Instructional Lesson Plan

Peak Interpolation With Quadratics

Shanley Valdes Romero, Andreas Spanias, Jennifer Blain Christen, Daniel Gulick, Ian Akamine

LESSON DETAILS

Subject Area(s): Mathematics (Algebra)

Focus Grade Level: 11th

Grade Level Range: 9th-14th

RESEARCH

Seizures are an anomaly that neurologists are still actively studying to this day. With the use of arrays implanted directly onto the surface of the brain, we are able to see where the responses are coming during seizures. However, with seizures being difficult to replicate multiple times, there needs to be a baseline to determine how effective any array is when monitoring responses. This is where we turn to stimulating a particular part of the body, and monitoring the response that we get. But doing this repeatedly, we are able to determine how consistent our array is, and then calculate the resolution of the image (array?) by using peak interpolation, or matching a quadratic curve to where the peak stimulation is occurring.

LESSON SUMMARY

Normally, students use quadratics to model bridges and throwing objects. However, in this lesson, they learn a whole new way to use quadratics in the real-world! By using a TENS unit to monitor stimulus activity in the forearm, they can find where the peak is occurring, and create a quadratic function to match the peak and its surrounding points. The point of doing this is also to allow the students to see a new feature to determine resolution: full-width half-maximum.

MATERIALS AND EQUIPMENT

- TENS Units (enough for groups)
- A device to monitor g-force acceleration (accelerometer)
- Graphing calculator
- Tape or pens

ATTACHMENTS

EDUCATIONAL STANDARDS

K-12 TEACHERS

NGSS Standards

- **HS-PS4-1.** Use mathematical representations to support a claim regarding relationships among frequency, wavelength, and speed of waves traveling in various media.
    - **Reasoning:** We're creating relationships between the heatmap and the signal to create a quadratic function.
- **HS-PS4-5.** Communicate technical information about how some technological devices use the principle of wave behavior and wave interactions with matter to transmit and capture information and energy.
    - **Reasoning:** Capturing signals and converting to heatmap—also used to store information and energy while researching stimulus and seizures.

AZ Standards

- **A2-N-Q.A.1—**Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays; include utilizing real-world context.
    - **Reasoning:** Interpreting the data displays (heatmaps, matrices, etc.) in terms of the stimulus.
- **A2.A-CED.A.1—**Create equations and inequalities in one variable and use them to solve problems. Include problem-solving opportunities utilizing real-word context.

  Focus on equations and inequalities arise from linear, quadratic, rational, and exponential functions.

    - **Reasoning:** This is where fitting the quadratic curve at the peak interpolation happens.
- **A2.F-IF.B.4—**For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms o the quantities, and sketch graphs showing key features given a verbal description of the relationship. Include problem-solving opportunities utilizing a real-world context. Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.

  Functions include linear, quadratic, exponential, polynomial, logarithmic, rational, sine, cosine, tangent, square root, cube root, and piecewise-defined functions.

    - **Reasoning:** This is where finding the FWHM is determined by using the minimums (sometimes zeros/intercepts) and the maximum.

LEARNING OBJECTIVES

SWBAT…

- 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

VOCABULARY	
vocab word/phrase (lower case)	*Definition punctuated like a complete sentence even if it's only a phrase.*
quadratic	A quadratic function is a function whose rate increases linearly. The graph is shaped as a parabola, which looks like a bowl.
peak interpolation	Peak interpolation is the process of using available points on a graph to create a quadratic function that estimates the maximum of the data set.
matrix	A matrix is a rectangular array, or a table of numbers, organized in rows and columns.
full-width, half-maximum	The full-width half-maximum is the width (or distance) of a parabola at exactly half of what the maximum point is.

LESSON PROCEDURE

INTRODUCTION/MOTIVATION

Via Padlet?

Discussion Question (5 minutes): **Where have you seen quadratics in the real world? Find 2 common ways and 1 way you haven't heard of before.**

LEARNING ACTIVITIES/STRATEGIES

Activity: TENS Stimulation (Groups of 4)

Set-Up

- Place the black electrode on the palm of the subject
- Tape out a "tic-tac-toe" grid on the forearm to indicate the areas where the red electrode will go
- Place the red electrode on the center of the grid
- Place the accelerometer in the subject's hand

Recording Data

- Turn the TENS on to 3
- Record the maximum g-force recorded on the accelerometer
- Repeat 4 more times in that section
- Take the average of all 5 attempts
- Rinse and repeat in the other 8 areas of the grid

Peak Interpolation

- Determine the peak are of stimulation
- Take the points to the left and right of the peak (this creates the x cross-section)
- Use those three points to create a quadratic function that passes through all 3 points
- Repeat using the peak and the points above and below the peak (this creates the y cross-section)

Full Width Half-Maximum

- From the x cross-section:
    - Determine the maximum (vertex) of the quadratic
    - Divide the maximum in half (this creates the half-maximum)
    - Determine the two coordinates that give the output of *exactly* the half-maximum
    - Calculate the distance between the two coordinates
- Repeat for the y cross-sections quadratic

CLOSURE

Discussion Question: How could doing the peak interpolation of a quadratic help in the medical field?

Discussion Question: What do you think could be wrong with your experiment if the quadratic you create gives you a minimum instead of a maximum?

ASSESSMENT

FORMATIVE ASSESSMENT

Discussion: Do you think you could still do full-width half-maximum if the quadratic you create gives a minimum? Why or why not?

SUMMATIVE ASSESSMENT

Exit Ticket: One matrix; determine the peak and full-width half-maximum of the x- and y-section

CONTRIBUTORS

INDIVIDUALS

List the names of any person who participated in the development of this instructional unit (teachers, mentor, lab director, education staff, etc.).

- Daniel Gulick
- Ian Akamine

REFERENCES

List citation information for any graphics or copyright material used in the development of this lesson.

SUPPORTING PROGRAM

RET Site: Sensor, Signal and Information Processing Algorithms and Software
Sensor, Signal and Information Processing Center (SenSIP), in partnership with Arizona State University and the National Science Foundation.

FUNDING ACKNOWLEDGEMENTS

This project is funded by the National Science Foundation (NSF) Award 1953745. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the author(s) and do not necessarily reflect those of the NSF.