Mathematical Physics Final Report

Poisson Noise

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Abstract

In this project, we want to demonstrate how the photons received by the CMOS; also find the Poisson noise (positive bound) and its Gaussian approach act on different brightness images. Using the synthetic images and real photographs, we conclude two outcomes. One is that the Poisson noise is small and signal-independent; the other is that we can use the large number limit by applying normal random variables to approximate the total noise fluctuations.

1 Introduction

Poisson noise is also called shot noise. It originates from the particle nature of photons or electrons; i.e., the discrete photons, etc. In this report, I will use photon to introduce this topic.

First of all, we consider how the image appears in the receiver (CMOS). Photons that originate from the light source will appear in evident patterns on the CMOS and if the receiver receives more photons the gray scale value, from white to black gray scale will control the value from 0 to 255, and will be more significant. What CMOS observed is the expectation value of a bunch of beam lights, not the exact number of photons; therefore, there will be signal fluctuations. These fluctuations are associated with the average photon number, which we call noise.

In the class and self-reading section, we have learned the Poisson distribution and the Poisson process. If the series of events follows the Poisson process, it is necessary to comply with this

- Whole events are discrete.
- The number of events that occur in two mutually exclusive time intervals is an independent random variable.
- If the time interval is larger, the number of events is more probable to happen.
- For an infinitesimal time interval, the number of events is pretty hard to happen.

$$P(t, \Delta t) = \lambda\Delta + \mathcal{O}(\Delta t)$$

- Two events cannot occur at the same time.

- There is no event in the begin, $N_0 = 0$.
- The average rate (events per time period) λ is constant.

2 Methodology

methodology

3 Numerical Results

Result
This is the code for finding the rate of the Poisson process. The first part is the probe and tag method to find a suitable position; the second part is to calculate the rate:

```
    # Python
PYTHON SCRIPT
```

4 Analysis

Analysis

5 Conclusion

Conslusion

Appendix

The essential code I have written in the methodology. The total codes are a little while too long, so I paste the link (Google CoLab) below. In the link I have annotated some explanations, please check, thanks!
MP project Poisson noise LINK: *https://reurl.cc/1ZOlxV*

References

[1] Quick facts #3: Poisson noise, https://reurl.cc/XjR2v3

[2] Changing the contrast and brightness of an image!-Theory, https://reurl.cc/Lm5aWK

[3] Gaussian Approach to Poisson Noise-Adding Poisson noise to an image, *slack overflow*, answer from *Vimieiro*, edited by *BOT*.

[4] Shot noise, Wikipedia, https://reurl.cc/ZAN4Xg

[5] Shot Noise, *sunny lee*, https://reurl.cc/NAb9Vn

$$
\begin{aligned}
K &= U_g && (1) \\
mgh &= \frac{1}{2}mv^2 && (2) \\
(10)(.225) &= \frac{1}{2}v^2 \\
4.5 &= v^2 \\
2.12\frac{m}{s} &= v && (3)
\end{aligned}
$$