Summary

Brain disorders represent an enormous disease burden, in terms of human suffering and economic cost. In fact, brain disorders have emerged as the top 3 contributors to the global disease burden and the motivation to reduce the implications of brain disorders calls for greater research in the area of neuroscience. Neurons express the intensity of stimulus via the occurrence rate of action potentials or more commonly known as spikes or firing. While the firing rate plays an important role in neural information processing, the complexity and variability of the trial to trial sequences make predicting the timing of each spike accurately difficult. Furthermore, the number of possible spike sequences is typically so large that approximating all of their probabilities of occurrences is hard. Nevertheless, one can use the stochastic class of model to investigate how spike train statistics affects the measure of neuronal activity.

This thesis seeks to explore two classical point processes, namely the homogenous Poisson process and inhomogeneous Poisson process to model after spike train statistics. The paper starts off introducing the various components of a neuron structure in Chapter 2 and analyses the properties of the two candidate models analytically and via computational simulations using R programme in Chapter 3.

The different methods to measure firing rates which include Peristimulus Time Histogram (PSTH) and kernel density estimation are then explored using real spike train data set obtained from an experiment conducted by Antoine Chaffiol in chapter 4. As the kernel density overcomes the problem face when using PSTH like discontinuity of the firing function and arbitrariness of the placement of the bin, the kernel density is preferred and is used in the exploratory analysis for this thesis. In the process, the importance in the

selection of bandwidth is also discovered. To illustrate the effect of bandwidth sizes on the performance of kernel density, a study using different bandwidths is conducted and the data points from the simulation are plotted with the true density superimposed for comparison. The thesis then moves on to introduce a method to obtain the optimal bandwidth.

This is followed by a conduct of exploratory analysis and discussion in Chapter 5. The Fano Factor and Coefficient of Variation are computed and the results indicate that Poisson assumption is reasonable. With the optimal bandwidth, spike train data are then simulated from the two candidate models mentioned above before subjecting them to Goodness of Fit tests. The results show that unlike the homogeneous Poisson process, the inhomogeneous Poisson process is suitable in modelling after the spike train data.

The thesis concludes with Chapter 6 discussing the findings and with recommendations for further future research.