Sensing Symmetries

Interactive, computer-generated patterns based on environmental data

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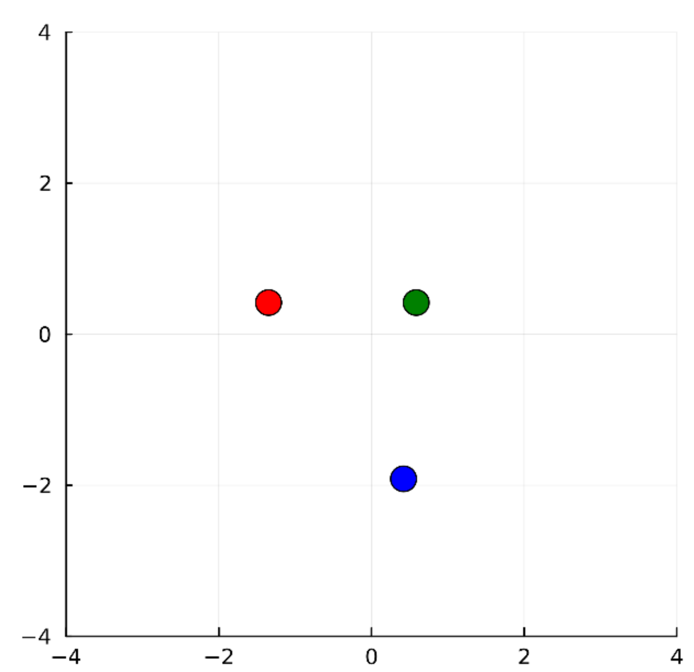
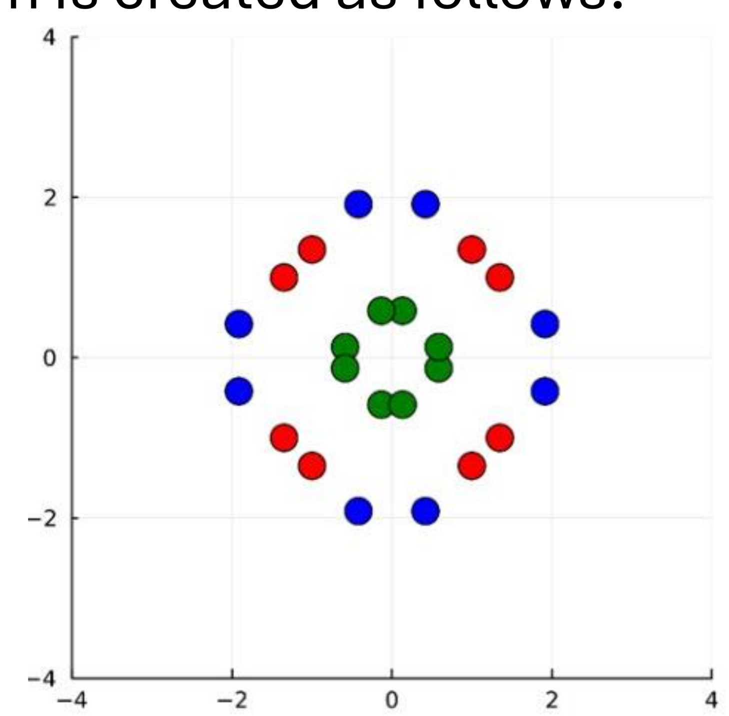
Introduction

This project explores how mathematical patterns can be used to create responsive visual art. By combining environmental sensors, an Arduino, and a Raspberry Pi, we collected real-time data and converted it into a continuously changing, unique animation. Our goal was to create an interactive display that responds to its environment and encourages viewer engagement through the visual representation of data.

