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Dose Rate Estimation by Extracting and Analyzing Colors from an Image Generated by a CMOS Image Sensor

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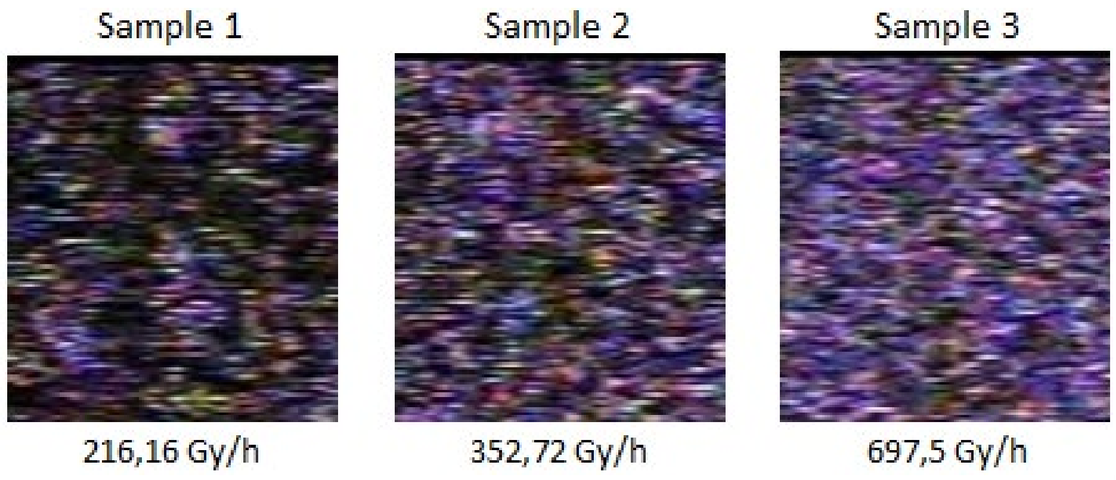
Introduction

In a project in which the development of a remotely controlled submersible robot (ROV) was carried out, a generic camera commonly used in surveillance devices or car maneuvering assistance systems was used as means of visual inspection. Said camera had a CMOS sensor, and it was subjected to tests under different dose rates of gamma radiation at the CDTN gamma irradiation laboratory.

The Gamma Irradiation Laboratory – LIG, located on the CDTN premises is classified as a Category II Multipurpose Panoramic Irradiator, manufactured by MDS Nordion in Canada, Model/serial number IR214 and type GB-127, equipped with a cobalt-60 source dry stoke with maximum activity of 2,200 TBq or 60,000 Ci.

Methodology

Several tests were carried out under different dose rates, with the aim of carrying out resistance tests on the ROV's internal circuit which was equipped with the before mentioned camera. It is worth highlighting here the possible variation of 10% in the recorded dose. Samples were taken from the images, specifically from a black square of 100 by 100 pixels on their corners.



It is also worth highlighting the capture of an image in which the dose rate was unknown. Such an image was captured during the cover-up of the cobalt-60 source, which resulted in such an unknown dose rate. This image generated sample number four.

Sample number 4, taken from an image of unknown dose rate.

Subsequently, an online tool was used to extract the predominant colors in the image.

The collected data were then displayed in table I, and the control group was added in order to establish a standard.

Table I: Percentage of each predominant color extracted from the samples.

