CS 754: Final Project Report

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1 About the project

1.1 Introduction

Dealing with noises is an important aspect in image-processing. In various computer vision tasks, such as edge detection, background subtraction etc it is important to determine whether or not the intensities of two pixels come from the same scene radiance. In this project the model induces a linear relationship between intensity and Skellam parameters, and finally show the results in two different applications, forgrunds subtraction and edge detection.

1.2 Reference

We implemented Difference-Based Image Noise Modeling Using Skellam Distribution paper authored by Youngbae Hwang, Jun-Sik Kim and In So Kweon. Cited as -
Y. Hwang, J. Kim and I. S. Kweon, "Difference-Based Image Noise Modeling Using Skellam Distribution," in IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 34, no. 7, pp. 1329-1341, July 2012, doi: 10.1109/TPAMI.2011.224.

1.3 Datasets used

- Shi-Gheller's dataset - Tested on real images of color checkers captured using different cameras under different conditions. (Spatial data)
- UCSD Background Subtraction dataset- Background subtraction data and ground truth.
- Synthetic noise added color checker dataset created using MATLAB script.
  We created a synthetic dataset of about 200 images based on the GretagMacbetch colourchecker. The RGB values of the patches were obtained from the website, and a 3D matrix was created using them. Then, to each pixel, Poisson noise proportional to its intensity. Finally, the resultant image was stored in the PNG format.

