CS 754 : Advanced Image Processing - Course Project
Difference-Based Image Noise Modeling Using Skellam Distribution

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1 Why Intensity difference

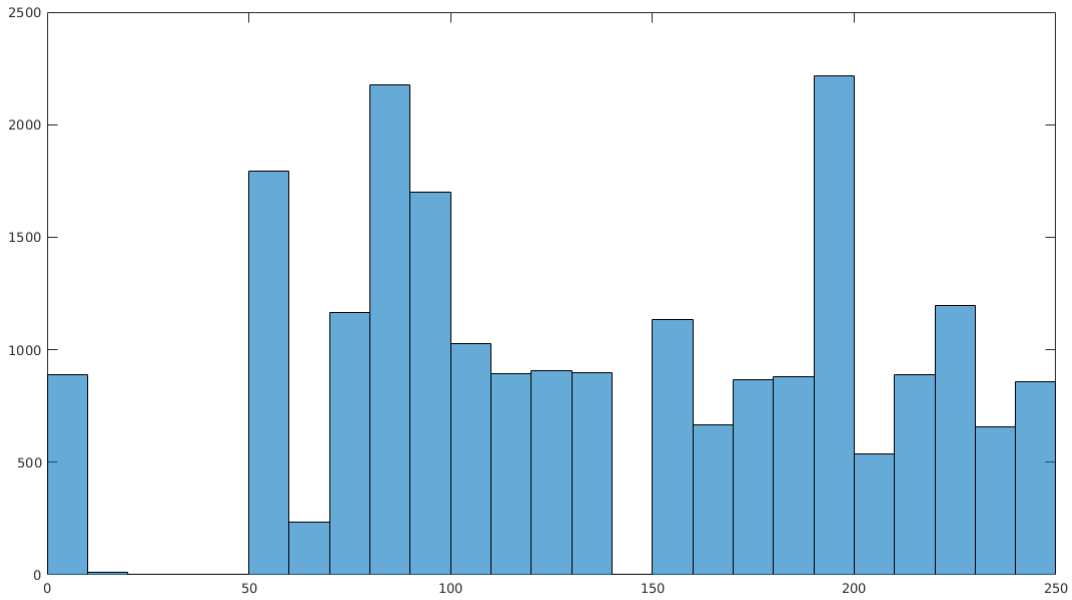

Figure 1: Histogram of Single Image

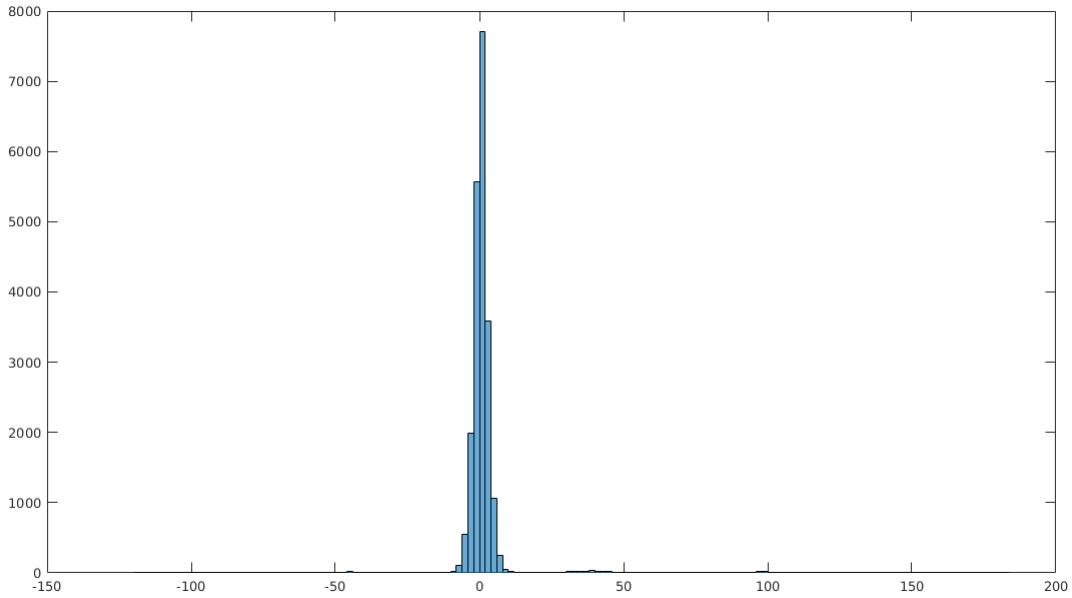

Figure 2: Histogram of Difference of Images

As can be clearly seen it is easier to fit a model on the difference of image, rather than a single image.

