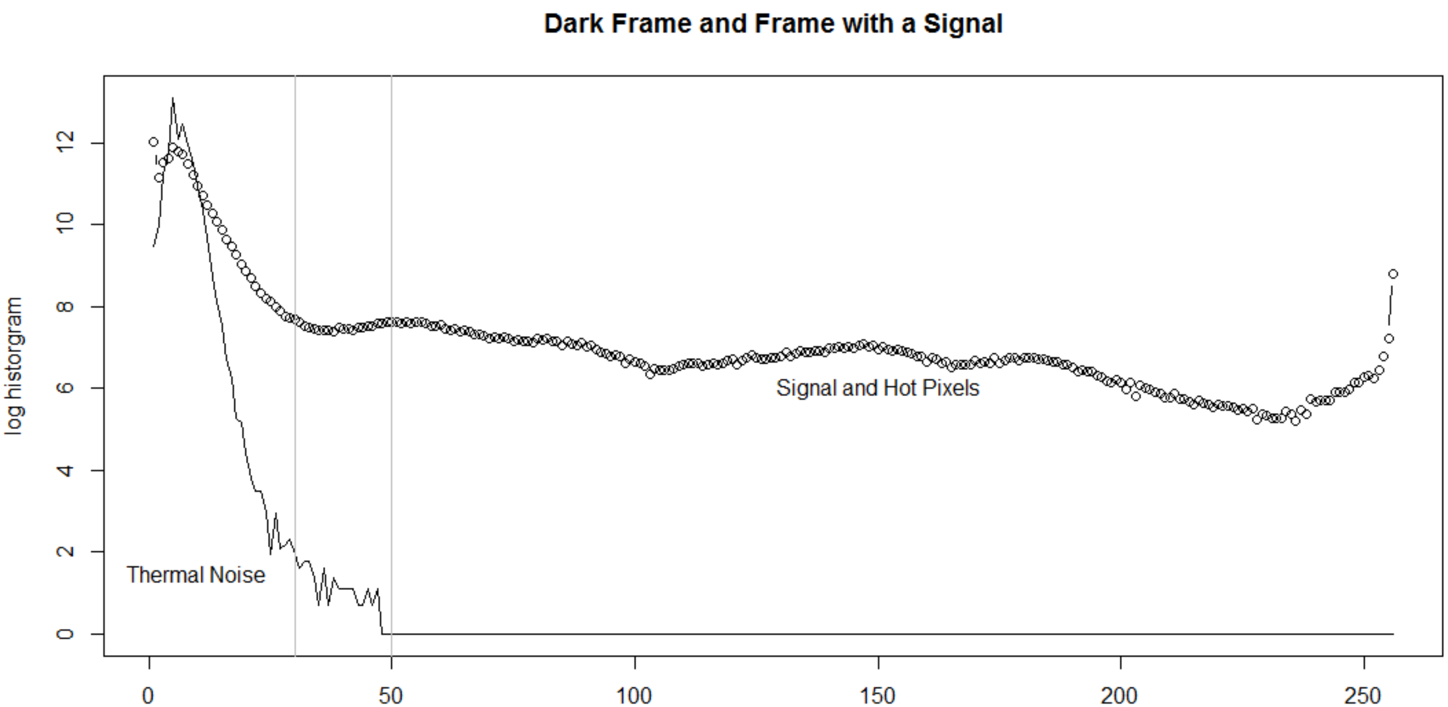
- thermal noise and spurious or oscillating hot pixels;
- non-stationary thermal regime;
- no exposure control in older versions of iOS;
- no practical dark frame generation and subtraction;
- sensitivity only to high-end of the energy spectrum;
- low count of detectable events in the range of interest.

- paper sticker improves sensitivity over foil-covered sticker (compare to [1]);
- front camera is more sensitive as it is not shielded by metal casing;
- lower resolution (native or binning) also helps.



