ENGG4802 Thesis Project

Project Seminar

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Neural network model of rat whisker sensory system for texture recognition applications

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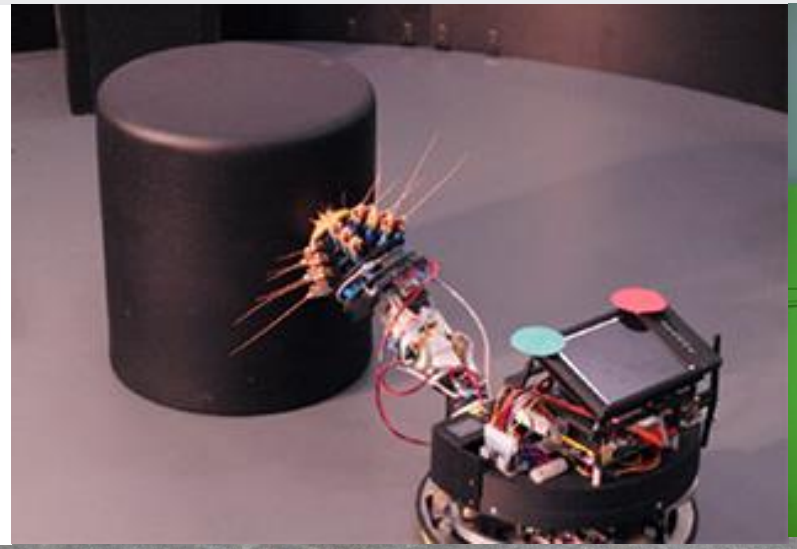
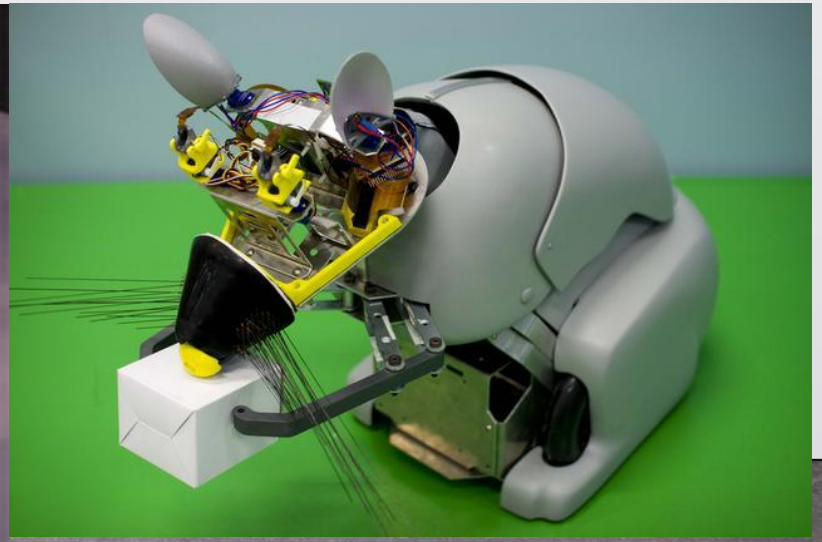
Problem definition

- Biomimetic robots simulating biological systems.
- Artificial whiskers that identify position, size and shape of objects.
- Navigation of robots such as iRat, Shrewbot, Psikharpax, etc.
- Little texture classification applications
- Improve robot navigation with extra knowledge of object characteristics.

[Source: Ball, et. al., 2010].



[Source: Ackerman, 2013].



[Source: Nguyen, 2018].

Scope

- Understand basics concepts of neuroscience behind whisker sensory system.
- Get data from artificial whiskers on different conditions.
  - Touch
  - Texture
- Visualize and process data on Matlab.
- Design neural network.