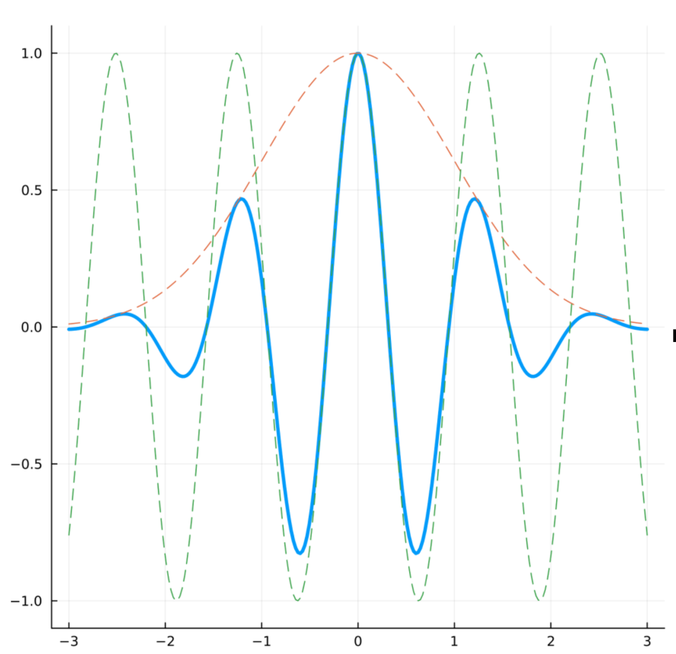
Patterns from Math

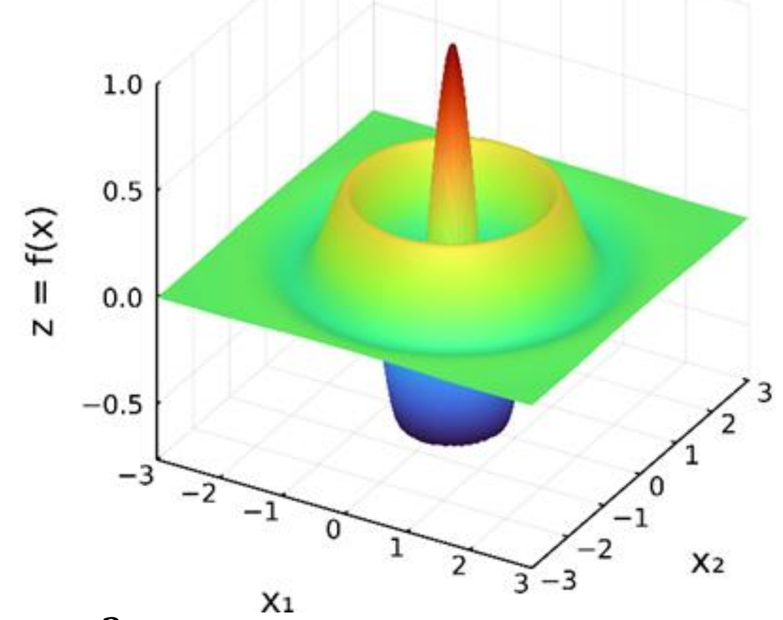
The final product of this project is the animation of randomly generated patterns. Each pattern is created as follows:





First, we pick N random points. A rotation matrix based on the symmetries of a regular polygon is then used to copy and rotate the random points, adding uniformity to the image.