Dental x-ray Signal
(inverse image)

- left - dark frame,
- left inset - enhanced noise shows hot pixels
- right - x-ray pulse.

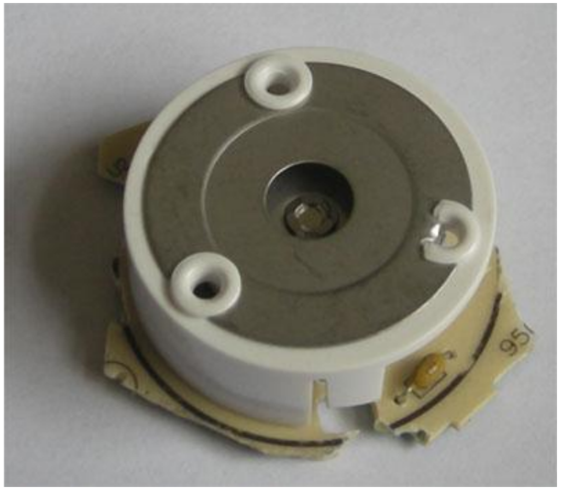


The histogram suggests thresholding pass to separate signal from noise.

Hot pixels remain.

- A test and rough calibration available with household means: smoke alarm provides a source usable for qualitative prove of idea.

- The source (Am-241) has to be exposed by removing the cover.



- Higher intensity sources provide better calibration due to larger number of detectable events.

Requirements:

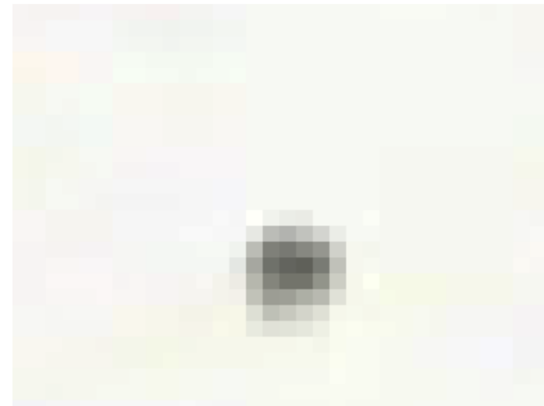
- Real time performance (i.e. no fancy image processing like Hough or morphological transforms, in particular on older devices). This suggests single-pass implementation;
- Low memory footprint (i.e. no extra buffers);
- **No false positives**;
- Portability (i.e. no reliance on custom libraries or API-specific functions).

The Algorithm Overview:

- ignore rgb and interpret signal as grey-scale without combining rgb values (x3 resolution);

- thresholding: ignore pixels darker than the empirical value;

- ignore isolated pixels (usually caused by spurious hot pixels)



An inverse image of a typical event.

- declare failure due to background light if contiguous pixels are covering "too large" area.

- Linear features may help in filtering (see also [1]).

Field Tests:

- detects listed test sources;
- does **not** detect in-flight radiation (one event per few minutes only);
- does **not** detect radioactivity of Potassium-40 in no-salt product.

Calibration has to deal with:

- Platform fragmentation, i.e.
  - variations in camera characteristics even across the same device model;
  - shielding by the casing and the lens;
  - back vs. front camera;
- Detectable events type and spectrum range requires additional investigation for each platform.

Conclusion:

- low precision and sensitivity;
- calibration is the main challenge, it requires lab equipment and controlled sources!
- the approach still valuable for providing rough estimations.

References:

1. Michelsburg, Matthias; Fehrenbach, Thomas; Puente León, Fernando "**Measuring ionizing radiation with a mobile device**" Multimedia on Mobile Devices 2012, Proc. of the SPIE, Volume 8304, article id. 83040A, 10 pp. doi: 10.1117/12.908757

2. Igor Borovikov, Guennadi Narychkine, **trueGeiger** v1.x iOS app, (2011)

See also www.trueGeiger.com for additional information.