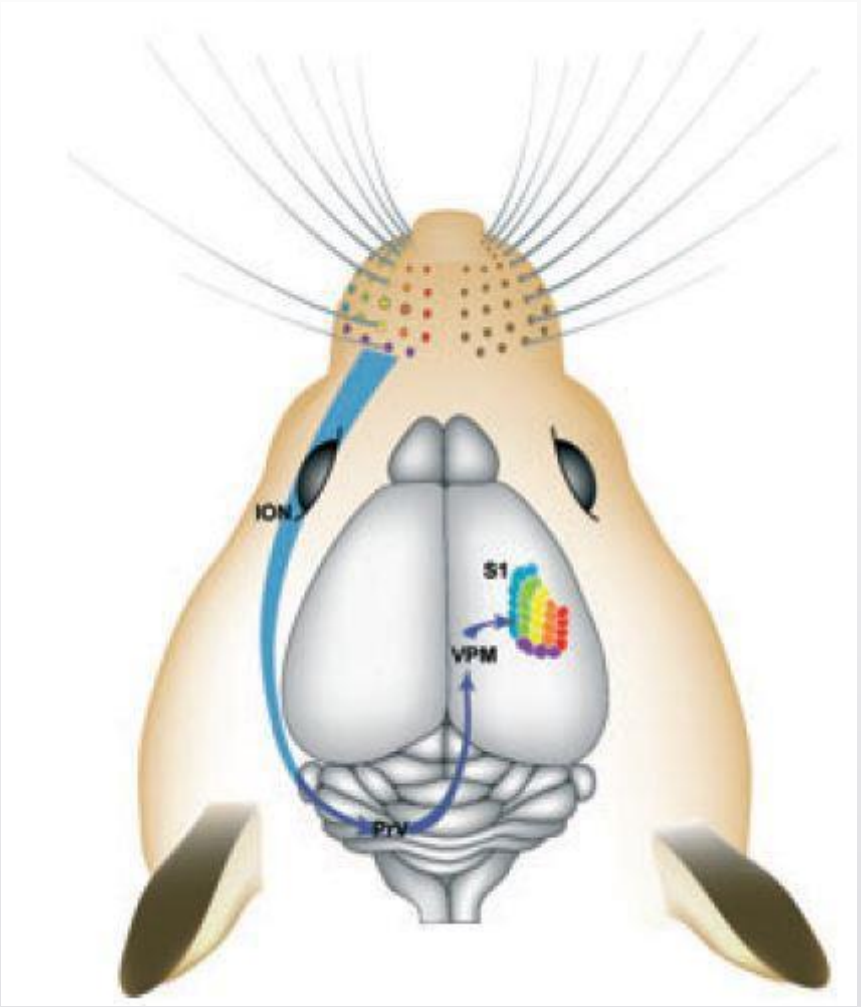
Project Objectives

- Implement biological algorithm on **biomimetic whiskers** for **texture** and **touch discrimination** using **neural networks.**

  - Can the neural network classify touch types?
  - Can the neural network classify touching or no touching?
  - Does the model correspond to a biological system?

Whisker/Brain system

- Whiskers arrangement map to the brain.
- Has 6 layers with different types of neurons.
- Each layer has its own function.



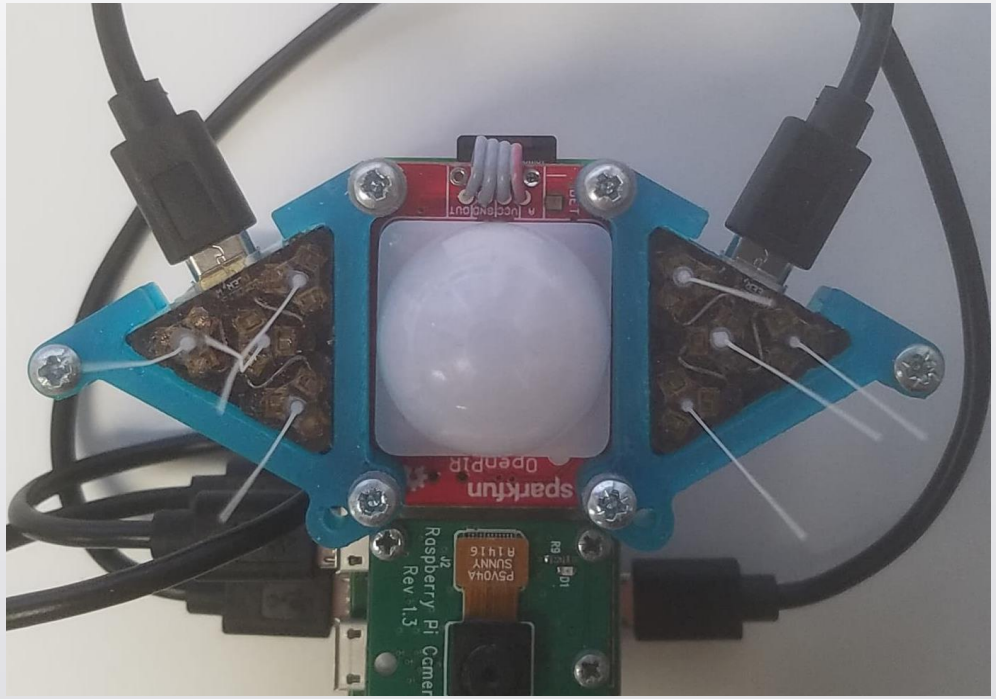
[Source: Wu, Ballesterd & Lu, 2011].

Texture Coding

- Measuring whisker vibration when whisking across surfaces:
  - Kinetic signatures (velocity profile)

Biomimetic whiskers

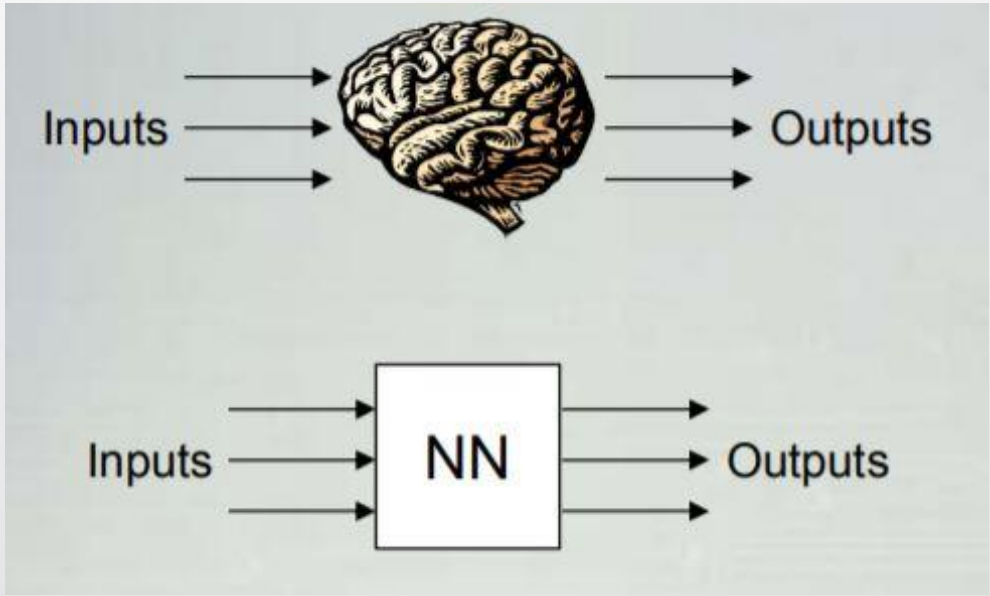
- iRat integration of artificial whiskers.
- Different sensors on the base of the whisker (made of different materials)
- Pressure sensors around ABS whisker arranged in triangular shape.



