RET Project: Neural Signal Analysis for Implantable Electrode Arrays

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11th Grade Algebra

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NSF Award 1953745

https://sensip.engineering.asu.edu/ret/

Research Background

- Seizures are an unstable phenomenon
- Arrays implanted onto the brain's surface help identify responses
- Stimulation of a specific body part to monitor response
- Calculating resolution of array through peak interpolation
- Establishing a baseline to evaluate array effectiveness

- What does this mean for future research?
  - Determining reliability of sensor
  - Applying it to monitoring various activity in the brain
  - Monitoring the other electrodes of M^3 array

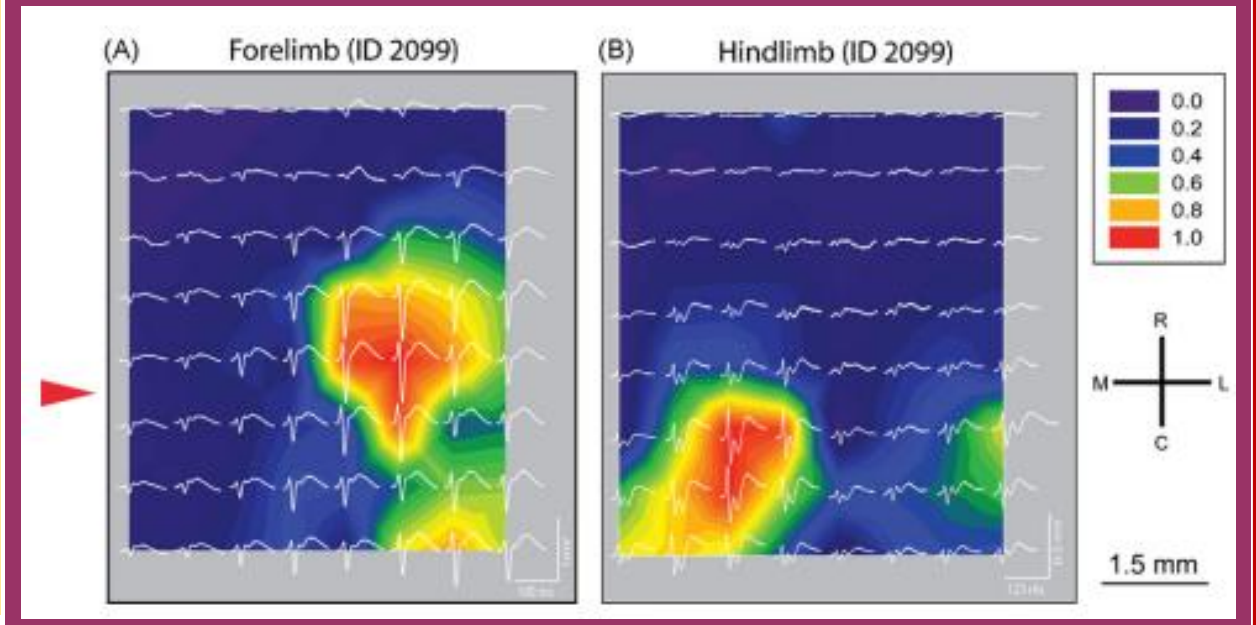


Fig. 1: An example somatosensory (stimulus) heatmap of the forelimb and hindlimb. From Journal of Neuroscience Methods (Jonas H., Volume 172, Issue 2, 30 July 2008, Pages 255-262)

Research Objectives

- Comparing two arrays: Neuro Nexus and M^3
- Objective(s):
  - Determine the peak of multiple cross sections
  - Fit a quadratic function to the cross sections
  - Calculate the full-width half-maximum of each quadratic
- Goal: Determining the resolution of each array

- Hypothesis: The M^3 array will be less accurate, because only the microelectrodes were monitored, not all three sizes

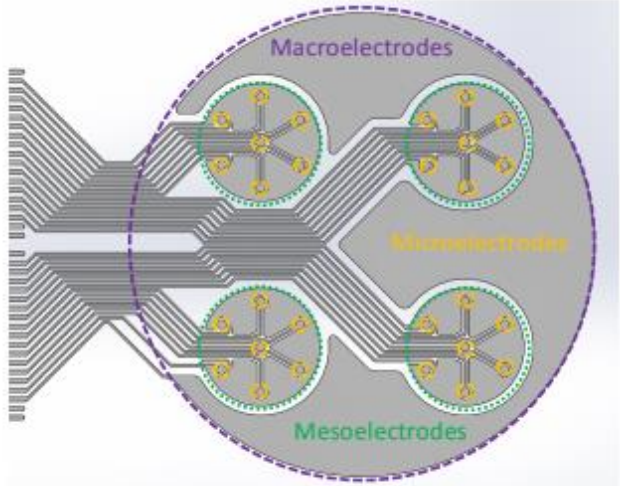


Fig. 2: An example layout of the M^3 array.