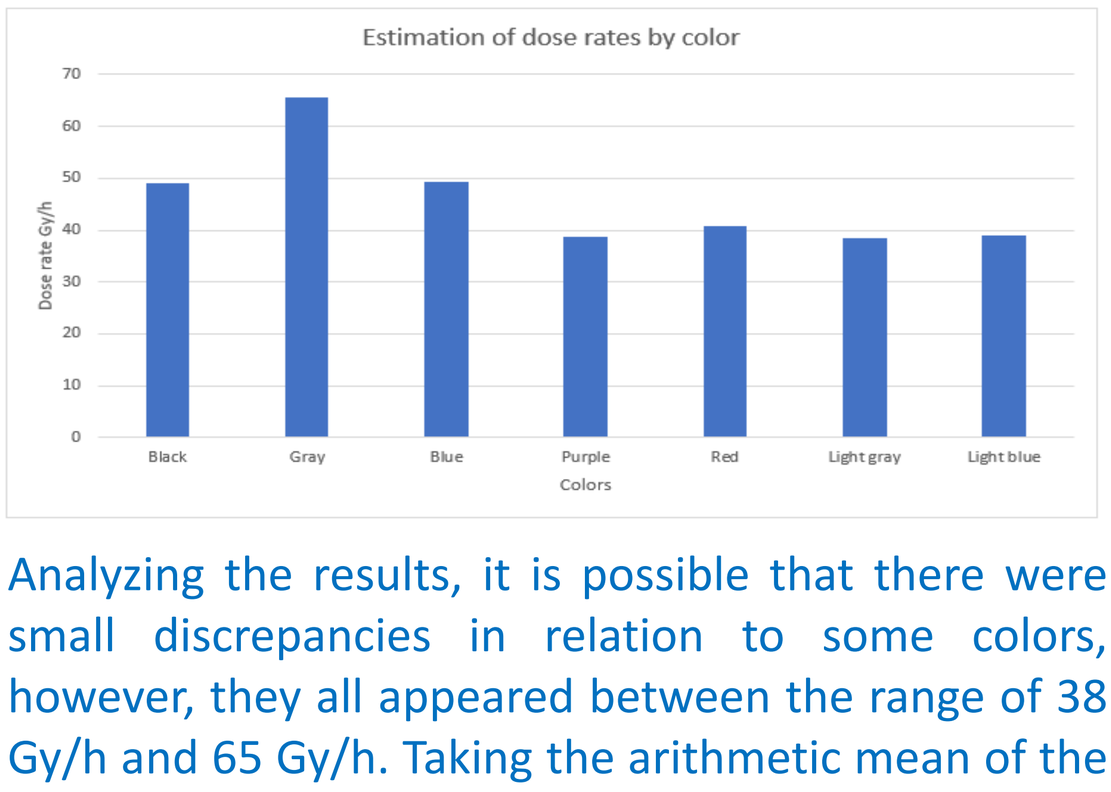
Color (Code)	Control (%)	Sample 1 (%)	Sample 2 (%)	Sample 3 (%)	Sample 4 (%)
Black (#000000)	100	51.6	24.51	8.03	84.9
Gray (#646464)	0	25.25	38.78	47.36	9
Blue (#000064)	0	6.4	10.36	10.07	1.79
Purple (#640064)	0	6.18	11.8	15.45	1.23
Red (#640000)	0	4.14	3.4	1.17	1.54
Light gray (#c8c8c8)	0	1.71	3	3.24	0.2
Yellow (#646400)	0	1.51	1.03	0	0.7
Light blue (#6464c8)	0	1.2	3.48	9.09	0.09

Using the MiniTab® program, it was possible to create graphs and generate trend lines which in turn generated equations for each of the colors, making it possible to carry out calculations to estimate the dose rate using the percentage values of each color in sample four

Results and Discussion

During testing, the camera exhibited artifacts due to electron transit during irradiation, with minor permanent damage observed after the second test. A critical failure occurred at 25 minutes during the third test, indicating permanent damage to the camera's semiconductor. This critical failure was repeated in all subsequent tests a few seconds after the irradiation began, the image returning to a normal state when the irradiation stopped. Subsequent testing was done to cause the Arduino Nano® board to fail.

Carrying out the calculations using the equations generated from the trend lines mentioned above, and considering the percentages of colors in sample four, it is possible to construct a graph which demonstrates the predicted dose rate for each of the colors



Analyzing the results, it is possible that there were small discrepancies in relation to some colors, however, they all appeared between the range of 38 Gy/h and 65 Gy/h. Taking the arithmetic mean of the previously mentioned values, a value of approximately 45.84 Gy/h is obtained, adjusted for the possible variation of 10% previously mentioned.

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