Progress Report:
Adaptive PSTH Algorithm for Improving Performance of Real-Time Spike Classification in Neural Prosthetic Control Systems

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Executive Summary

Neuromuscular deficit as a result of debilitating neurological disease like quadriplegia, paraplegia, cerebral palsy or injury is one of the major causes of paralysis in most or part of the body seen in millions of patients. For people with such deficits, a viable therapeutic intervention would be a recording neural prosthesis utilizing neuronal signals from the brain to control the prosthetic device enabling communication or movement. These cortical neural prostheses (CNP) can process spike trains from the brain to decode the intent of movement along with other parameters like position and velocity intent in real-time and use it to control the neural prosthetic device. The activities of the motor cortex establish it as a reliable source for such neural control activity. Among the currently used techniques for processing spike data, the Peri-Stimulus Time Histogram (PSTH) based method has been shown to be computationally more efficient. The PSTH method consists of creating a sense of templates based on the average neural response to stimuli and classifying each single trial by assigning it to the stimulus with the closest template using a Euclidean distance measure. Multiple channels of single unit activity from the cortex can be recorded simultaneously and conditioned by discriminating spike activity. However, the drawback of the PSTH system is that the classification performance of this algorithm is not sustained for prolonged periods in predicting motor activities or detecting motor intent.

For this project, recorded neural activity from the rat sensorimotor hind limb cortex will be used to decode movement parameters. The rats implanted bilaterally with microwire arrays in their hind limb sensorimotor cortex are trained to perform skilled hind limb movement in response to an auditory stimulus. The neural spike data obtained from this experiment would be used for the analysis. One of the major constraints for this project centered around neural spike analysis is that neuron firing rates change continuously and so, the firing rate tuning functions are usually unimodal and noisy with no discrete on and off states and the spike activity will be poorly sorted in real-time. Also, the reliability of the animal model faces a certain bias depending on the state the animal is in while the experiment is being conducted.

In order to develop a signal processing routine that can update the previously defined PSTH based classifier to maintain its classification performance, a threshold for performance decay of the algorithm needs to be defined. Based on the observation from the preliminary data, the classification performance declines below 90% TP within the first two days. This value of TP% is set as benchmark performance for designing the adaptive algorithm, i.e. TP%>90, False Positive (FP)%<10. Based on this performance decay analysis, the adaptive algorithm must be developed with the goal of maintaining the classification performance for at least four weeks before it falls below the benchmark TP% value. The PSTH algorithm will be optimized by changing the size of the response window, bin clumping, number of training trials and the variables used during classification. Based on the live performance of the algorithm on offline spike data, it will be determined which parameter or combination of parameters if updated on a real time basis will result in maximizing time before failure as defined by threshold. Implementation of such a design in a neural prosthetic in a clinical setting will significantly decrease the frequency with which a patient has to visit his/her physician for resetting weights.
**Introduction**

Millions of people are unable to move due to debilitating neurological injury, disease or conditions often paralyzing one or more parts of the body like paraplegia following spinal cord contusion injury. A way to improve quality of life for people with such conditions is to overcome injury by utilizing neural signals from the brain to control prosthetic devices. A drawback of existing neural spike data processing techniques is that spike classification is computationally intensive and cannot keep up with requirements of real time processing needs. A Peri-Stimulus Time Histogram (PSTH) based classification of sensory stimuli using ensembles of single neurons (Foffani et Moxon, 2004) reported to achieve superior computation efficiency with respect to other standard techniques such as Artificial Neural Networks (ANN), Principal Component Analysis (PCA), Independent Component Analysis (ICA), Linear Discriminant Analysis (LDA), etc. Classification performance of this algorithm is not sustained for prolonged periods in predicting motor activities or detecting motor intent as demonstrated in experiments in water deprived rats trained to press a button in response to auditory stimuli for a reward. Therefore there is a need to develop a more intelligent algorithm which can automatically update its parameters in response to changing conditions so that classification performance over prolonged periods of activity is conserved and thus minimize the need for manual intervention.

**Solution**

The solution consists of modifying a Euclidean distance based PSTH classifier described in Foffani, Moxon 2004 to include an adaptive algorithm that automatically updates its templates. This is expected to improve the classifier’s long term performance.