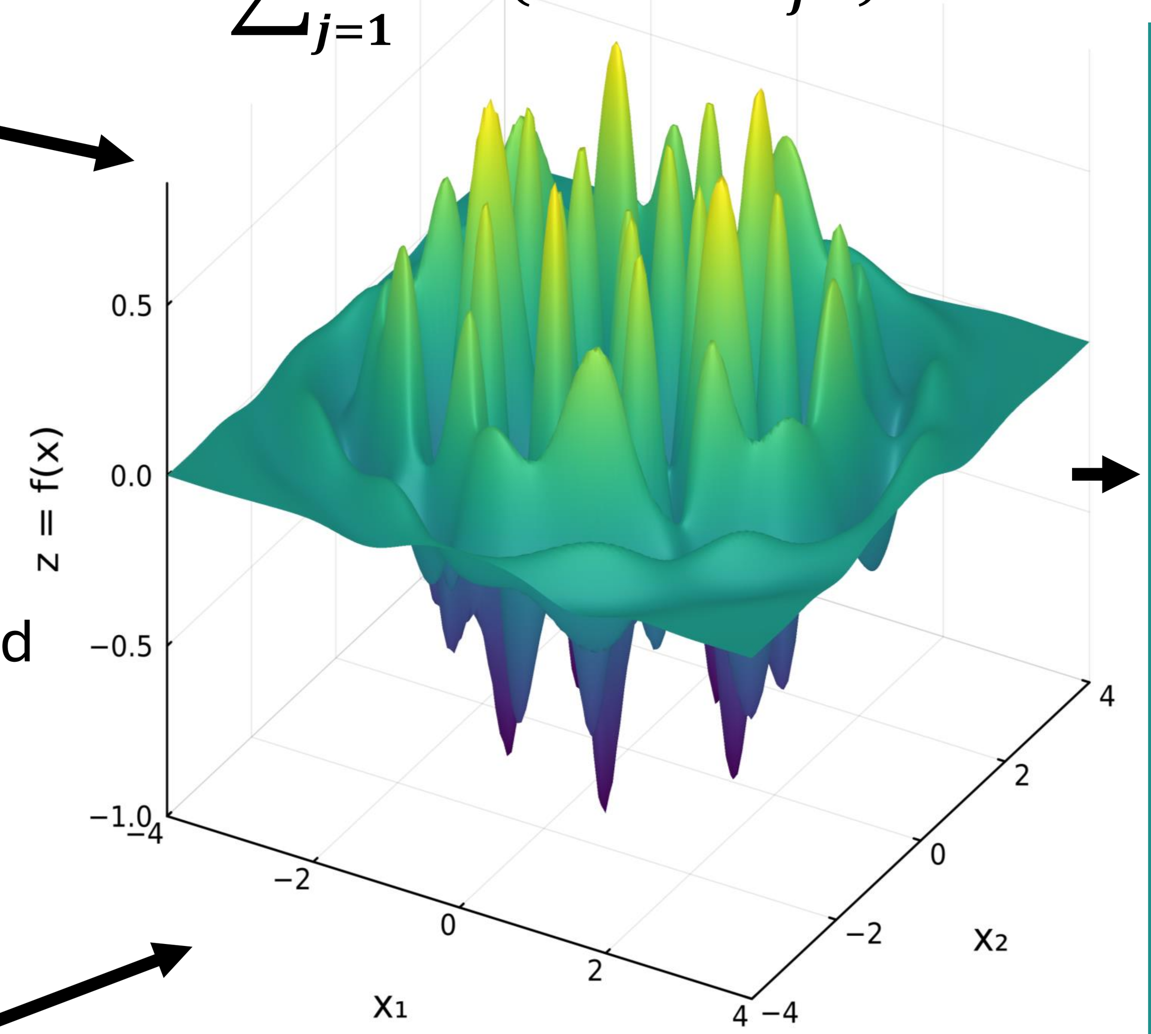


The graph of $f(x) = cos(kx)e^{-ax^2}$ is rotated about the z-axis to create a 3-dimensional graph. k is the frequency of oscillation and a is the scale of the Gaussian distribution. To the right is the plot of the associated level curves which create a color map.

