Stimulus Response Latency Estimation

Keyla Pagán-Rivera (Student presentor)

Gideon Zamba, PhD (Mentor)

Ming Yang and Erik L. Nylen (Research Assistants)
Order

- Stimulus response latency
- Change point
- Purpose
- Application and simulation results
- References
Stimulus response latency

- It is the time between the stimulus and the neural activity (Friedman and Priebe, 1997).
- They compare different types of estimators: Maunsell-Gibson, Half-Height, Maximum Likelihood, Least Square.
- In order to obtain a good latency estimator, the MLE of the change point can be used.
- MLE works with the neural spikes rather than the peri-stimulus histogram.
Cont.

- The point in which the histogram changes is call the change point.
- It is important to choose the optimal smoothing bandwidth for the peri-stimulus histogram to obtain a better way to represent the data. It can be obtained using bootstrapping (Friedman and Priebe, 1997).
- This smoothed histogram is use for the Half-Height technique, but that technique has limitations.
Neural response periods

- Nonstimulus evoked rate
- Initial stimulus evoked rate
- Terminal stimulus evoked rate
- Transitions between periods are change points, but this project will concern only in the first.
Peri-stimulus histogram of spike arrivals
Smoothed peri-stimulus histogram

- Stimulus onset
- Maximum
- Half-height

Spike counts

Time from stimulus onset (msec)
The change point technique is used to see shifts in mean or variance (Hawkins and Zamba, 2005).

Change point technique,

\[
X_i \sim \begin{cases} 
F(\mu_1, \sigma_1) & ; \ i \leq \tau \\
F(\mu_2, \sigma_2) & ; \ i > \tau 
\end{cases}
\]

\[
X_1, \ldots, X_\tau; \ X_{\tau+1}, \ldots, X_n
\]

Changes in mean, variance or both
If $\tau = k$, define $V_{i,k} = \sum_{j=i+1}^{k} (X_j - \bar{X}_{ik})^2$ and $S_{i,k} = V_{i,k} / (k-i)$

GLR for shift at time $k$ is

$$GLR = k \log(S_{o,k} / S_{o,n}) + (n-k) \log(S_{k,n} / S_{o,n})$$

$S_{i,k}$ is the MLE of variance

$$\bar{X}_{ik} = \sum_{j=i+1}^{k} X_j / (k-i)$$

$G_{k,n} = \frac{GLR}{c}$; where $c$ is the correction factor,

$$c = 1 + 11/12[1/k + 1/(n-k) -1/n] + [1/k^2 + 1/(n-k)^2 -1/n^2]$$

$G_{\max,n} = \max_k G_{k,n}$

The maximizing index is the likelihood ratio estimate of the change point.
Dynamically and sequentially

- Iteration process (about $G_{\text{max},n}$)
  - if $G_{\text{max},n} \leq h_n$, no evidence
  - if $G_{\text{max},n} > h_n$, evidence

- \( \hat{\tau} \) will then be the maximizing index.

- The time from $\tau$ to $\hat{\tau}$ is the latency.
The hazard function is the probability of failure of a unit at time \( n \) given that it did not fail before. 

\( h_n \) is chosen to maintain a constant hazard function.

For a specified type I error \( \alpha \)

\[
P[G_{\max,n} > h_n, \ G_{\max,j,\alpha} \leq h_{j,\alpha}; \ j < n] = \alpha
\]
$G_{\text{max}, n}$ and $h_{0.002, n}$

Figure 5: $G_{\text{max}, n}$ and $h_{0.002, n}$
Purpose

- This project explores the latency estimation by applying change-point methods (based on the generalized likelihood ratio test) to the empirical distribution of the spike arrival times. It further compares the change-point method to the peri-stimulus histogram approach.
Application and simulation results

- The data was taken from a laboratory where they applied a stimulus to a person and then they examined the spike arrivals in a peri-stimulus histogram.
- The change point is 61 if is used the cumulative density function (cdf) and 58 if is used the probability density function (pdf).
With those results it can be shown that this method is more efficient than older methods, which requires 500 data to find the change point (avoid unnecessary data).

Using the pdf:
- The mean and variance before the parameter change [1:58] are $\mu_1 = .12$ and $\sigma_1 = .14$
- The mean and variance after the parameter change [59:74] are $\mu_2 = 2.75$ and $\sigma_2 = 19.4$
- The size of the change is $| \mu_1 - \mu_2 | = 2.63$
Using the cdf:

- The mean and variance before $\tau$ [1:61] are $\mu_1 = 2.23$ and $\sigma_1 = 7.95$
- The mean and variance after $\tau$ [62:71] are $\mu_2 = 28.2$ and $\sigma_2 = 71.96$
- The size of the change is $|\mu_1 - \mu_2| = 25.97$
There were 1000 Monte Carlo simulations.

The Half-Height technique had a 42% of efficiency, but the change point had 90%.

The efficiency of the change point over the Half-Height is 2.14
References