Designed by William Deer

Neural Networks

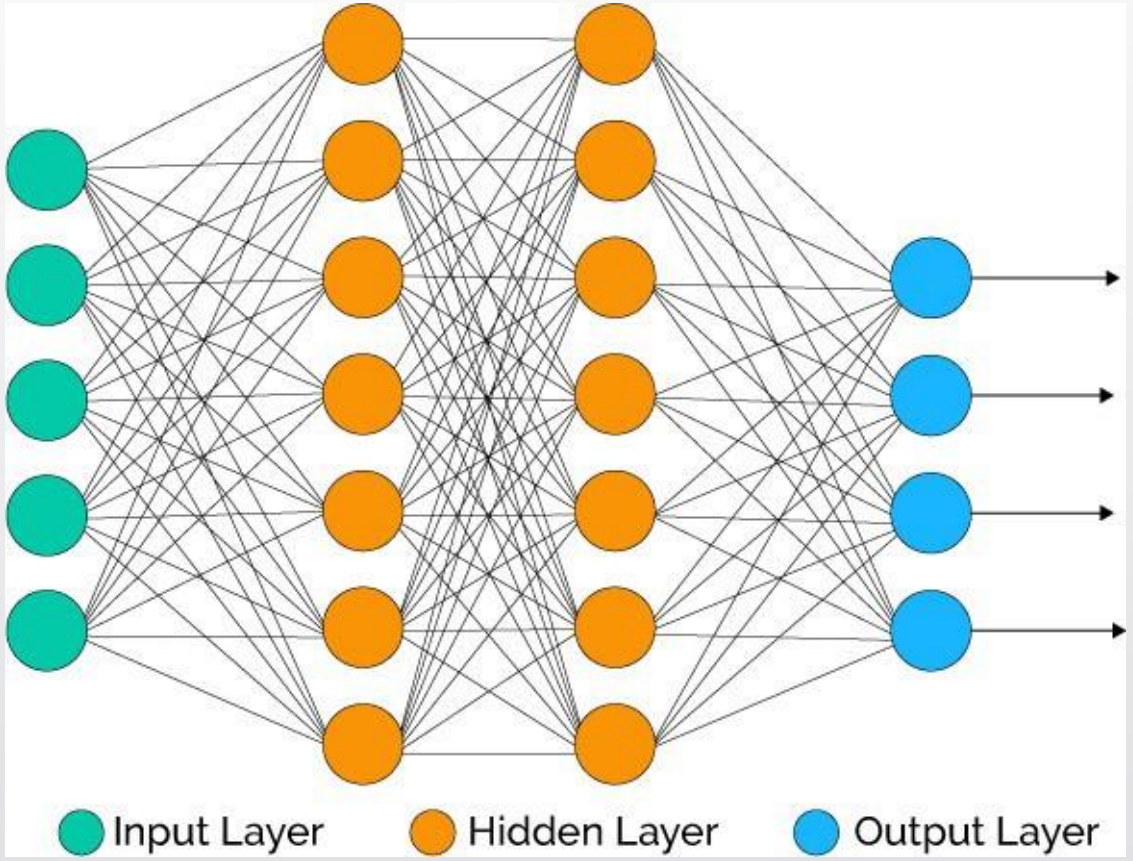
- Algorithms based on brain characteristics.
- Composed of many neurons.
- Identify patterns, using input, training data, targets, weights, etc
- Different networks: Feed-forward, MLP (multilayer perceptron), etc.



[Source: Cheung& Cannons, 2002].