For the case of raw images, where the noise is primarily poisson noise, the differnce of images have a skellam distribution.

2 Skellam Parameter Estimation

Now we want to estimate the skellam parameters for a particular dslr.

The synthetic image used

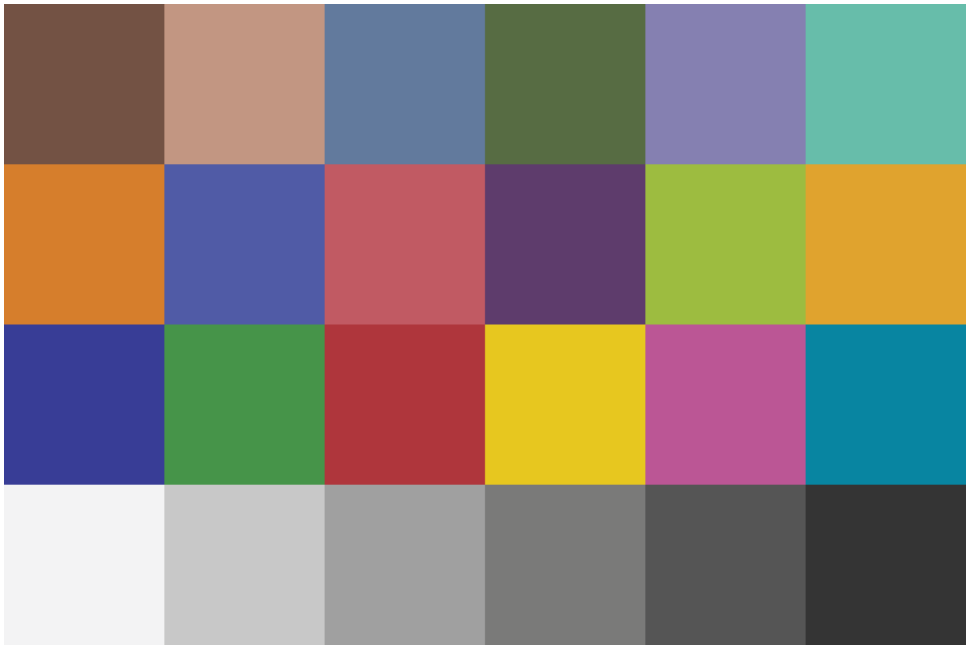

Figure 3: Synthetic image

We have simulated this situation, by creating our own colorchecker board (which is the ground truth img), and physically adding poisson noise to it.

2.1 Temporal Domain

We then save 10k such images to get skellam parameters μ_1 and μ_2.

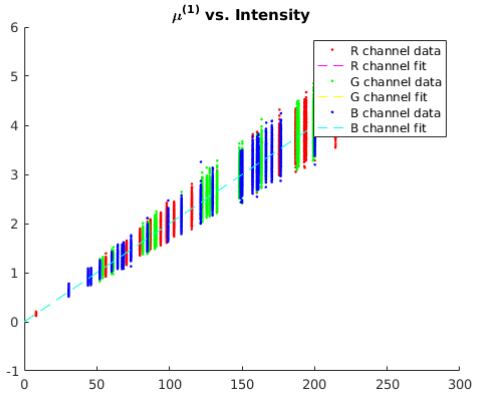

Figure 4: Skellam Parameter in Temporal Domain

2.2 Spatial Domain

Now we estimate the same parameters from a single image. Here we try to estimate from a single image.