**Preliminary Data Analysis:**
The objectives of preliminary data analysis were to:

1. Determine whether single neuron or population function analysis of neural data is superior in terms of classification performance in discriminating between press/no press activity
2. Determine performance of classifier in decoding slow/small, medium, large/high values of some key parameters like reaction time, press amplitude, speed of press and press duration

Based on the results of the above preliminary analysis the following solution tracks are possible and describe the general strategy for updating templates:

![Schematic Representation of Proposed Solution](image)

**Figure 1. Schematic Representation of Proposed Solution**

**Alternatives for updating templates:**

**Approach 1:**

The first approach for updating the trials will consist of updating the PSTH template based on design parameters:

The algorithm will keep incrementing the number of trials in the template without discriminating between TP and FP trials as long as the classification performance remains greater than or equal to the threshold.
If classification performance falls below the threshold, all the misclassified trials will be subtracted from the training set and test if the classification performance improves as a result.

\[ \frac{1}{T} \left( \sum_{i=1}^{T} v_{i,j} \right) \]

Number of trials \( (T) \) increases and the training set evolves and expands in size over time as more trials are analyzed.

**Approach 2:**

In the second approach, the number of trials in the training set will be kept constant such that the algorithm will add the newest trial and drop off the oldest trial from the training set.

\[ \frac{1}{T'} \left( \sum_{i=k+1}^{k+T'} v_{i,j} \right) \]

Where \( T' \) is the number of trials in the template, \( n \) is the indexing variable for the number of trials to be eliminated from the training set.

**Relation between Approach 1 and Approach 2**

\[ \frac{1}{T'} \left( \sum_{i=1}^{T} v_{i,j} - \sum_{i=1}^{k} v_{i,j} - \sum_{i=k+T'+1}^{T} v_{i,j} \right) \]

\( T \) is the number of trials in the training set, \( k \) is an indexing variable in the trial.
Figure 2 provides a schematic representation of the entire training set. Using an indexing variable \( k \), a subset of the entire training set is defined as the template \( T' \) for Approach 2. However, in Approach 1 all the trials in the Training Set (i.e. \( T \)) are used to generate the Template.

In case of Neural Population Function (NPF) performing better, the strategy will be to either keep ICA weights constant or update both the ICA weights and the trials in the training set. Here, the algorithm will use the exact same procedure for updating the PSTH template (Approach 1 or 2). Additionally, it will generate NPFs based on the most recent single trials, perform PCA, select the best Independent Component and then update the ICA weights.

**Specifications**

1. Based on the observation from the preliminary data, the classification performance declines below 90% TP within the first two days. This value of TP% is set as benchmark performance for designing the adaptive algorithm, i.e. TP%>90, False Positive (FP)%<10

2. The adaptive algorithm must be developed with the goal of maintaining the classification performance for at least four weeks before it falls below the benchmark TP% value defined above. It is expected that such maximization will result in performance time improvements so that the patient visits to the physician using neural prosthetics is minimized.

3. The adaptive algorithm must also be optimized in terms of computational efficiency which is the time taken by the adaptive PEH classifier to discriminate single trials with respect to the existing methods (non-adaptive PEH classifier, Artificial Neural Networks,
Linear Discriminant Analysis, etc). The computation time of the adaptive PEH classifier must be less than these candidate decoding procedures as well as the original PEH classifier and within 100 to 150 ms. This is the response time i.e. the time window after sounding the auditory stimulus during which the Neural Activity for Movement is generated in the brain as reported in literature (Wu, Black, 2003).

**Constraints**

1. Reliability of the animal model faces a certain bias depending on the state (e.g. attentive, resting, etc.) the animal is in while the experiment is being conducted.
2. Specificity of the spike sorting procedure in discriminating the firing of individual neurons.
3. The number of neurons from which data has been recorded might be changing (decreasing or even increasing) from day to day, thus changing the dimensions of the PEM matrix (i.e. Neurons x Bins).
4. The identity of the neurons connected to a given channel in an electrode might be changing (i.e. 1a might be 1b the next day).

Due to constraints 3 and 4 it was decided to perform an initial proof-of-concept analysis on a per channel basis using three days worth of recordings to see if classification performance is improved. Based on the results of the proof-of-concept analysis the final prototype will be created which can automatically concatenate trials to generate a continuously updating template.
**Design Parameters**

The following parameters will be optimized for maximizing classification performance duration, that is, how long the performance remains above the threshold of TP% > 90%. These parameters will be input as initial conditions. Based on the live performance of the algorithm on offline spike data, the combination of parameters required to maximize time before failure will be determined and used to update the algorithm on a real time basis.

i. Bin size - An appropriate bin size for discriminating movement/pre-chime for classifying movement intent needs to be determined empirically for updating the existing PSTH algorithm based on the SNR, True Positive and False Positive values.

ii. Number of trials used to generate the templates (T’). The size of the template in terms of the number of trials comprising the template can be varied to find the optimal minimum number of trials for which classification performance at TP%>90 when ICA weights are also updated daily.

iii. The frequency with which the algorithm may update itself: This means how often the adaptive PEH classifier updates the trials in its templates and/or the weights of its ICA matrix.

iv. Time window about an event can be varied and its effect on classification performance quantified.