2 Noise Model

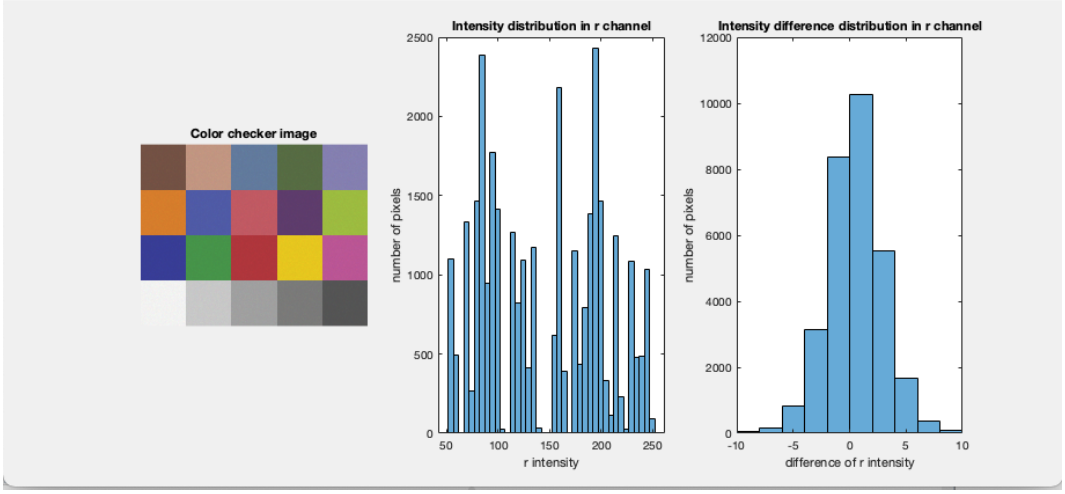


Figure 1: Histogram of Intensity and Intensity difference for generated image

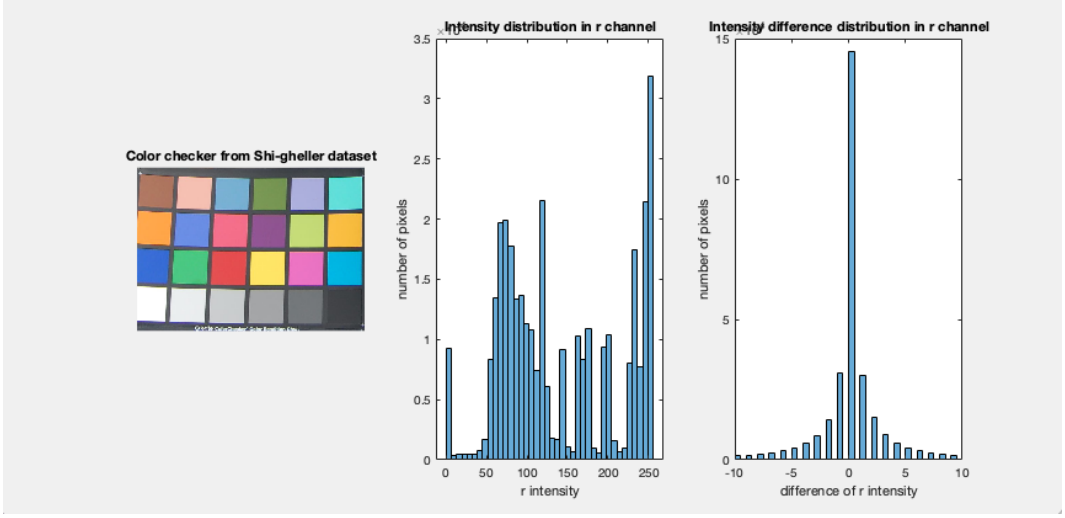
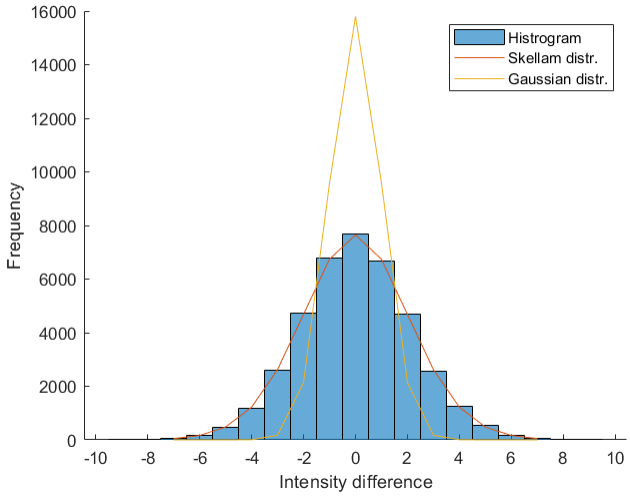


Figure 2: Histogram of Intensity and Intensity difference for a natural image obtained from Shi-Gheller dataset

The above shows that conventional additive models do not explain the distribution well, while intensity difference modeling can explain the distribution better.

Figure 3: Colorchecker generated

For the first patch, we obtained the following histogram of intensity differences:



We observe that the Skellam distribution fits the histogram for the patch perfectly, whereas that is not the case for the Gaussian distribution.

The following table indicates the value of I_α observed for selected values of α for the first patch:

Value of α	I_α
0.500000	2
0.750000	3
0.800000	4
0.900000	5
0.950000	6
0.990000	7
0.995000	8
0.999000	9