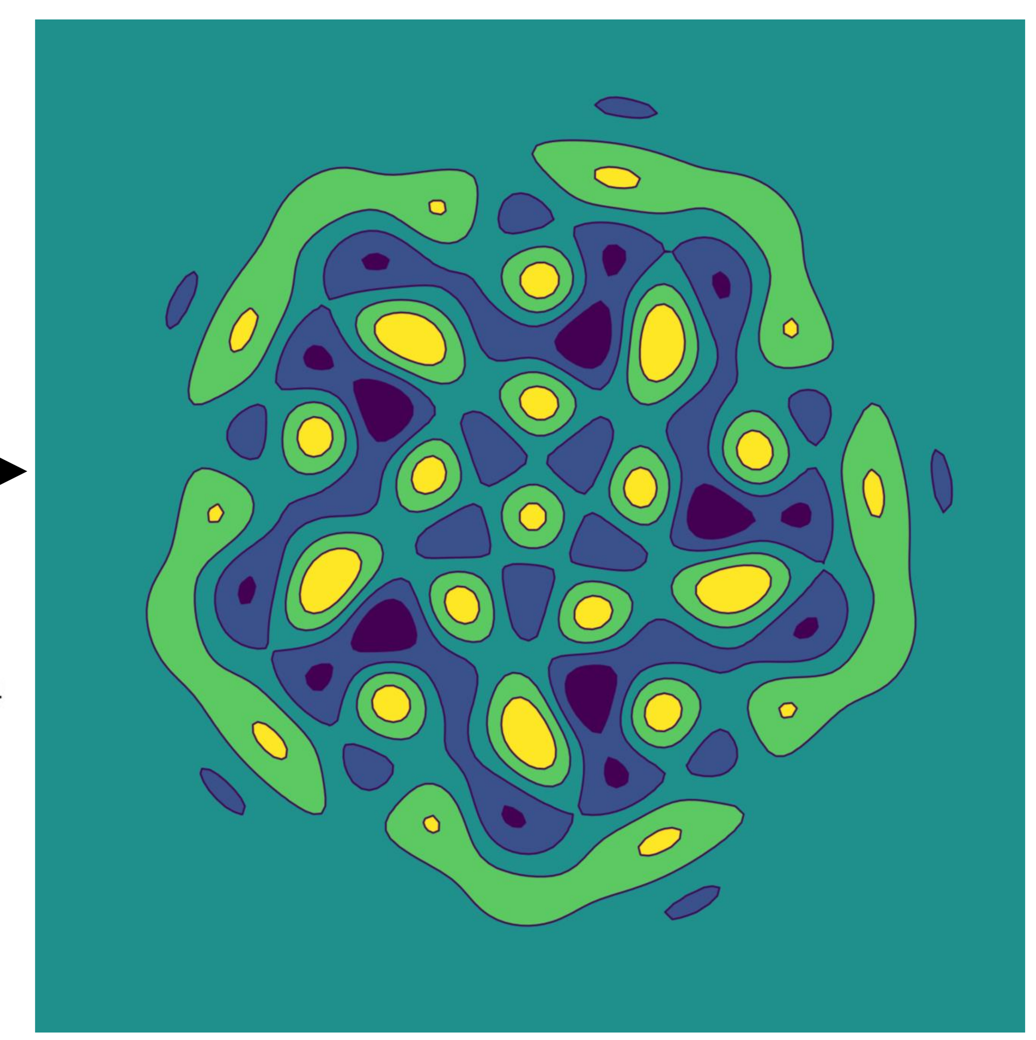
Sensor Data

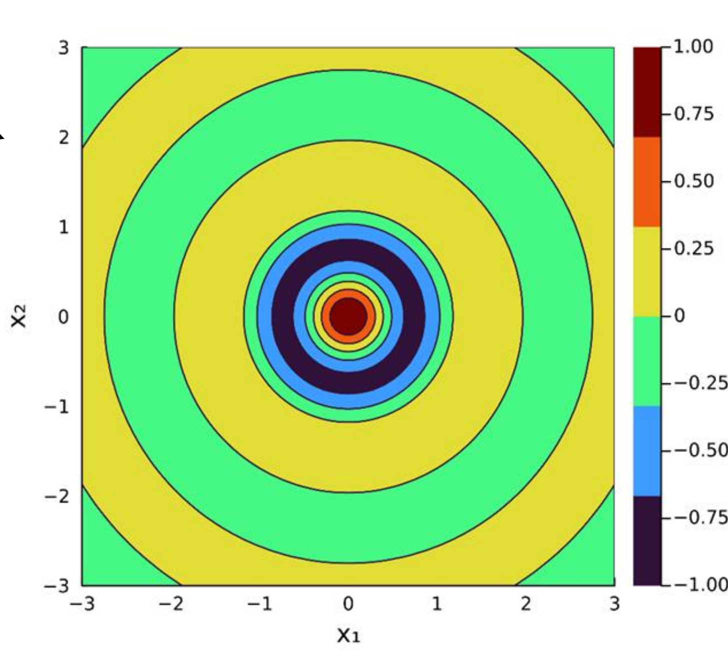
Sensor	What it Changes	How it Changes
BH1750: Light	The saturation of the colors and scale of ripples (a, k)	Increased light level saturates the image and makes the ripples faster
SCD-40: CO_2 and Temperature	The color gradient	As the ambient CO_2 and temperature increase, the hue becomes more red
SHT30: Humidity	Rotation rate, ω	As the humidity increases, the graph rotates faster