<table>
<thead>
<tr>
<th>Neurons</th>
<th>Bins</th>
<th>No. Trials in template at any given time</th>
<th>Bin size (ms)</th>
<th>Time window (s)</th>
<th>Pre-Chime</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1, 2, … B</td>
<td>50, 100, 300, 500</td>
<td>5, 10, 25, 50</td>
<td>±(0.5, 1, 1.5, 3)</td>
<td>…</td>
</tr>
<tr>
<td></td>
<td>1, 2, … B</td>
<td>50, 100, 300, 500</td>
<td>5, 10, 25, 50</td>
<td>±(0.5, 1, 1.5, 3)</td>
<td>…</td>
</tr>
<tr>
<td></td>
<td>1, 2, … B</td>
<td>50, 100, 300, 500</td>
<td>5, 10, 25, 50</td>
<td>±(0.5, 1, 1.5, 3)</td>
<td>…</td>
</tr>
<tr>
<td></td>
<td>1, 2, … B</td>
<td>50, 100, 300, 500</td>
<td>5, 10, 25, 50</td>
<td>±(0.5, 1, 1.5, 3)</td>
<td>…</td>
</tr>
</tbody>
</table>
Table 3. Dataset organization for a classification of movement intent for a given stimulus using N neurons, with B bins per stimulus. Each row in the chart represents a single trial. The parameters for classification are given in the columns. The figure is reformatted with permission from: Foffani, Guglielmo, and Karen A. Moxon. “PSTH-based classification of sensory stimuli using ensembles of single neurons.” Journal of Neuroscience Methods (2004)

<table>
<thead>
<tr>
<th>Post-Chime/Movement</th>
<th>T</th>
<th>T+1</th>
<th>…</th>
<th>2T</th>
<th>Trials</th>
</tr>
</thead>
</table>

Description of Prototype to Date

Prototype Description

The prototype consists of a modified version of the existing PSTH based classifier described in Foffani, Moxon, 2004. It will utilize single neuron analysis of raw spike train data to decode for movement activity or intent. Additionally, it must automatically update its templates according to the procedure described above to sustain classification performance over sustained periods as defined in the design specifications.

Project Status

1. Completed single neuron analysis of neural data to determine performance of PSTH classifier in decoding press/no press activity and found it to be superior to Neural Population Function (NPF) analysis.

2. Currently performing single neuron analysis of neural data to determine the performance of the PSTH based classifier in decoding parameters like reaction time, press amplitude, speed of press and press duration for slow/small, medium and high/large values. The
results from the single neuron vs. NPF analysis of spike train data for decoding movement indicates that single neuron analysis performs superior to NPF analysis.

<table>
<thead>
<tr>
<th>Control Mode</th>
<th>Day</th>
<th>Single Neuron Analysis</th>
<th>NPF</th>
</tr>
</thead>
<tbody>
<tr>
<td>behavior</td>
<td>060309.WB009.WB.PR02</td>
<td>97.4%</td>
<td>82.6%</td>
</tr>
<tr>
<td>behavior</td>
<td>060509.WB009.WB.PR04</td>
<td>97.4%</td>
<td>61.3%</td>
</tr>
<tr>
<td>behavior</td>
<td>060609.WB009.WB.PR05</td>
<td>93.4%</td>
<td>61.6%</td>
</tr>
<tr>
<td>behavior</td>
<td>102408.WB010.WB.PR02</td>
<td>93.4%</td>
<td>95.5%</td>
</tr>
<tr>
<td>behavior</td>
<td>110208.WB010.WB.PR07</td>
<td>92.1%</td>
<td>84.7%</td>
</tr>
<tr>
<td>behavior</td>
<td>110308.WB010.WB.PR08</td>
<td>100.0%</td>
<td>89.9%</td>
</tr>
<tr>
<td>behavior</td>
<td>110408.WB010.WB.PR09</td>
<td>96.1%</td>
<td>89.5%</td>
</tr>
<tr>
<td>behavior</td>
<td>110508.WB010.WB.PR10</td>
<td>97.4%</td>
<td>87.4%</td>
</tr>
<tr>
<td>behavior</td>
<td>022009.WB011.WB.PR02</td>
<td>96.1%</td>
<td>84.4%</td>
</tr>
<tr>
<td>behavior</td>
<td>022109.WB011.WB.PR03</td>
<td>93.4%</td>
<td>68.6%</td>
</tr>
<tr>
<td>behavior</td>
<td>022309.WB011.WB.PR04</td>
<td>100.0%</td>
<td>85.2%</td>
</tr>
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<td>behavior</td>
<td>022409.WB011.WB.PR05</td>
<td>94.7%</td>
<td>65.2%</td>
</tr>
<tr>
<td>behavior</td>
<td>022609.WB011.WB.PR07</td>
<td>94.7%</td>
<td>68.3%</td>
</tr>
<tr>
<td>behavior</td>
<td>022709.WB011.WB.PR08</td>
<td>98.7%</td>
<td>83.8%</td>
</tr>
<tr>
<td>behavior</td>
<td>031209.WB012.WB.PR02</td>
<td>90.8%</td>
<td>61.6%</td>
</tr>
<tr>
<td>behavior</td>
<td>031409.WB012.WB.PR03</td>
<td>100.0%</td>
<td>82.0%</td>
</tr>
<tr>
<td>behavior</td>
<td>031509.WB012.WB.PR04</td>
<td>98.7%</td>
<td>74.0%</td>
</tr>
<tr>
<td>behavior</td>
<td>031609.WB012.WB.PR05</td>
<td>98.7%</td>
<td>80.4%</td>
</tr>
</tbody>
</table>