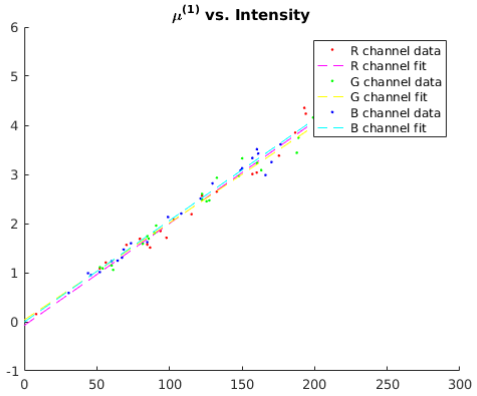

Figure 5: Skellam Parameter in Spatial Domain

For this we have created patches from the given images, by comparing the μ_s between different patches.

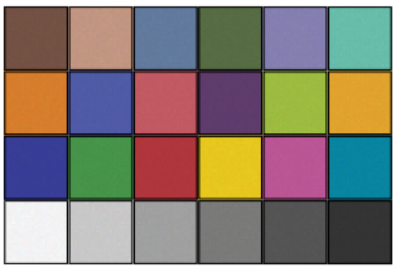

Figure 6: Training patches

Clearly both of them give very similar results proving that this is an ergodic process.

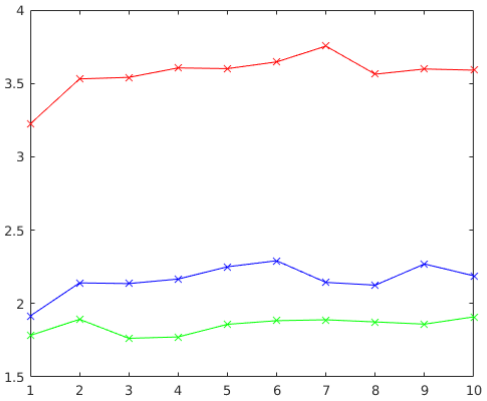

Figure 7: Disparity plot in spatial domain

Here we note that there is dip, which is happening because of png compression.

3 Noise Statistics Estimation using Skellam Parameters

3.1 Skellam Intensity Line

For a particular camera, we should get a straight skellam intensity line.

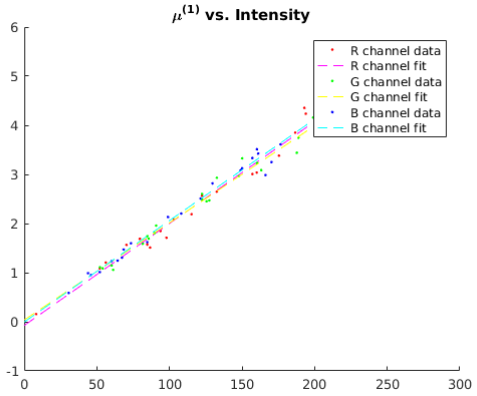

Figure 8: Skellam Intensity Line

3.2 Determining Acceptance Region

We use hypothesis testing to determine acceptable region. We have tuned the parameters for both Background Subtraction and Edge Detection, and correspondingly chose $\alpha = 1e - 5$ as the type I error.

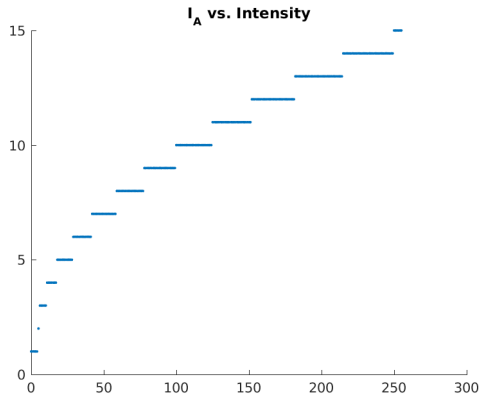

Figure 9: I_a vs Intensity graph

4 Background Subtraction in Temporal Domain

We have taken 2000 images of the synthetic image, and added an object in some frames.

Figure 10: Background subtraction Sample

Figure 11: Background Subtraction mask

Hence we are able to effectively differentiate the foreground and Background.

5 Edge Detection in Spatial Domain

For edge detection, we do it on both the synthetic dataset, as well as another image. Here we try to estimate the skellam parameters from a single image. We have taken both bright and dark images.