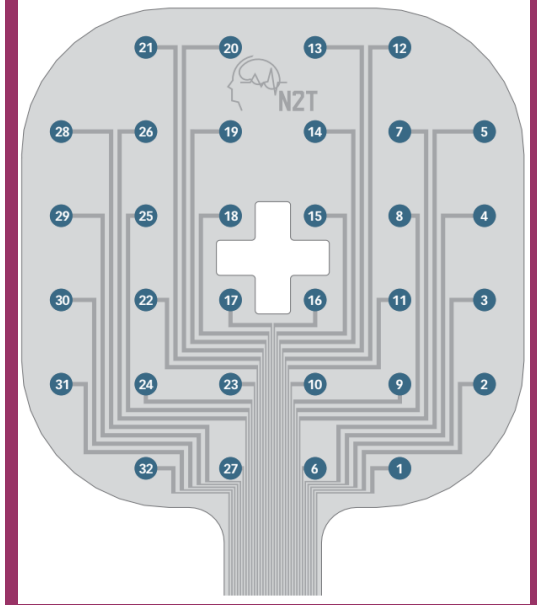


Fig. 3: The layout of the Neuro Nexus array

Research Results

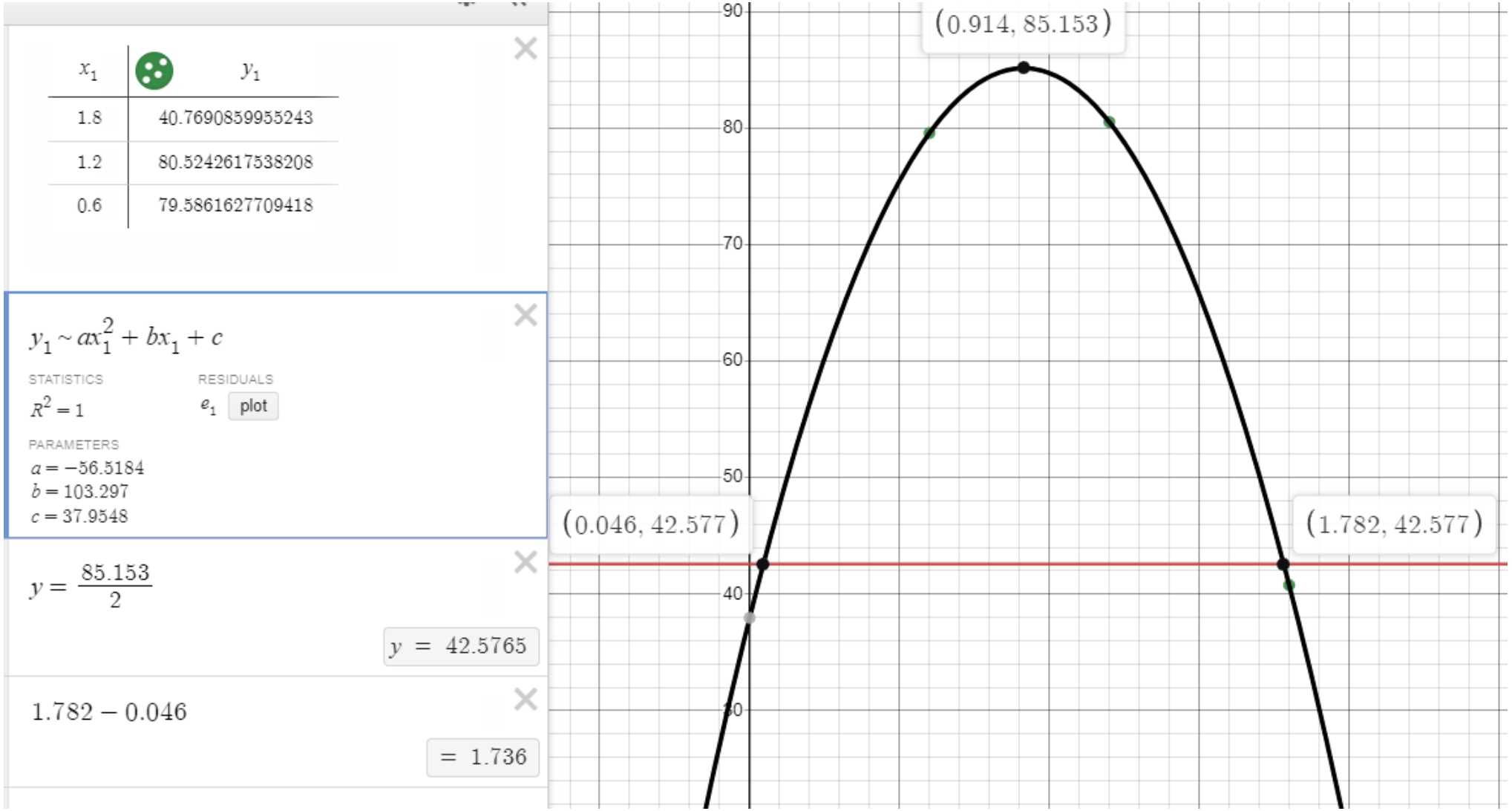


Fig. 6: The y cross-section peak interpolation of the Neuro Nexus array.

Research Results

- What was discovered?
  - Microelectrodes in M^3 array were damaged
  - Peak interpolation for the M^3 x cross-section is not accurate
  - FWHM Results