Table 1. Results from comparison of correctly classified trials for decoding press/no press activity using single neuron versus neural population function analysis. Each Water Box (WB) number represents a different animal. Each PR number represents a different day of the recording session.
Table 2. Results for classification performance for decoding speed of press (slow and fast trials) using single neuron analysis.

Note: We have generated the concatenated PEMs from individual channels. There are some debugging issues with the continuous PSTH algorithm, which we expect will be completed latest by March 5th.

Plan of action for Spring Term

*Developing Prototype*

1. The preliminary phase to select either NPF analysis or single neuron analysis is almost complete
2. By the end of the Winter quarter it is estimated that Approach 1 (as described above) will be developed and tested versus the original classifier
3. During first half of spring quarter Approach 2 will be developed and both approaches will be evaluated and tested with respect to each other and the original classifier
4. During the remaining half of spring quarter the prototypes will be tested in a live recording session and modified as needed
5. The testing procedure is described in more detail below
6. The finalized automated template prototypes will also be developed in the Spring term based on the results of the proof of concept analysis of the two approaches by the end of the winter quarter.
Testing

After developing an updated PSTH routine incorporating an adaptive approach to template generation, it will be tested using offline preliminary data. The effects of varying each parameter will be quantified in terms of its effect on True Positive%, False Positive% and SNR. Computational efficiency of the new adaptive PEH Classifier will be tested in comparison to the old non-adaptive PEH classifier. If the new adaptive PEH classifier meets the threshold criteria (i.e. TP % > 90, FP % < 10) then it will be tested in an online recording session using a similar behavior model as described above. The rationale for applying it in a live animal recording session is the observation that decoding filters developed using offline data may behave very differently in terms of classification performance during online recording sessions.

Societal and Environmental Impact

The project aims to device an efficient way of updating the PSTH algorithm for neural prosthetics to minimize the need for manual intervention. This can be used to develop an efficient cortical neural prosthetic (CNP) control system that would allow a speed adaptive limb movement. For this to be a real-time system, it would be critical to make parallel recordings from multiple microwire arrays which would require chronic intra-cortical implantation of these microelectrodes. One of the common problems of chronically implanted electrodes is the electrode-tissue interface. The invasive implantation of these electrodes may possibly damage the parenchyma, disrupt blood vessels or lead to microhemorrhage. The intra-cortical implantation of the electrode leads to a proliferation in astrocyte number causing the formation of a loose encapsulation around the electrodes which results in poorly discriminated cascade of
signaling events. This may further lead to an infiltration of immune components, nonlocal cellular elements and epithelial cell proliferation (Schwartz, 2004).

A clinical implementation of such a design potentiates to improve the quality of life of a lot of patients with debilitating neuromuscular deficits caused by a broad range of spinal cord diseases and injury. It is critical for the system to be cost effective, low maintenance and affordable to be able to target a considerable portion of the clinical market. A downside to building such an application is that it may have certain unanticipated negative impacts on the quality of life and hazardous situations in the event of improper classification of the neural data. Moreover, an adaptive algorithm developed using rat spiking data may perform differently for human prosthetic devices for any given task and the element of inter-patient variability just adds to the uncertainty of the observed on-line system performance. Additionally, there is no proper way of defining True Positive classification in real time and this must be established for any clinical realization of prosthetics using the modified algorithm proposed in the solution. However, this is beyond the scope of the current project.

