CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

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Project Number

J1501

Project Title

The Mathematics of the Mandelbrot and Julia Sets

Abstract

Objectives/Goals

My goal is to understand where the Julia and Mandelbrot sets come from and answer many intriguing questions: How many different types of Julia sets are there? Do Julia sets of complex conjugate c values always have the same symmetry (like reflection across the imaginary axis) and if so why? Are the causes of the infinite repetition such as those in swirling patterns understood? Can they seem obvious if you understand the math well enough? If the critical orbit (the orbit of z = 0) escapes, is the hole left repeated "fractally" everywhere so there is no area that doesn#t have holes or gaps? Is this the origin of the fractal dust Julia Sets? Are these just like the cantor set? Does the Mandelbrot set contain every Julia set? How is the Mandelbrot set related to the Julia sets? Is every point on the Mandelbrot set the center point for a Julia set with the same parameters?

Methods/Materials

I studied the mathematics behind these sets: trigonometry, complex numbers, and complex number geometry. I used the Java programming language to visualize complex behavior of iterations and search for patterns in fractals.

Results

I was able to answer many questions I had about the Mandelbrot and Julia sets, but many remain. I generated my own Julia sets for different c values and then expanded on interesting areas where the images changed dramatically for small changes in c. From these I was able to see symmetries: for example that complex conjugate c values are indeed mirror images across the imaginary axis. I found that if the center of a Julia set escapes, then it is a Cantor Set; every point eventually escapes and no region is free of holes, no matter how small.

Conclusions/Discussion

When I began this project I not only wanted to understand these sets, I wanted to explain them to others. I believe lots of people could take an interest in these structures and the math behind them because they appeal to the artistic side of people and feed their curiosity. Mandelbrot and Julia sets provide a way for people to become involved with math. I believe my project demonstrates a way to understand Mandelbrot and Julia sets, not just as beautiful pictures, but as a fun and interesting branch of mathematics.

Summary Statement

By learning about trigonometry and complex numbers I was able to better understand and appreciate the inner workings of the fractals.

Help Received

My dad helped me write Java programs to visualize fractals. He also helped me with my poster.