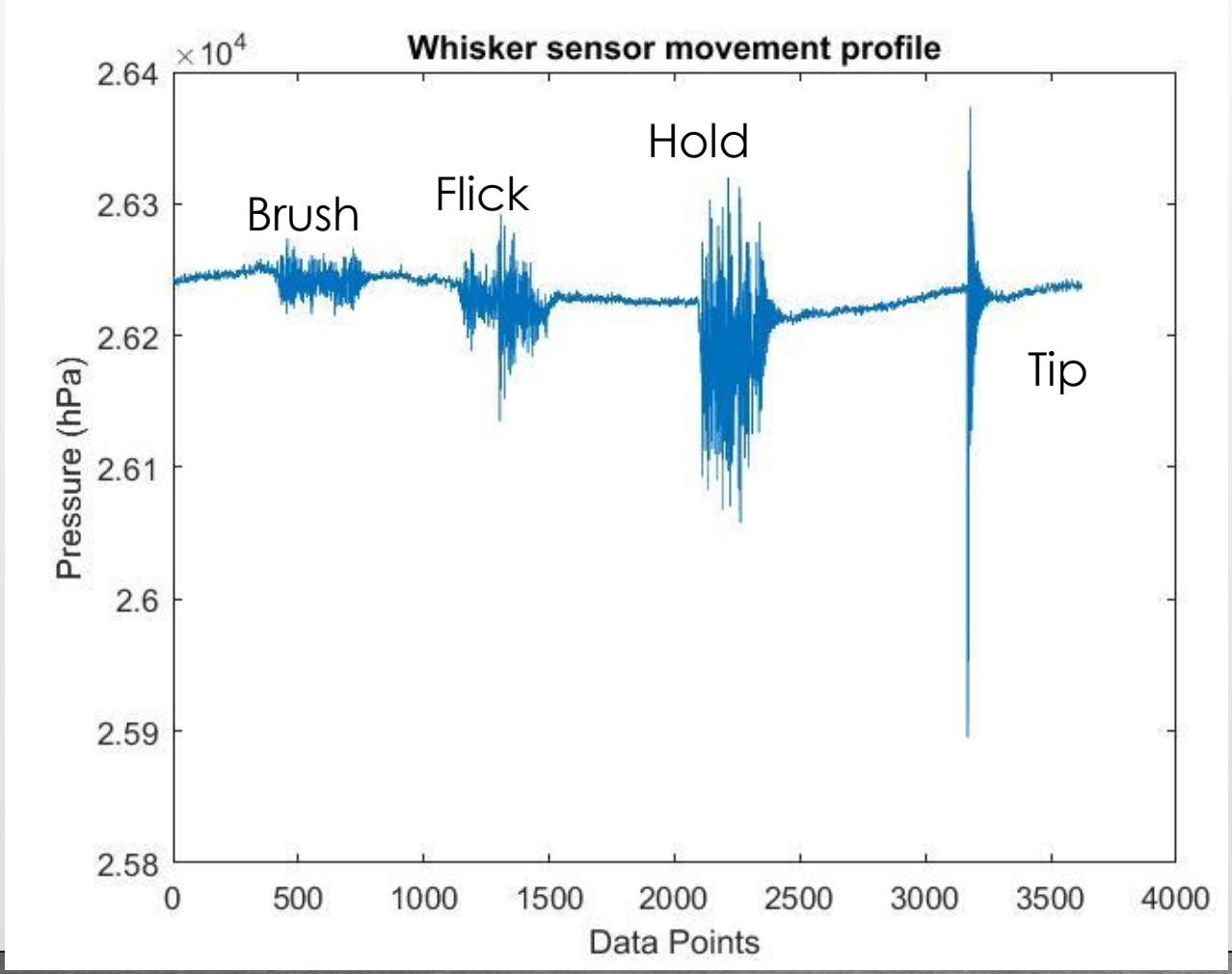
Neural Networks

- Activation functions.
- Backpropagation, gradient descent, Levenberg-Marquardt
- Ability to learn and generalize.



[Source: McDonald, 2017].