Budget

To develop a prototype of the solution, facilities at the Neurorobotics Laboratory, School of Biomedical Engineering and Health Sciences will be utilized. The development of the prototype involves computational work on MATLAB and as such does not involve funding requirement. The preliminary data that will be used for initial development of the algorithm was supported by Research Grant #8590 from the Shriner’s Hospital for Children in Philadelphia, and by NIH P01 NS24707.

The requirements for the online testing of the signal processing routine are:
1. Animal model- Adult Long-Evans rats for recording spike data by implanting microwire electrodes

2. Implantable brain microwire electrodes for recording spike data. Arrays manufactured by Neurolinc Corp (Basking Ridge, NJ 07920) with row/column spacing of 350 mm.

3. Hardware- Multi Neuron Acquisition Processor (MNAP) for amplifying analog signals

4. Software- MATLAB for programming, Plexon for discriminating single neuron analog signals, SpikeAnalyzer (tool) to generate PSTH

Since these equipments are already present in the laboratory no additional funding is required for this aspect of the project. It is estimated that 8 Adult Long Evans (LE) rats (4 recording sessions per rat) weighing 250 g each need to be ordered for the animal testing part of the project (this number of rats has been reported to be required for similar studies in the same lab for acquiring statistically significant data). A single 250 g LE male rat costs $32.75 and this 8 rats will cost $\((32.75 \times 8) = 262.00\). It is expected that funding for the animals will be obtained from the above mentioned grants.

**Schedule (Gantt Chart in Appendix 4)**

1.) September-December

The phase of the design project will involve and require the completion of the following steps

a. Preliminary data analysis

   i. Raw spike data formatting from mat files

   ii. Generating Peri Event Matrix and PSTH from formatted data
iii. Determining threshold for performance decay empirically from the spike data. (This is an important step since the threshold value is required in order to develop an updated PSTH classifying algorithm)

iv. Literature search on various adaptive algorithms such as Kalman filter, switching Kalman filter, LDA, ANN, PVA; as an other alternatives for the design model

v. Determine best weights from ICA

2.) January-February

The second phase in the designing process will involve developing an adaptive logical algorithm for PSTH classification

   a. Develop adaptive algorithm based on preliminary data

      i. Test and optimize Design Parameters i, ii, iii, iv using offline spike data (January)

      ii. Test/Develop Method of Solution 1(a) and 1(b) (January-February 1st half)

         1. Test Strategy for Updating PSTH template: (evolving template)

         2. Test Strategy for Updating PSTH template: oldest trial subtraction

      iii. Determine optimal frequency of updating ICA weights (January 2nd half)

3.) February-March

   a. Test/Develop Method of Solution for multi unit recordings

   b. Testing and finalizing adaptive algorithm using offline data

4.) March-April

   a. Perform Real Time Spike Classification using new adaptive PEH Algorithm in Rat behavioral paradigm using four rats

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b. Modify algorithm based on above animal testing

5.) April-May

a. Comparing Computational efficiencies of new adaptive PEH classifier vs. existing PEH classifier and other candidate decoding approaches. (April 1\textsuperscript{st} half)

b. Finalizing Code for the adaptive PEH classifier (April)

c. Testing the final PEH classifier on offline spike data and animal model (May)
References:


Appendix 1: Table of Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANN</td>
<td>Artificial Neural Networks</td>
</tr>
<tr>
<td>CNP</td>
<td>Cortical Neural Prosthesis</td>
</tr>
<tr>
<td>ICA</td>
<td>Independent Component Analysis</td>
</tr>
<tr>
<td>LDA</td>
<td>Linear Discriminant Analysis</td>
</tr>
<tr>
<td>LE</td>
<td>Long Evans</td>
</tr>
<tr>
<td>MNAP</td>
<td>Multi Neuron Acquisition Processor</td>
</tr>
<tr>
<td>NC</td>
<td>Neural Control</td>
</tr>
<tr>
<td>NPF</td>
<td>Neural Population Function</td>
</tr>
<tr>
<td>PCA</td>
<td>Principal Component Analysis</td>
</tr>
<tr>
<td>PEH</td>
<td>Peri Event Histogram</td>
</tr>
<tr>
<td>PSTH</td>
<td>Peri Stimulus Time Histogram</td>
</tr>
<tr>
<td>PVA</td>
<td>Population Vector Algorithm</td>
</tr>
<tr>
<td>SNR</td>
<td>Signal to Noise Ratio</td>
</tr>
<tr>
<td>TP</td>
<td>True Positives</td>
</tr>
</tbody>
</table>