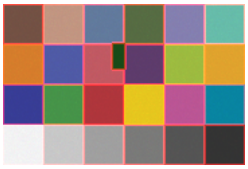

Figure 12: Noisy image with highlighted edges

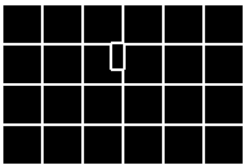

Figure 13: skellam_edge

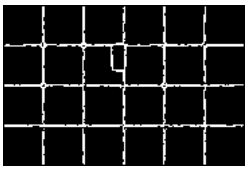

Figure 14: canny_edge

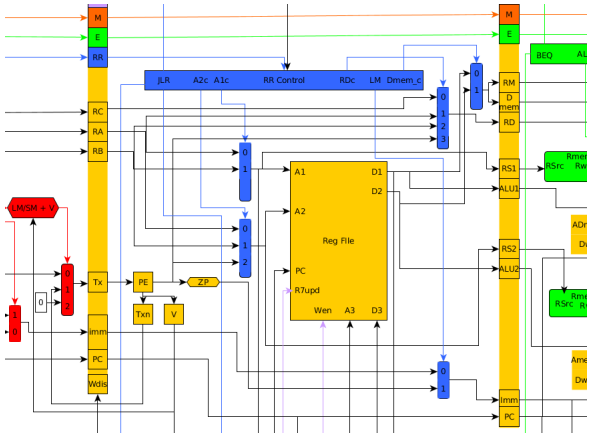

Figure 15: Actual Pipeline image

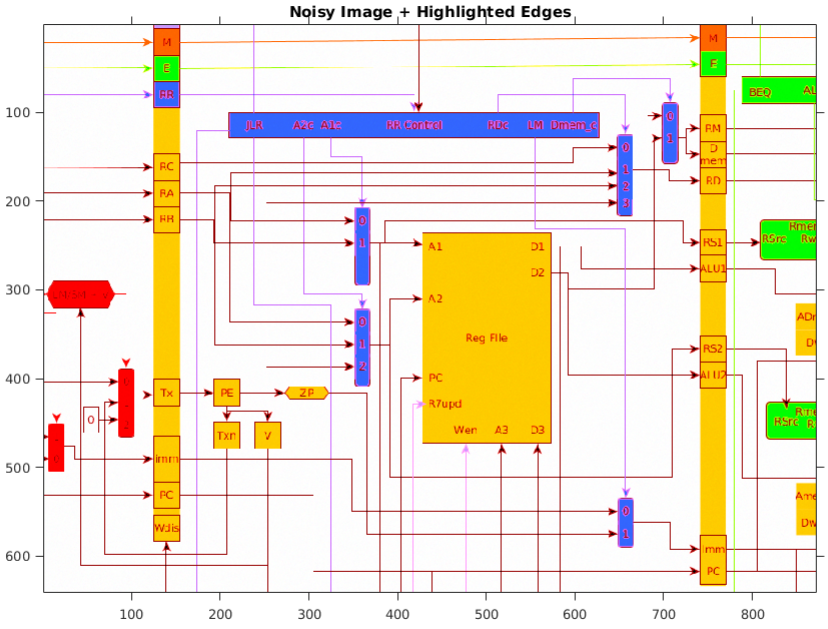