Initial work

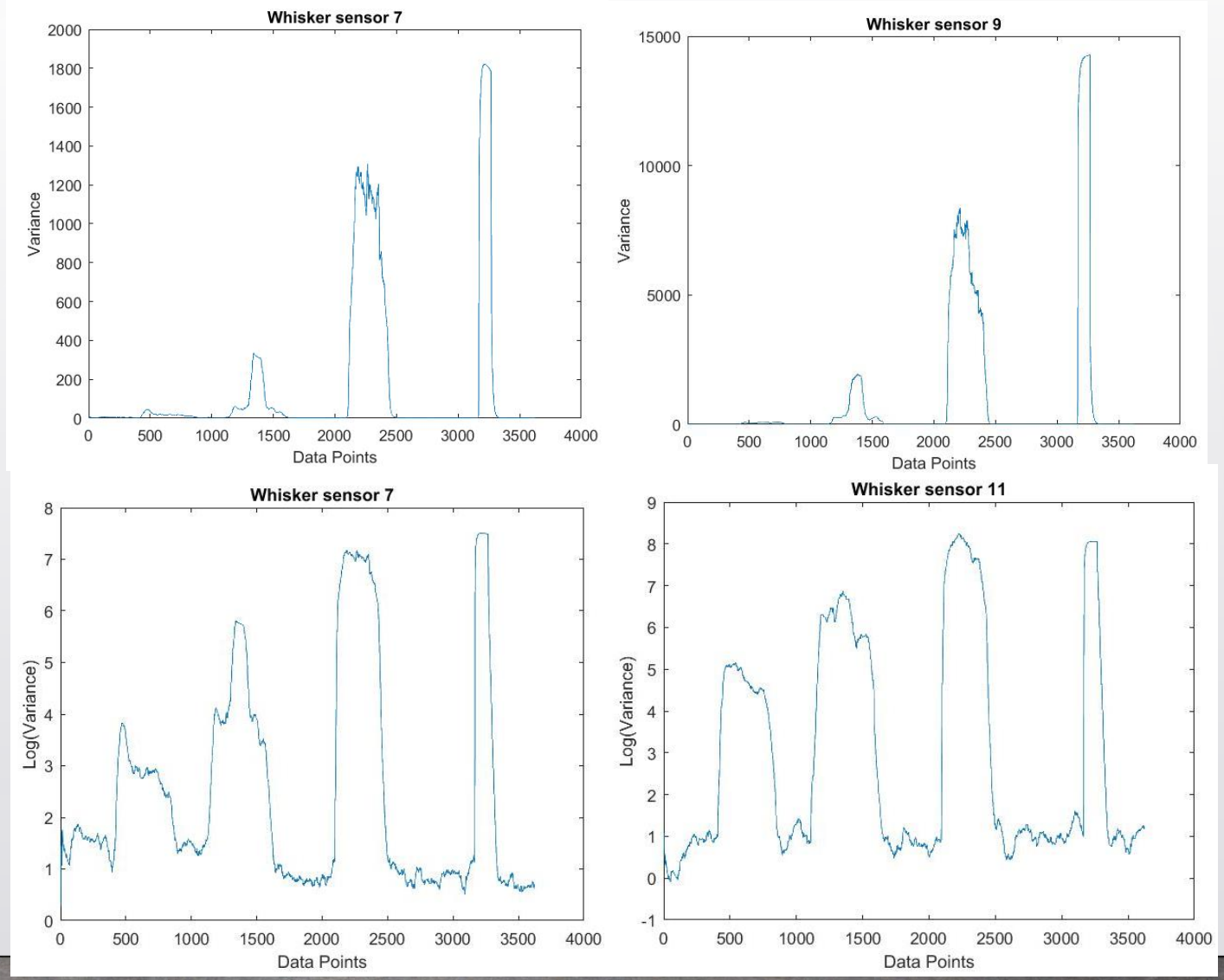


- Data from experiment on **4** different **whisker** movements (**3 sensors in each whisker**)
- Brush, Flick, Hold and Tip for 3624 points.
- Process data: moving average, variance, standard deviation, etc.
- Use threshold to clean data.

Experiment conducted by Jonathon Taufatofua

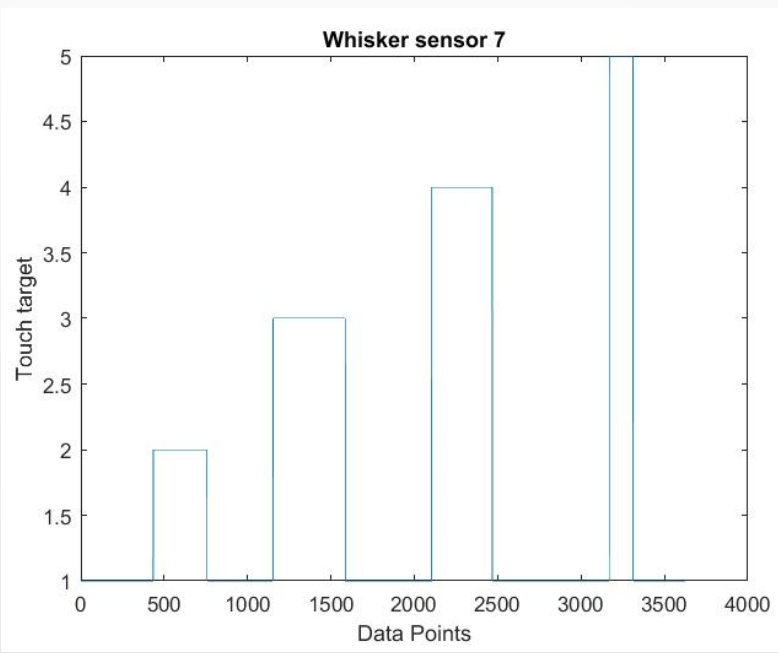
Processing data

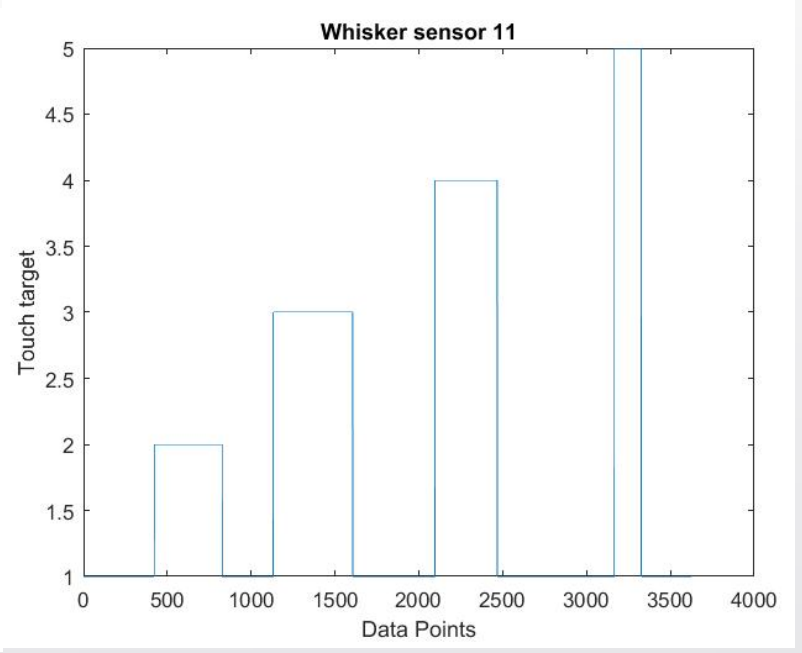
- Logarithmic variance.
- Threshold to clean data (if data less than zero, it would be recognized as if there is no signal).
- Get targets manually, 5 different outputs using a matrix of 5 x 3624.

