Robust in Hardware Mapping of Hot Pixels and Hot Pixel Data Reconstruction

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Abstract:
While originally aimed at imaging applications, robust in hardware mapping of hot pixels and hot pixel data reconstruction may also provide starting point for algorithmic cluster reduction in future detector system. The method addresses issues with radiation defects and mitigation of radiation effects while establishing the hot pixel map or list.

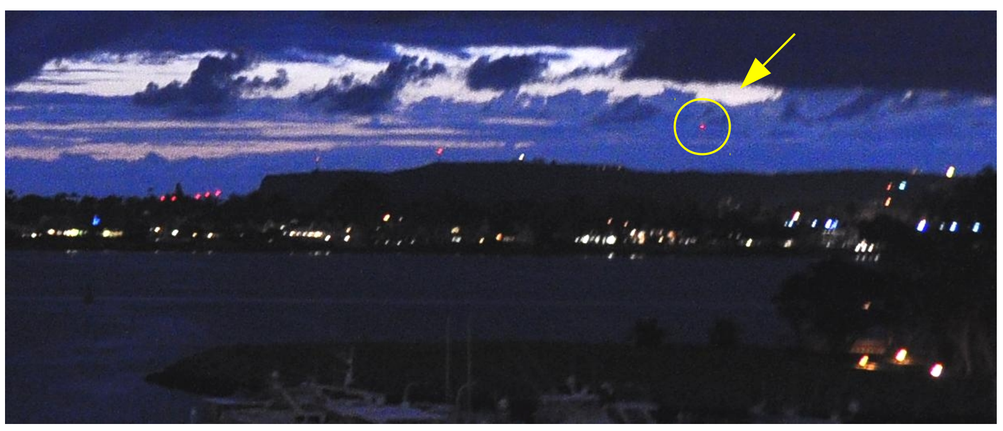

Fig1: Example of a hot pixel in a 100% crop from DX/APS-C jpg image taken at 800 ISO with exposure time 1/3 s. The hot pixel shows up as red dot high up in the cloud here. This and other weaker hot pixels were freshly acquired during a trans-Atlantic flight a few days before. The hot pixel data is slightly spread out because of jpg compression. Imaged lights show a slight directional blur due to camera motion.

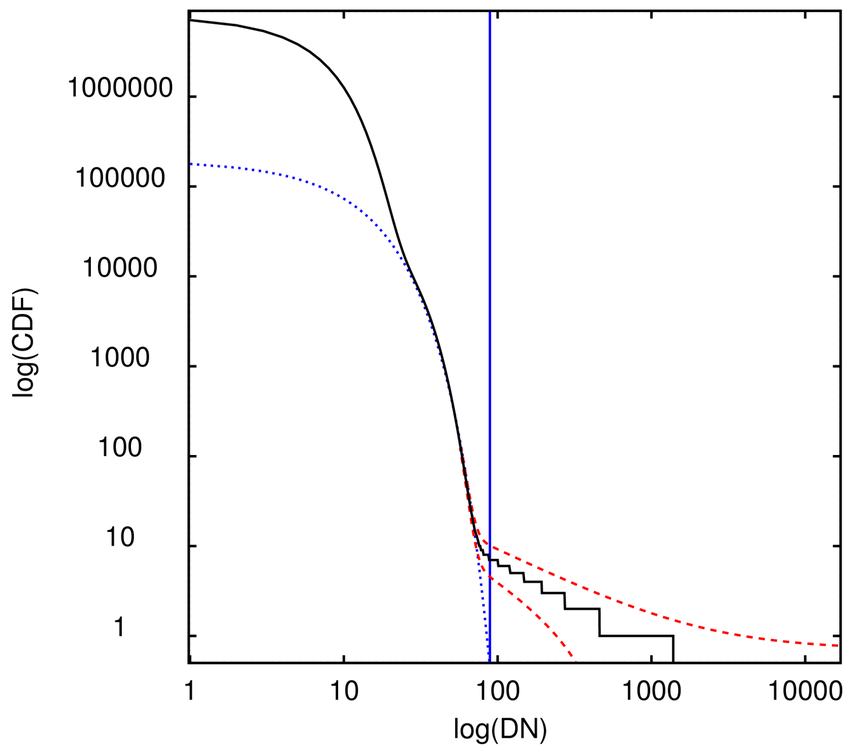

Fig3: Schematic CDF arising from Gaussian distribution of noise DN with two small sub-populations, one having a wider Gaussian and the other an algebraic probability distribution. The red dashed lines show the 1σ limits for the CDF arising from Poisson statistics: the shape of the CDF is uncertain in the hot pixel tail. It is easy to extrapolate the CDF to the point where the expectation for a count from the Gaussian distributions falls below 1. Blue dotted, CDF from Gaussian distribution. Blue line, a natural threshold for hot pixels.