Appendix 2: List of Figures

<table>
<thead>
<tr>
<th>Figure Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1: Demonstration of pre-processing of spike data recorded from adult Long Evans rat. Dimensionality of the single neuron recordings is reduced by PCA and the best set of ICA weights is used to generate the NPF</td>
<td>6</td>
</tr>
<tr>
<td>Figure 2: Time course of classification performance post implant shows significant decay in the NC-only mode when weights from the first recording session of the animal are used throughout instead of updating the weights on daily basis</td>
<td>7</td>
</tr>
<tr>
<td>Figure 3: Dataset organization for a classification of movement intent for a given stimulus using N neurons, with B bins per stimulus. Each row in the chart represents a single trial. The parameters for classification are given in the columns. The figure is based on Foffani, Moxon, 2004</td>
<td>11</td>
</tr>
<tr>
<td>Figure 4: The Kalman filter model using a “hidden state” weight evolving in a Markov chain to predict the movement trajectory</td>
<td>14</td>
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</table>
## Appendix 3: List of Variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>T′</td>
<td>Number of trials in the template</td>
</tr>
<tr>
<td>T</td>
<td>Number of trials in the training set</td>
</tr>
<tr>
<td>n</td>
<td>Indexing variable for the number of trials to be eliminated from the training set</td>
</tr>
<tr>
<td>v</td>
<td>Spike Counts</td>
</tr>
<tr>
<td>i</td>
<td>Varies from 1 to the total number of trials (T) per stimulus (s)</td>
</tr>
<tr>
<td>j</td>
<td>Vector where the jth element of the template</td>
</tr>
<tr>
<td>s</td>
<td>Stimulus</td>
</tr>
<tr>
<td>c&lt;sub&gt;i&lt;/sub&gt;</td>
<td>Describes which stimulus corresponds to the ith trial</td>
</tr>
<tr>
<td>N</td>
<td>Neuron</td>
</tr>
<tr>
<td>B</td>
<td>Bin</td>
</tr>
<tr>
<td>d</td>
<td>Euclidean Distance between single trial and template</td>
</tr>
</tbody>
</table>
Appendix 4: Gantt Chart for Schedule

Gantt Chart

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Literature search on adaptive algorithms</td>
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<tr>
<td>Raw data formatting from mat files</td>
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<tr>
<td>Generating PEM and PSTH</td>
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<tr>
<td>Determining threshold for performance decay</td>
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<tr>
<td>Classification using single neurons vs. neural population function using</td>
<td></td>
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<tr>
<td>Determine optimum parameters for classification</td>
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<td></td>
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<td>Determine best weights from ICA</td>
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<td>Test Strategy for Updating PSTH template: evolving template</td>
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<td>Test Strategy for Updating PSTH template: oldest trial subtraction</td>
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<td>Determine optimal frequency of updating ICA weights</td>
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<td>Test/Develop Method of Solution for multi unit recordings</td>
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<td>Perform Real Time Spike Classification using animal model</td>
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<td>Modify algorithm based on above animal testing</td>
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<td>Comparing Computational efficiencies of new adaptive PEH classifier</td>
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<td>Finalizing Code for the adaptive PEH classifier</td>
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<td>Testing the final PEH classifier on offline spike data and animal model</td>
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Appendix 5: Resumes of Team Members

ANKITA NARAYAN

☎ 3305 Powelton Avenue, Apartment 1F ● Philadelphia, PA 19104 ♦ (646) 352.2772 ✉ an87@drexel.edu

OBJECTIVE
To secure a full-time position that offers the opportunity to utilize my aptitude and research abilities in biology and in vivo studies.

Summary:
Self motivated, career oriented, versatile scientist with diverse experiences from engineering to cell biology and in vivo animal studies and necropsy

EDUCATION
Bachelor of Science in Biomedical Engineering, (Expected June, 2010)
Drexel University, Philadelphia, PA

Relevant Coursework:

HONORS AND AWARDS
• Dean's Scholar, Drexel University, 2006-2009
• Dean's Scholarship, Drexel University, 2006-2011
• Pennoni Honors College, Drexel University, 2006-2011
• Nominated as a member of the National Society of Collegiate Scholars, 2007

PROFESSIONAL EXPERIENCE

MERCK INC.
RESEARCH INTERN
SEPTEMBER, 07 – MARCH, 08 & SEPTEMBER, 08 – MARCH, 09

- Worked with a research group studying anti-inflammatory compounds that target nuclear receptors
- Analyzed the effects of compounds in cell-based transcription assays
- Isolated RNA from tissues and cultured cells using spin column method
- Participated in cDNA synthesis and subsequent real-time qPCR (TaqMan) analysis
- Participated in animal necropsy to collect tissues, bone marrow samples from rodents
- Used various statistical softwares like StatView to analyze the results.