Figure 16: Pipeline img bright noisy

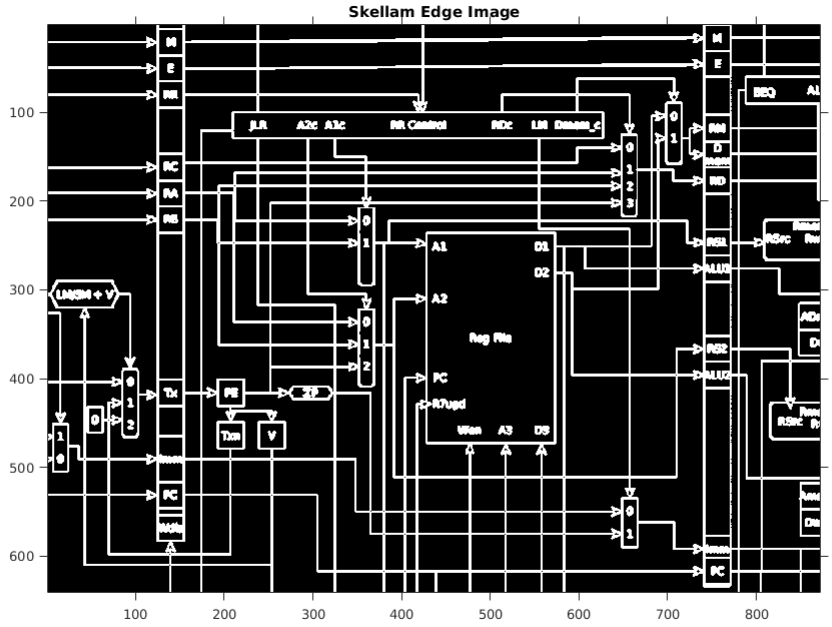

Figure 17: Pipeline img bright skellam edges

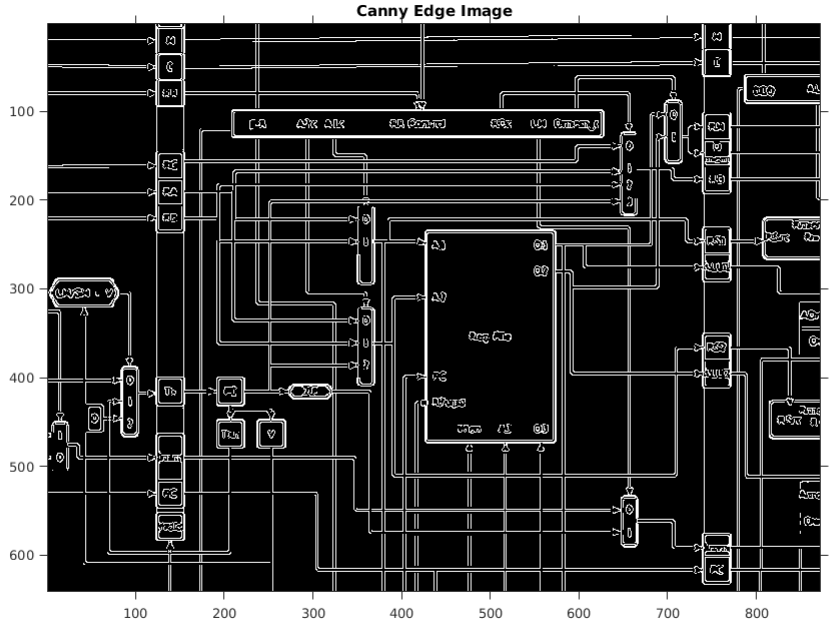

Figure 18: Pipeline img bright canny edges

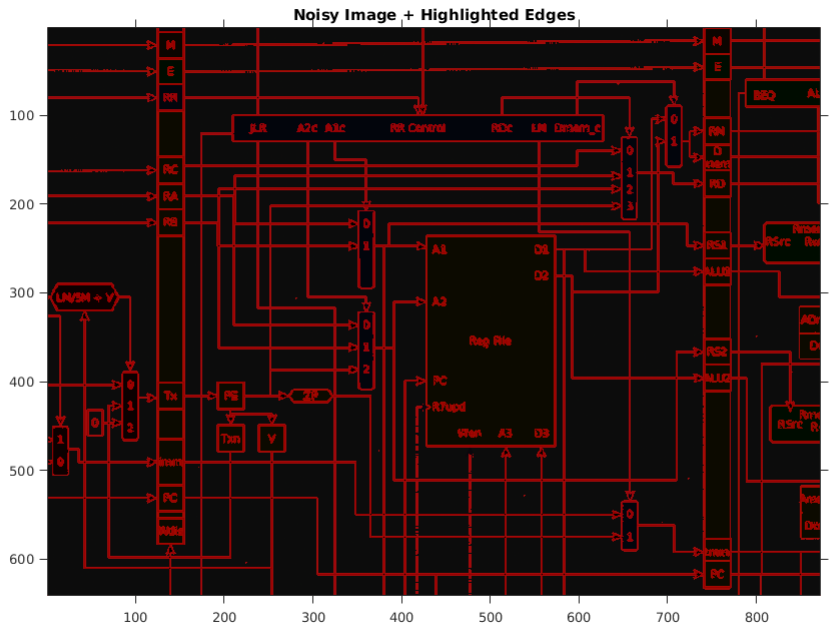

Figure 19: Pipeline img dark noisy

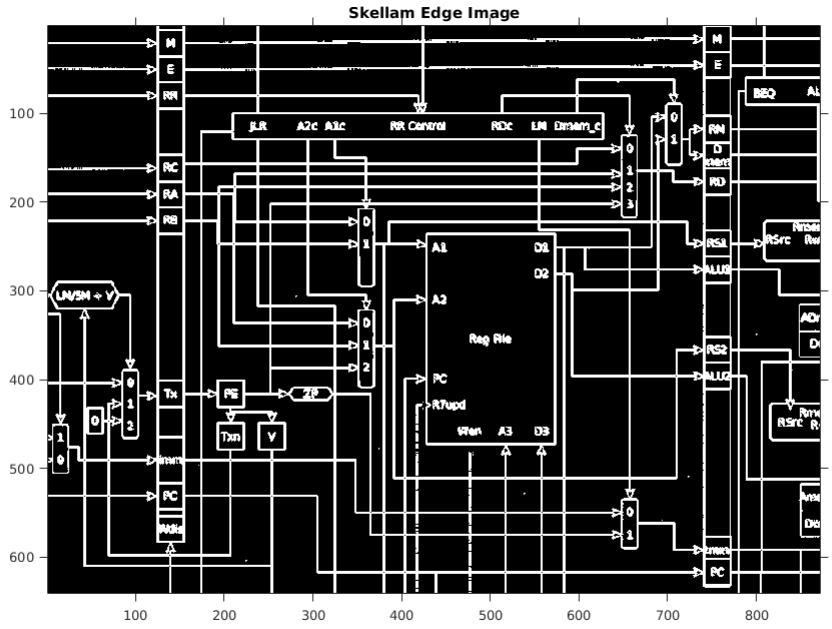