$$z = \sum_{j=1}^{n} cos(k \parallel x - X_j \parallel) e^{-a\|x-X_j\|^2}$$



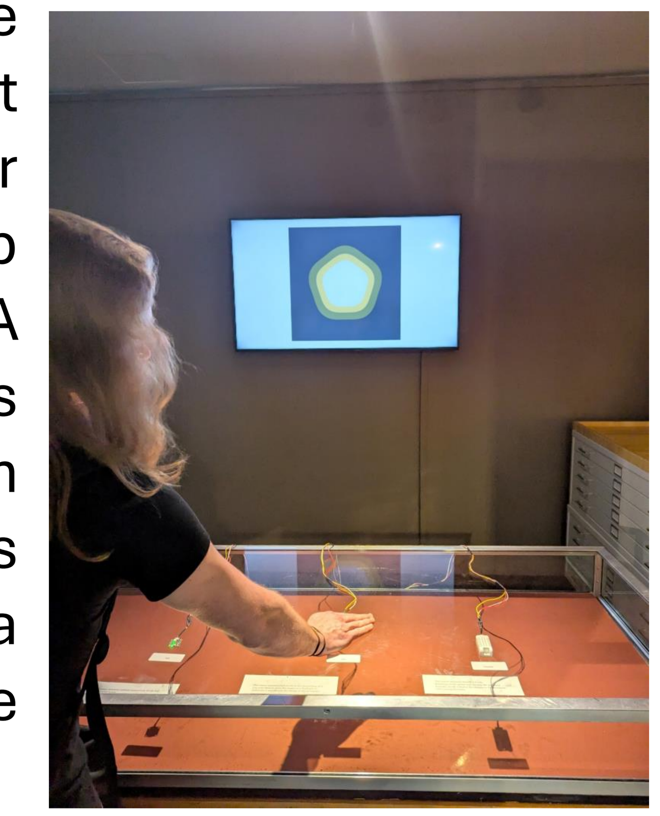
One frame from the animation.





Gaussian distributions are superimposed at each of the generated random points, creating a more complex graph with multiple peaks and troughs. The final pattern is the colored contour map of the superposition. Once the pattern is animated, 2 new variables can be manipulated: the rotation rate, ω, and the color map.

Implementation at PCAC



As part of this project, we had the pleasure of presenting our art at the Paul Creative Arts Center (PCAC) Gallery of Art with the help of Professor Benjamin Cariens. A prototype of the project was implemented at the PCAC from March 28 to April 11. The sensors were placed on a table in front of a monitor, which displayed the pattern. The three sensors were connected to an Arduino, which transmitted the collected data to a Raspberry Pi. Code running on the Raspberry Pi modified the animation in real time, allowing viewers to engage with the exhibit. Directions instructed viewers on how to effectively interact with each sensor.

Conclusion

This project allowed us to bridge the gap between art and science in an engaging way. Through the process, we developed skills in electronics, programming, mathematics, and communication. We overcame technical challenges integrating the sensors and optimizing the fluidity of the animation. We were able to present the project to an audience at the PCAC, driving interest in the patterns and symmetries that permeate our world. In the future, we hope to improve this project by adding more sensors, interactivity, and complex animations to showcase the wonders of mathematics.

Acknowledgments

We would like to thank Professor John F. Gibson, Professor Benjamin Cariens, and the staff at the CEPS Makerspace for their invaluable support on this project. Additional thanks to Professor Shawna Hollen for coordinating the Innovation Scholars program.