    - NNx x-section: 1.445
    - NNx y-section: 1.736
    - M^3 x-section: 1.233
    - M^3 y-section: 1.344

- Real-World Application
  - Peak interpolation and full-width half-maximum determine resolution of image
  - Monitoring seizure activity

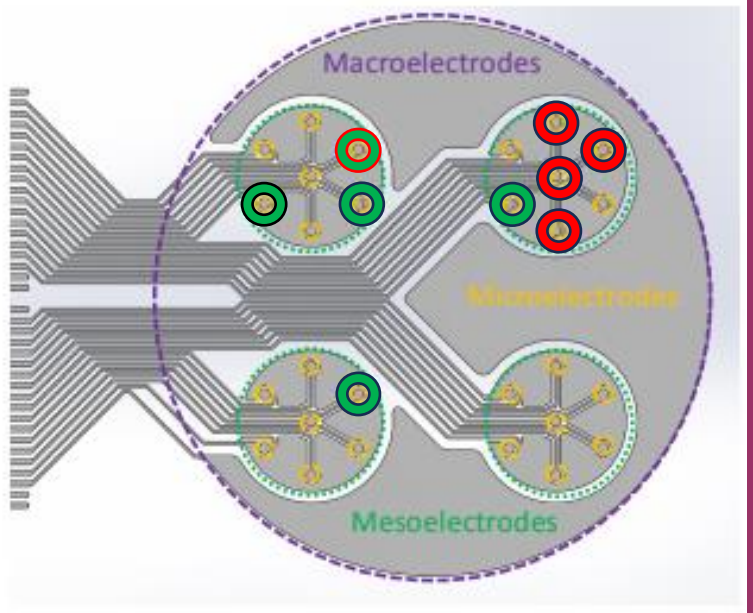


Fig. 4: The damaged areas (red) and areas used for peak interpolation (green) of the M^3 array.