Figure 20: Pipeline img dark skellam edges

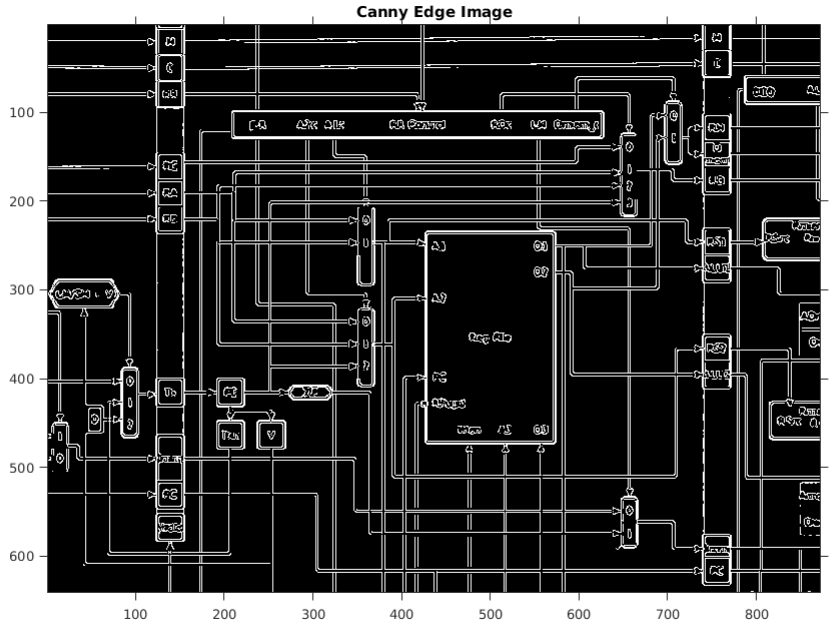

Figure 21: Pipeline img dark canny edges

6 How to generate Datasets

There are two files to generate the datasets: create_synth_dataset.m : To generate synthetic color checker Image create_noisy_bg_dataset.m : To generate Background subtraction Dataset.