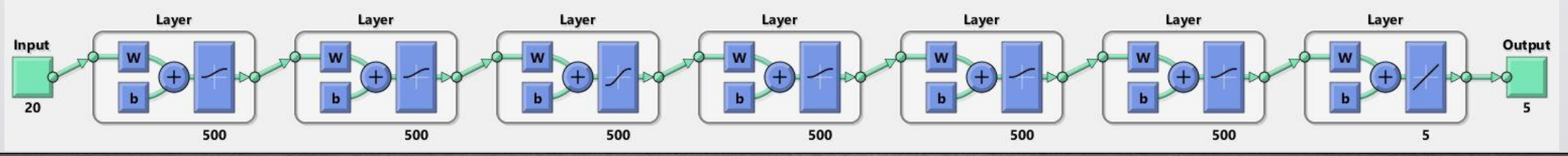


Processing data

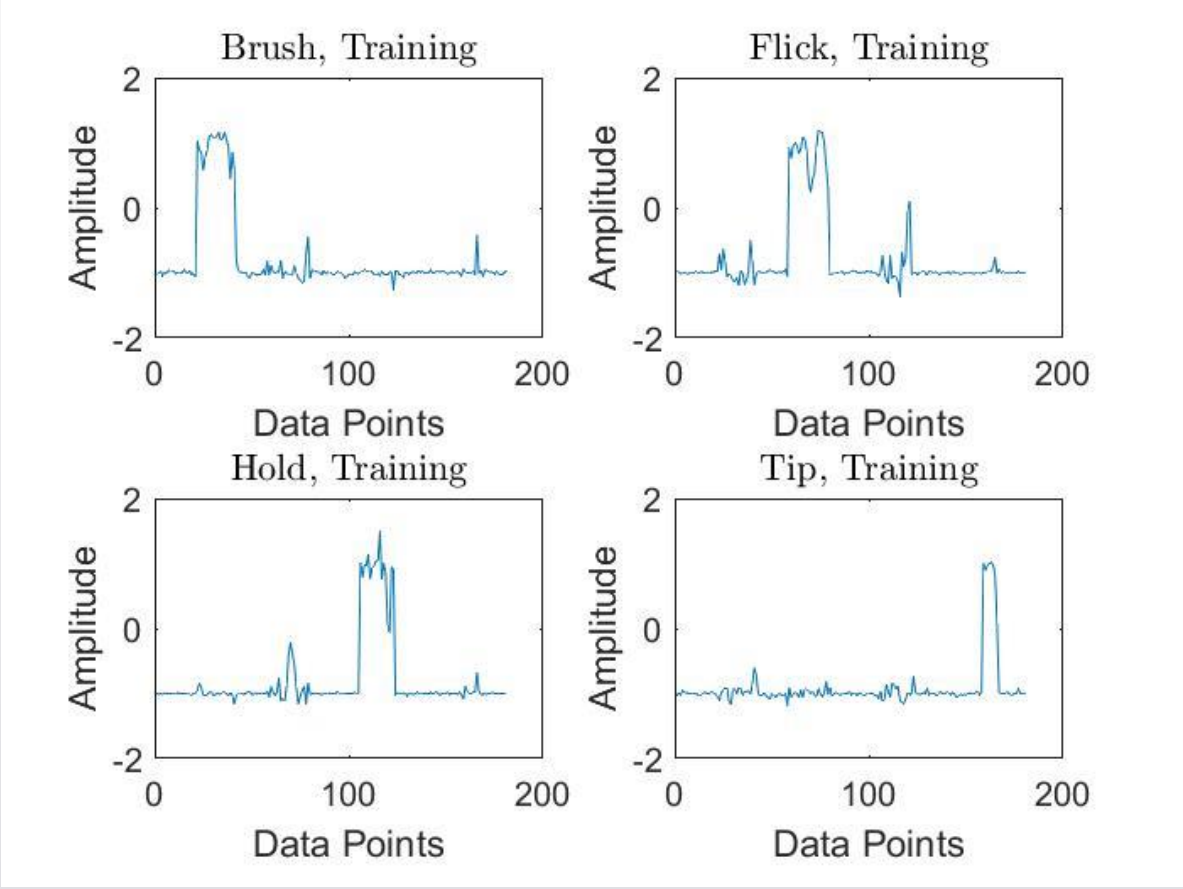
- Get training sets and testing data, for inputs and targets.
- Reshape inputs and targets vectors.
- Use of feedforward network.
- Training with Conjugate gradient with Polak-Ribiere.
- Performance: MSE