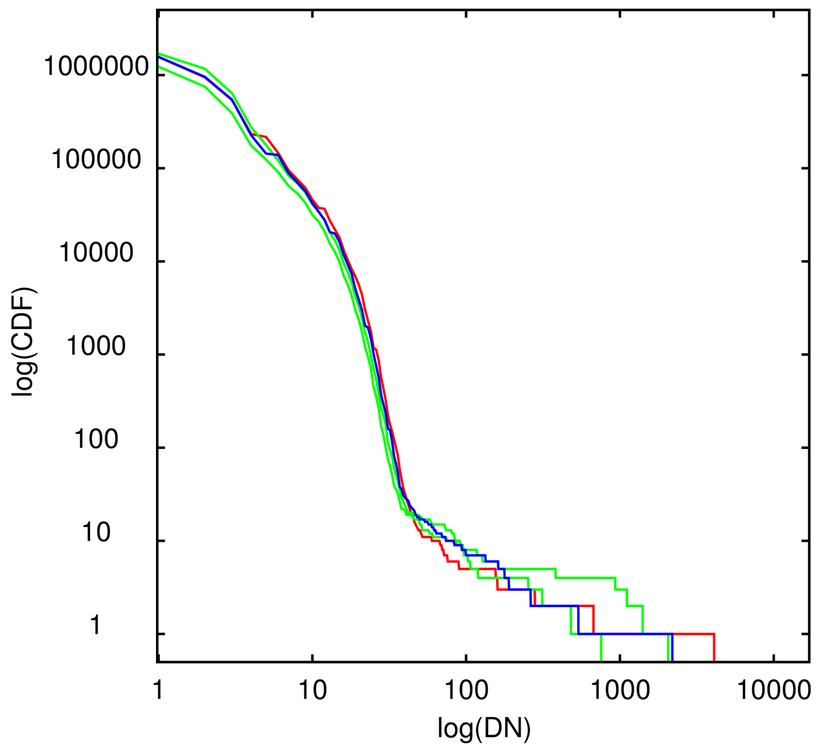

Fig2: Example of a log-log plot of the color separated complementary cumulative distribution function (CDF) showing how many pixels have a digitized value (DN) exceeding the abscissa value. This example is from a black frame at ISO 800, 0.8s. Some tens of hot pixels fall in the tail of the distribution.The single pixel with a saturated 12bit DN of 4095 here, is the one showing up as red spot in Fig 1.

Message: The CDF from a black frame provides a robust handle to discriminate hot pixels against normal pixel behavior arising from manufacture details, thermal properties and possibly radiation background. The basic procedure has very low hardware requirements and is amenable to a capability of photographic cameras (DSLR and other) that would complement the currently built in sensor cleaning capability at very little additional cost. This camera application is in a patent pending stage, to be published Sept 2012.The patent also describes a fitting replacement procedure to substitute hot pixel DN by plausible image values, while maintaining insensitivity towards clustered hot pixels.

Background: There are three fundamental methods to eliminate image defects cause by hot pixels:
M1, methods using a map or list of hot pixels, such as the present one. The weak point is the up-to-date-ness of the map. M1 is not fooled by image detail and can be insensitive to hot pixel clusters.
M2, methods inspect the image details to decide on revisions. Advantages and disadvantages are just opposite M1. Combination of M1 M2 combines the disadvantages in the first place.
M3 methods subtract a black frame. This is good for non saturated pixels. But, taking a black frame for each picture slows down total image capture time. The noise is increased by the black frame statistics.

Outlook: The present procedure can be refined at the price of more bookkeeping and calculations for scientific and medical imaging applications. The Gaussian distributions can be narrowed by averaging. Insensitivity towards bright pixels from momentary response to background radiation can be achieved by requiring coincidence among more than one black frame.