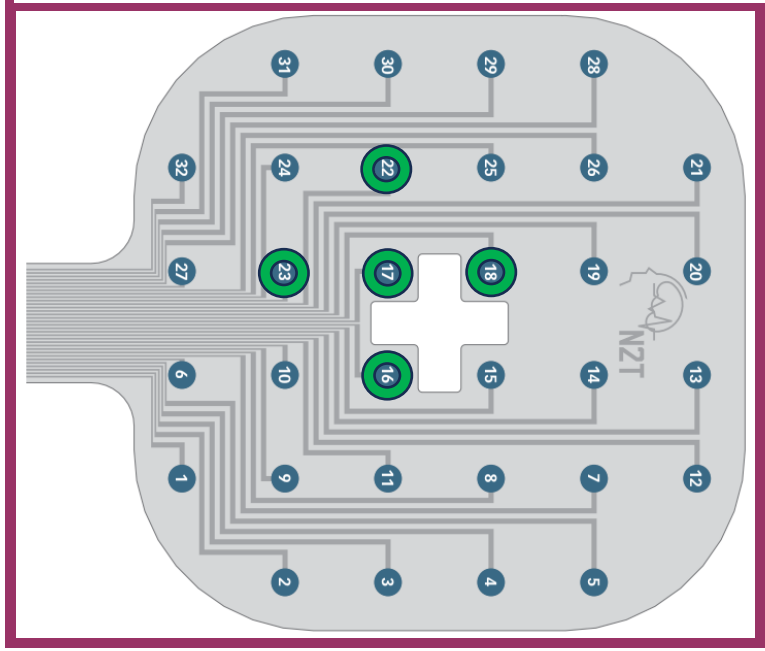


Fig. 5: The location of peak stimulation on the Neuro Nexus array.

Lesson Description

- ❑ What will the learning look like?
  - ❑ Guided Desmos Activity
  - ❑ Activity: TENS Stimulation
    - ❑ Goal: Recreate stimulation used in the research
    - ❑ Create a matrix from data to do peak interpolation
- ❑ Learning Outcomes
  - ❑ Fitting a quadratic to non-key points
  - ❑ Creating and using a matrix for peak interpolation
  - ❑ Learn a new key feature of functions with FWHM
- ❑ Assessments
  - ❑ Informal checks throughout the lesson
  - ❑ Exit Ticket Discussion
  - ❑ Independent Practice

Fig. 6: The layout to create the peak matrix

Lesson Objectives

- Objective(s):
  - Determine the peak of a stimulus matrix and it's surrounding cross-sections.
  - Synthesize a quadratic function that fits the three points in a cross-section
  - Analyze the peak of the quadratic synthesized
  - Determine the full-width half-maximum of a quadratic function