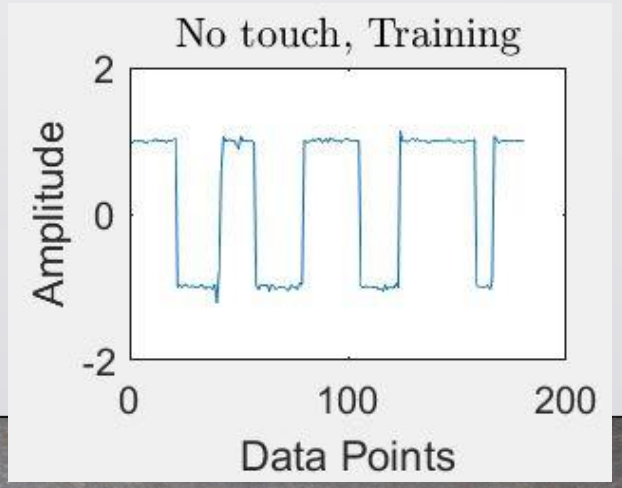




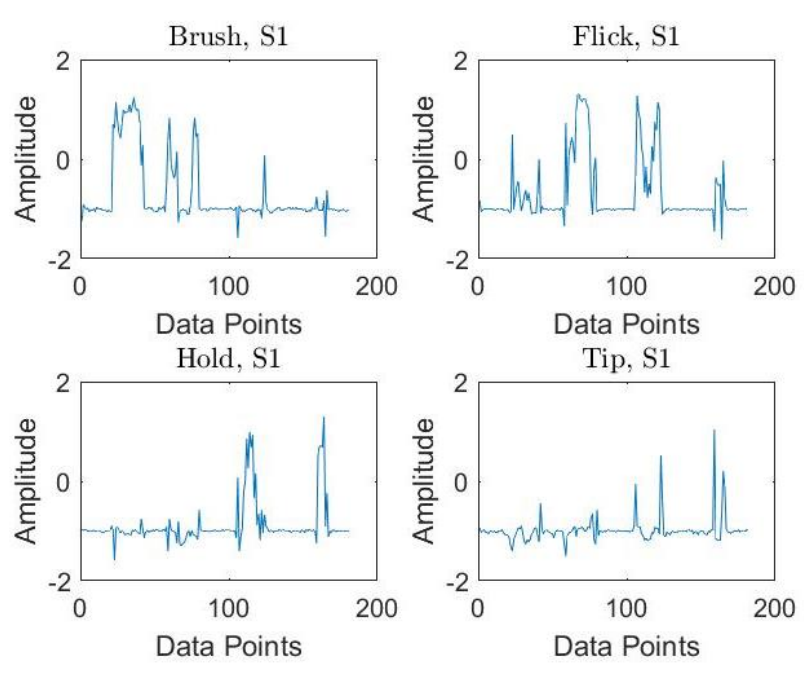
Training Neural Network



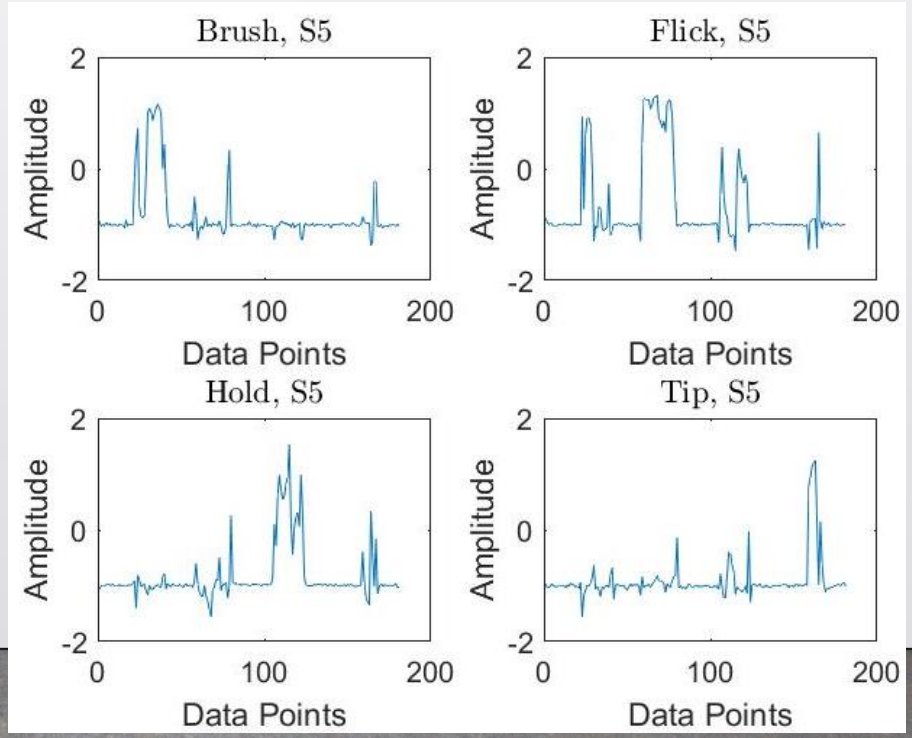
- Use of newff Matlab function.
- 7 Layers, transfer functions:
  - Tansig, logsig, purelin
- Run for 500 epochs.
- Train using input and target already processed.