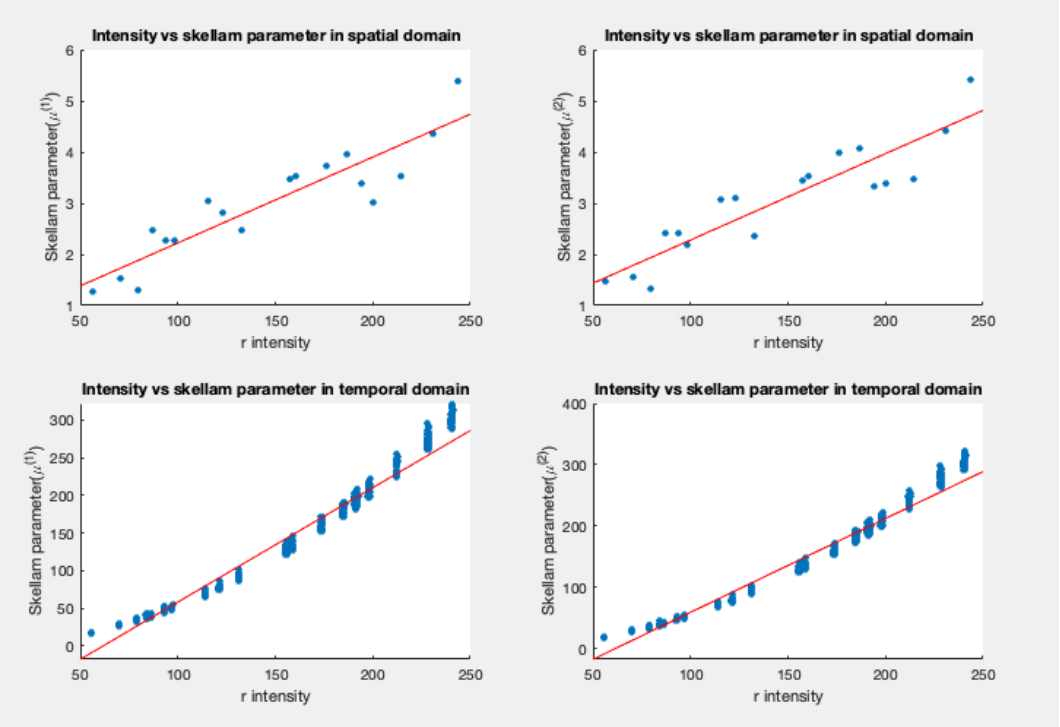


Figure 4: Linear relationship between skellam parameters and intensities in spatial and temporal domains

The above plotting does not come accurately linear, as depicted the difference is most likely due to improper dataset. Still we get a nearly linear fit of skellam paramters with intensity in both spatial and temporal domains as plotted above.

3 Background Detection using Skellam parameters

Figure 5: Background determined from generated dataset

We propose an on the go skellam parameters measurement and background determination method. The paper proposed that for a fixed camera gain, we use the same skellam parameters and the background was determined from unchanged pixel of T consecutive frames.
We obtained the background and skellam parameters at the same time after which we can obtain the background mask using intensity acceptance ranges.
At every pixel, we find the mode of the intensity values. An accepted deviation from the mode(due to noises) is learnt. We take the corresponding pixel from only those frames which lie within the threshold and obtain the corresponding parameters from those pixels only. The background at that point is set to mean of chosen intensities.
The below we trained on a set of 170 images from the mentioned dataset to obtain the background and parameters.

Tolerable range from mode	Variance from ground truth
40	0.033520
50	0.033208
60	0.032782
70	0.032697
80	0.032896

Table 1: Table of tolerable ranges from mode and variance of background from ground truth

In the above simulation a threshold of 70 gave the lowest variance from ground truth among tested thresholds, we can further use a binary search for finding the optimal threshold.