COMPUTER SCIENCE DEPARTMENT, DREXEL UNIVERSITY
TEACHING ASSISTANT
APRIL, 08 – SEPTEMBER, 08

- Assisted with the freshman programming courses in Maple and answer any course related or grading concerns

RESIDENTIAL LIVING OFFICE, DREXEL UNIVERSITY
FRONT DESK REPRESENTATIVE
SEPTEMBER, 06 – PRESENT

- Communicated with the incoming students to resolve student issues
- Managed the front desk and general security

LABORATORY TECHNIQUES
- RNA/DNA Isolation from tissues and cultured cells and Purification
Team 3 Progress Report- A. Narayan, N. Bailwal, A. Sengupta

- cDNA synthesis and real-time qPCR (TaqMan) analysis
- Protein purification and Quantification using Bradford, Bicinchoninic acid (BCA), ELISA and cell proliferation assays
- Affinity chromatography on serum albumin and analysis
- Western Blot and Coomassie staining
- Peptide Mapping using Chymotrypsin digestion
- Chromosomal Isolation and Spec Analysis on Bacterial Cultures
- Restriction Digestion, Quantification and Ligation
- Transformation, Screening, Plasmid Mini and Maxi Prep and Restriction Mapping
- Worked on cell culture assays, Gel Electrophoresis (Agarose and SDS PAGE)
- In-vivo experience in collecting tissue, bone and bone marrow samples from rodents
- PCR, RT-PCR, qRT-PCR, RNA/DNA purification.
- Molecular cloning, sequencing
- In-vivo techniques: animal handling, general necropsy

**SKILLS**

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<th>Software</th>
<th>Matlab, Maple, LabView, AutoCad, Microsoft Office, Operating Systems XP,2000, 95,</th>
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<tbody>
<tr>
<td>Certifications</td>
<td>Radiation safety, Animal handling, Blood and pathogen safety</td>
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</table>
Team 3 Progress Report - A. Narayan, N. Bailwal, A. Sengupta

Abhishek Sengupta
534 N 35th St
Philadelphia PA 19104
+1 (646) 341-7201
abhishek.sengupta@gmail.com

EDUCATION
Drexel University Philadelphia, PA
Bachelor of Science Anticipated Graduation: 12 June 2010
Biomedical Engineering

EMPLOYMENT
Max-Planck-Institute for Medical Research Heidelberg, Germany
Intern, Developmental Genetics of the Nervous System April 2009 - September 2009

• Establishing stress response readout in zebrafish utilizing live in vivo bioluminescence signal from genetically encoded Calcium sensor Aequorin
• Screening for promoter activity to generate stable transgenic line
• Analyzing and manipulating the activity of neurons involved in the stress response using various stressors and tool compounds and studying the activation of zebrafish pituitary neurons
• Generating (cloning) RNA probes for in situ hybridization
• Characterizing second generation fish mutants with hypothalamic lesions i.e. mutant screening and specification of mutation through hybridization experiments

GlaxoSmithKline Research & Development King of Prussia, PA
Intern, Heart Failure Biochemistry & Cell Biology March 2008 - September 2008

• Proposed, developed and validated image-based high content screening methods for the quantification of agonist/antagonist induced changes in cell morphology, intracellular signaling including a novel and highly sensitive assay format for classifying Myocytes as hypertrophic or control based on perinuclear antibody signaling
• Performed image-based elucidation/quantification of drug target protein complex formation by image colocalization techniques
• Developed a procedure for quantification of GFP transduction
• Developed a procedure for quantification of GFP transduction
• Identified optimal immunostaining protocols, developed robust macro-based image analysis algorithms, identified endpoint readouts of agonist response from multiparameter image analysis data, optimized cell isolation/seeding density protocol, etc.
• Benchmarked newly developed assays against tool compounds, target gene plasmids and siRNA
• Isolated and characterized primary cardiac myocytes from rodent and human sources; developed and deployed methods for quantification of marker transcripts and proteins
• Gained insight beyond own projects by supporting imaging and target validation related needs of various groups in the department
• Technologies utilized in this job include primary mammalian tissue culture, RT PCR, PCR, cloning, automated fluorescence microscopy, i.e. GE InCell 1000, image analysis algorithm development in GE InCell Analyzer/Developer Modules, image-based immunocytochemistry, ELISA, pharmacological data analysis in Prism and Spotfire, animal handling techniques including dosing and thoracotomy