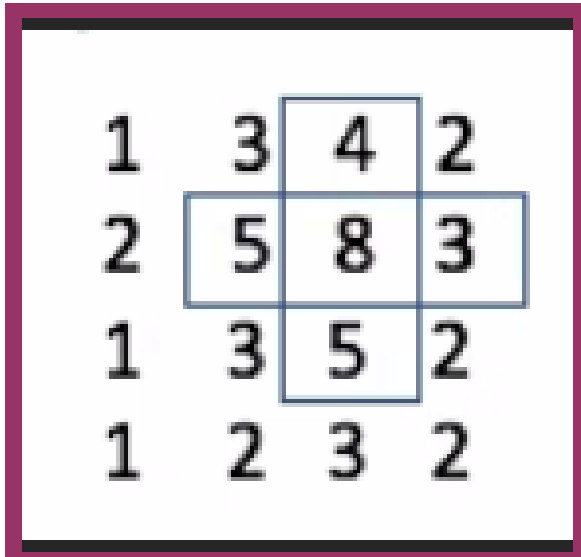


Fig. 7: An example matrix to determine the peak

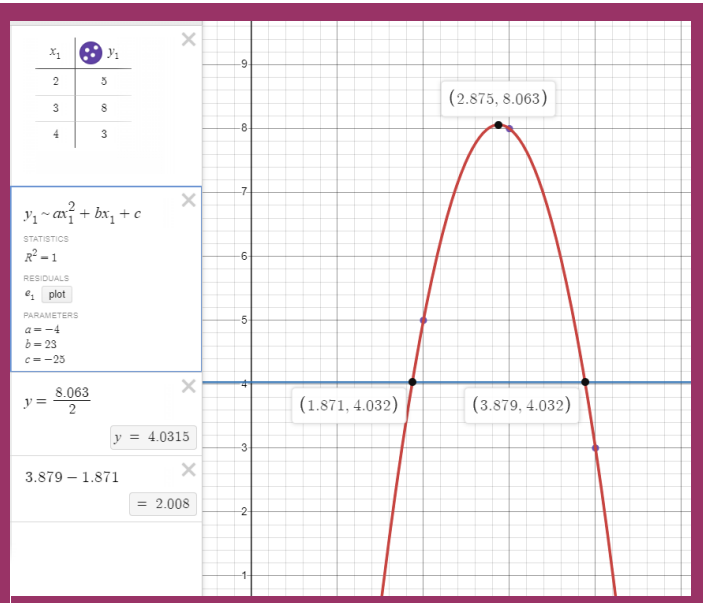


Fig. 8: x cross-section peak interpolation

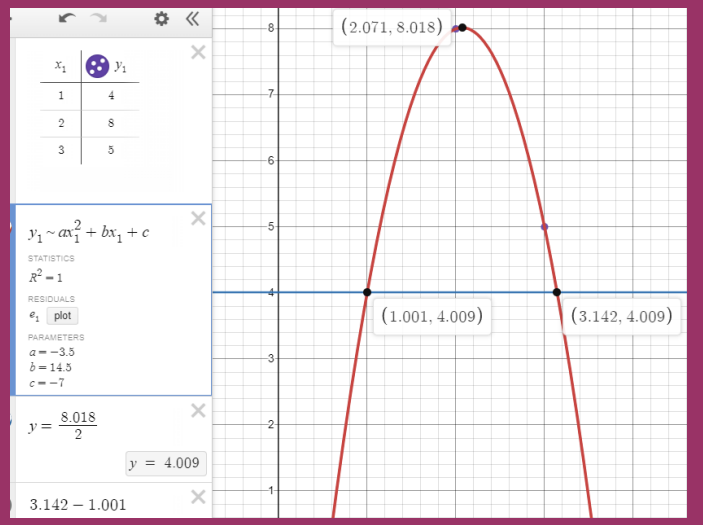
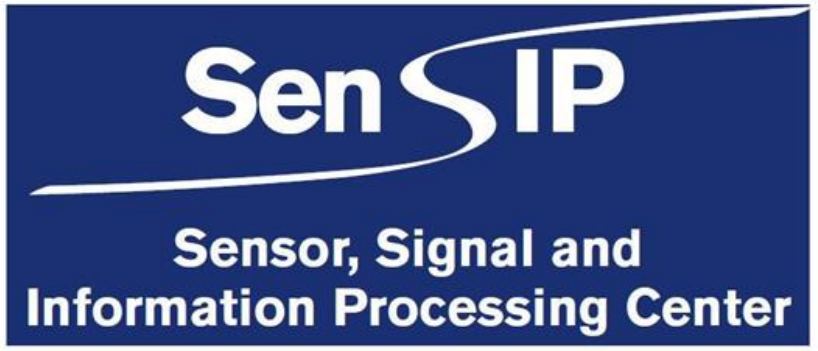


Fig. 9: y cross-section peak interpolation

Concluding Remarks

- Key outcomes
  - New key feature to measure functions
  - New way to apply quadratics to the real world
  - Experimented with Brainstorm in MATLAB
- Transition to the classroom
  - Finding a group of students to teach the lesson to
  - Gathering TENS Units
  - Refining the Desmos activity to make it more interactive
  - Continue refining the activity so it's straightforward and easy to follow

- Self-Assessment/New Skills
  - Has sparked in interest in seizure activity
  - Want to learn more about how the brain works
  - Learned to do proper research
  - Presented—informally and formally
  - Took research and created a lesson



Thank you!
Questions?

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References

J. Hosp, K. Molina-Luna, B. Hertler, C. Atiemo, A. Stett, and A. Luft, "Thin-film epidural microelectrode arrays for somatosensory and motor cortex mapping in rat," Journal of Neuroscience Methods, vol. 172, pp. 255-262, May 2008. doi: 10.1016/j.jneumeth.2008.05.010.

H. Yeh, J.V. Garich, I.R. Akamine, J.M. Blain-Christen, and S.A. Hara, "Laser Micromachining of Thin-Film Polyimide Microelectrode Arrays: Alternative Processes to Photolithography," in Proceedings of the 2020 Design of Medical Devices Conference, Minneapolis, Minnesota, USA, April 6–9, 2020, paper V001T04A002, ASME, doi: 10.1115/DMD2020-9057.

“ECOG Surface Grids.” NeuroNexus, www.neuronexus.com/products/electrode-arrays/ecog-surface-grids/. (June 15, 2023)