Testing Neural network



- Touch type classification results, test with 12 sensors
- Spikes (filtering)
- Differentiate bigger (amplitude) spikes



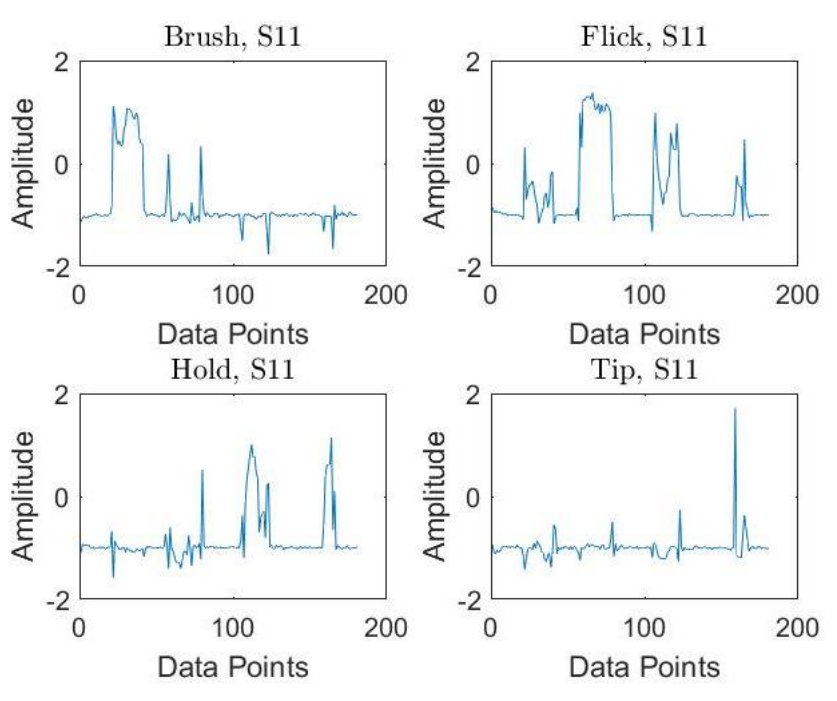
- Training set used from the input and target of one whisker

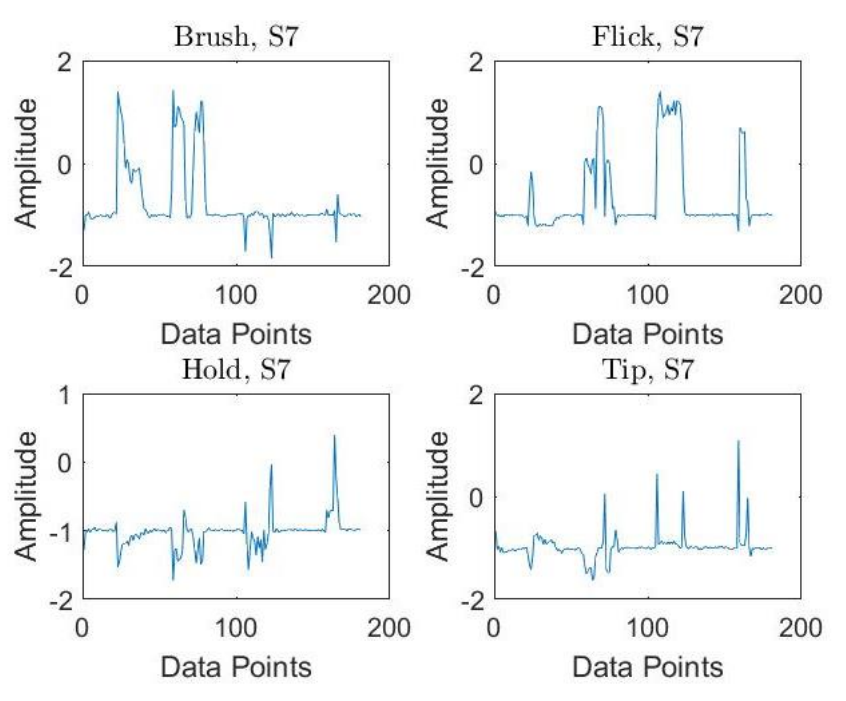
Neural network Performance

Sensor	Brush	Flick	Hold	Tip	Score	MSE
1	1	0	0	1	0.5	0.1828
2	1	1	1	1	1	0
3	1	0	0	1	0.5	0.3061
4	1	1	0	1	0.75	0.0919
5	1	1	1	1	1	0.0885
6	1	1	0	1	0.75	0.2403
7	1	0	0	1	0.5	0.3471
8	1	1	0	1	0.75	0.2079
9	1	1	1	1	1	0.1281
10	1	0	1	1	0.75	0.3299
11	1	1	1	1	1	0.1154
12	1	1	0	1	0.75	0.1200

- Training set can be changed into different windows or whisker sensors (total mean).
- Detect touch type, choose most useful (accurate).
- The final results can be averaged.

Future work





- Average final results: lose accuracy on sets that match the touch classification.
- Neural network for selecting best outcomes.
- Test with more sets of data.

Future work

- Design experiment for collecting whiskers data when touching textures
- Collect data from the experiment
- Process raw data according to neural network purposes
- Construct neural network that represents the sensory system of rats
- Validate results

Questions?