Merck Research Laboratories West Point, PA
Bioinformatics Co-op, RNA Therapeutics April 2007 - September 2007

• Worked closely in team environment with biologists, mathematicians, and software engineers to support development of informatics software tools for visualizing large, complex data sets obtained from multiparameter phenotypic cellular imaging assays
• Assisted in development and evaluation of statistical and cluster-based automated data analysis, data mining and visualization tools
• Used these tools to generate signatures of cell response to chemical or siRNA perturbation and to compare drug mechanisms
• Participated in sterile cell culture of multiple cell lines
• Developed and optimized intracellular staining protocols, i.e., fluorescent dyes and antibodies
• Conducted experiments on intracellular trafficking, drug-induced apoptosis and kinetic studies of fluorescently labeled novel drug candidates
• Routinely imaged cell plates on a GE InCell 1000 automated microscope
• Developed and optimized analysis protocols using different approaches/algorithms in GE InCells Analyzer and Developer
• Experiments for detecting calibration issues in different lab equipment
• Completed projects include validation of a statistical data analysis tool, effective staining protocols for dyes and antibodies for studying drug uptake, analysis algorithms, characterization of fluorescence emitted by certain dyes, apoptotic effect of a compound used for evaluating cellular uptake of novel drug

HONORS
• Zung Pah Woo Biomedical Engineering Endowment (2009)
• University of Heidelberg Stipend (2009)
• Drexel University Dean’s Merit Scholarship (2005-present)
• Drexel University Honors Program (2005-present)

MEMBERSHIPS
• Active Subscription, Elsevier Cell
• Member, Biomedical Engineering Society Drexel University Chapter
• National Student Member, American Institute of Chemical Engineers
• Member, The Laboratory Robotics Interest Group Philadelphia Chapter
Neha Bailwal
63 Westminster Dr
Voorhees, NJ 08043
609-502-5003
neha.bailwal@drexel.edu

Education

Drexel University
Philadelphia, PA
Bachelor of Science in Biomedical Engineering
Anticipated Graduation - June 2010

Temple University
Philadelphia, PA
Pre-Pharmacy
August 2004 - May 2006

Honors and Awards

• Member of The National Society of Collegiate Scholars, September 2005 - Present
• Dean's List of Elite Students of the College of Science and Technology, Temple University, December 2005
• Dean's List of Elite Students of the College of Science and Technology, Temple University, May 2005

Related Coursework

Human Physiology Organic Chemistry Biomechanics Laboratory
Material Science Electrical Circuits Engineering Principles and Living System
Thermodynamics Cell and Genetics Biomedical Ethics and Law
AutoCad

Laboratory Skills

• Performed DNA fingerprinting which included micropipetting techniques, Polymerase Chain Reaction, and Agarose gel electrophoresis.
• Dissected chicken leg to study the biomechanical properties of femur, tibia, and cartilage using MTS Bionix.
• Dissected fetal pig, squid, sheep brain and liver to study the general anatomy.
• Prepared Calcium alginate beads to study the diffusion pattern and its load-bearing capacity.
• Performed Gas Chromatography of Gasoline, IR and NMR spectroscopy of compounds.

Computer Skills

• Software: Microsoft Office Suite, MATLAB, Maple, LabView, Autocad, InforSense
• Languages: Visual C++, SQL
• Misc: Web Designing

Employment Experience

GlaxoSmithKline
Collegeville, PA
Co-op/Molecular Discovery Research IT Chemistry Domain September 2008- March 2009

- Collaborated in creating business solutions and improvements using information technology
- Created business workflows using InforSense for Molecular Discovery Research

Hospitality Management, Drexel University Philadelphia, PA
Librarian September 2007- Present
• Worked as a solo librarian and administered library relocation.
• Cataloged and designed an online library database.
• Helped the Culinary School administration in student costing and budgeting.

Insurance Services Office Marlton, NJ
File Room Clerk May 2006 - August 2006
• Organized filing room alphabetically.
• Scanned and uploaded information on the company server for insurance purposes.
• Communicated with field representatives and organized updated survey reports.

Projects

• Biomechanics: Designed project proposals for testing biomechanical properties of chicken femur, tibia and cartilage.
• Body Synthetic: Volunteered to lead a team of five Engineering students for researching the 'Cardiac Patch' and designed a website for the project.
• Freshman Design: Collaborated and teamed up with four Engineering students to work on the Roomba module and the Freshman Design Project (Heat Stroke Monitor); and presented the Design Proposal.
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