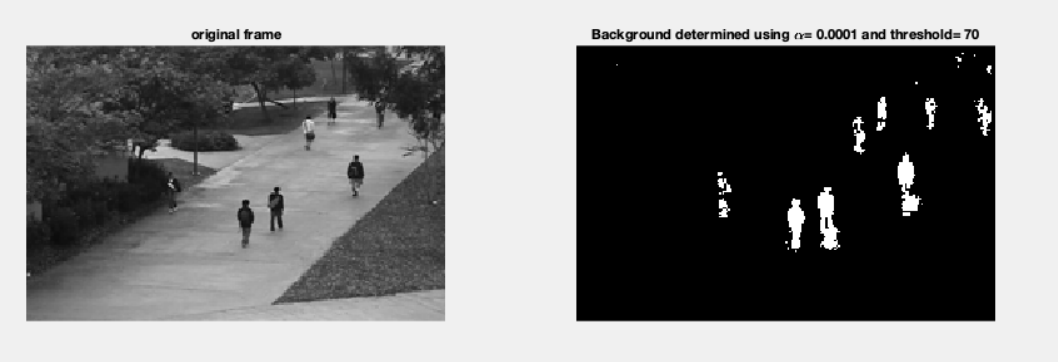


Figure 6: Background determined from real dataset frame 70

Figure 7: Background determined from real dataset frame 120

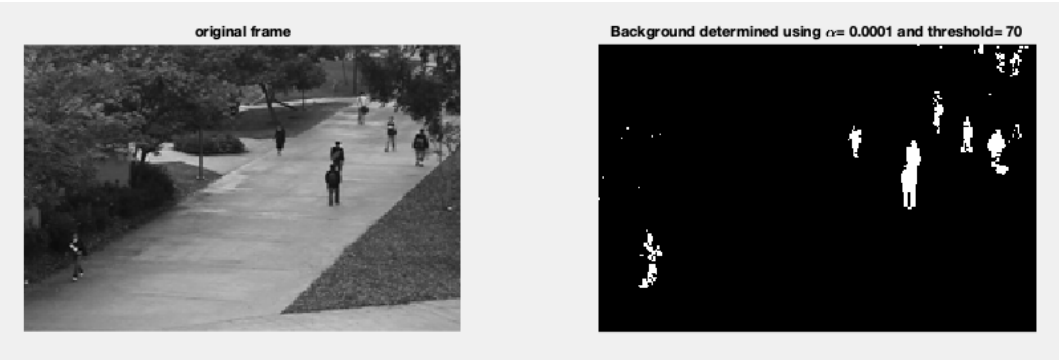
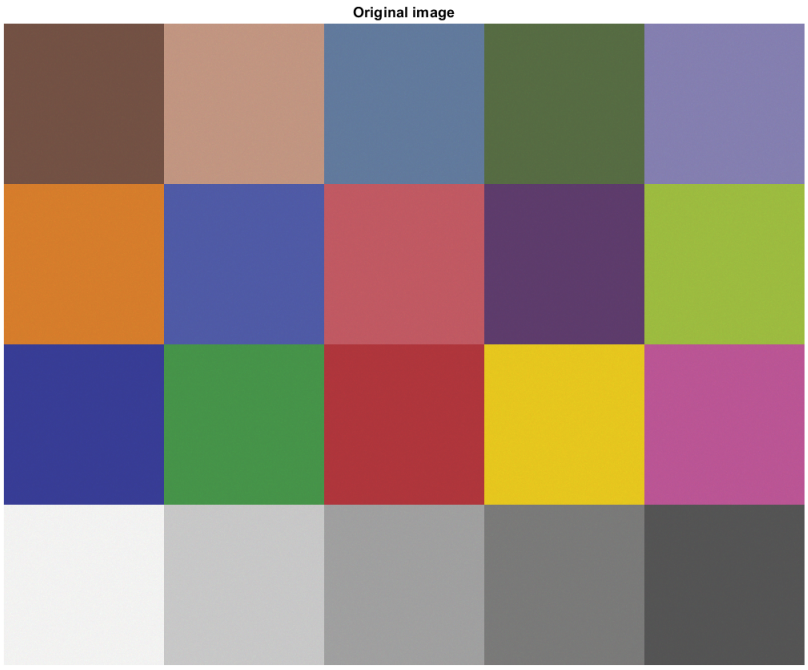


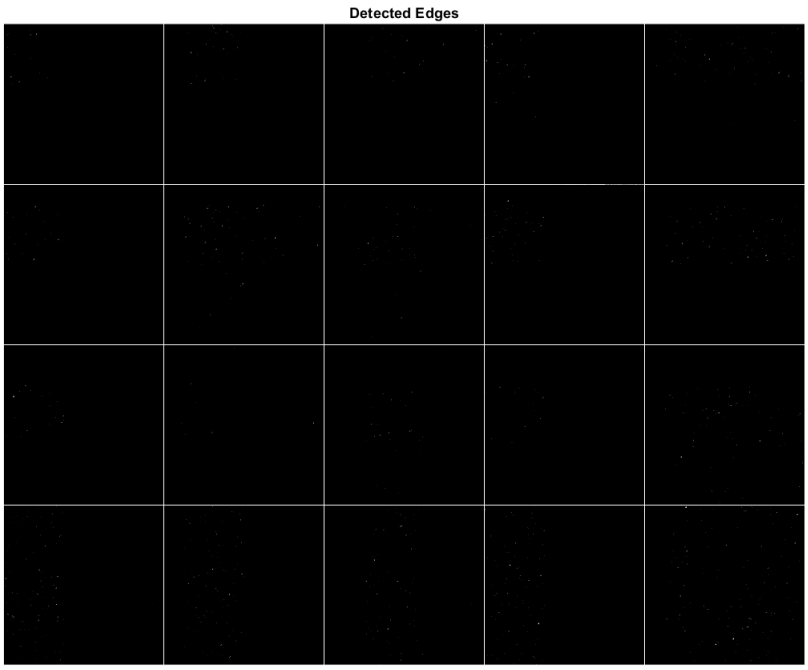
Figure 8: Background determined from real dataset frame 140

Figure 9: Background determined from real dataset frame 160

4 Edge Detection using Skellam parameters

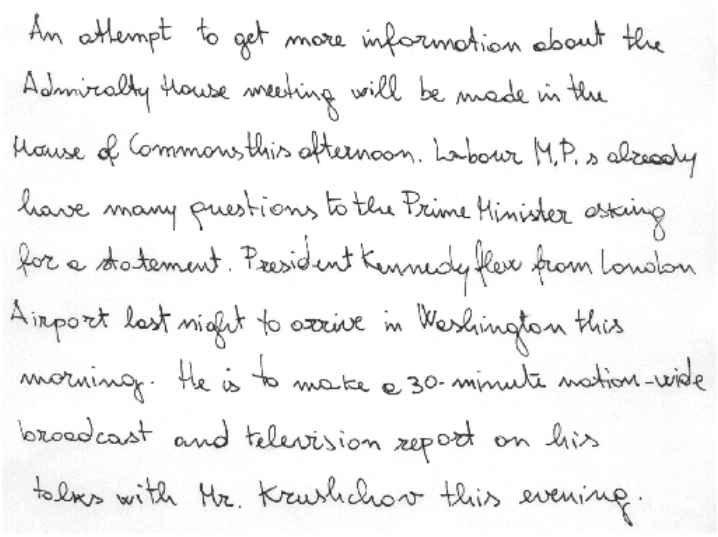
We simulated an image of the first 5×4 blocks of the GretagMacbeth colour checker, with Poisson noise added to it. Then, the edge detection method mentioned in the paper was used to obtain the following result:



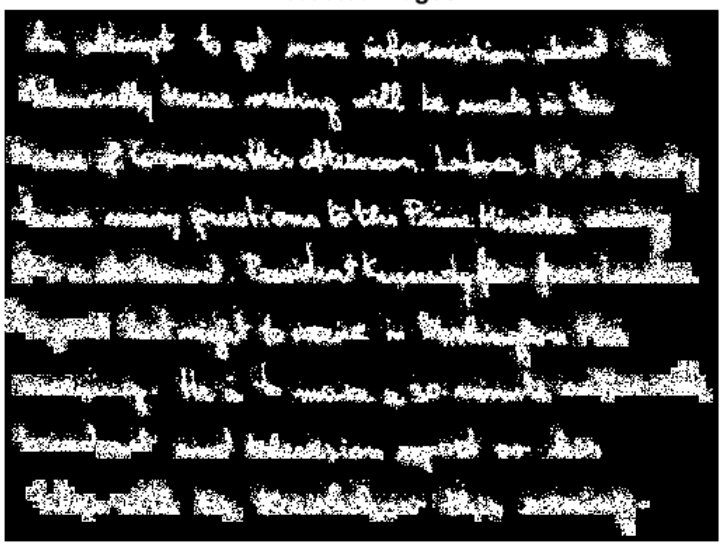


We also tested the edge detection algorithm on a natural image of handwritten text. The following results were obtained:

Original image



Detected Edges



While the result is slightly noisy, we can still make out most of the words from the text.