Classifying Magic Squares and Their Associated Symmetries Using a Chord Diagram Approach

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Magic squares are defined as matrices whose rows, columns, and main diagonals all add to the same number. They have existed and have been a topic of great interest since as early as 190 BCE, appearing in several different cultures. Some of the greatest minds in mathematics dedicated time to their exploration and construction including Euler, Ramanujan, and Fermat. Even with their prevalence throughout the mathematical world, few general theorems have been proven about magic squares and their properties. Through the course of this project, a novel approach to studying the squares was developed that represents the matrix elements as connected points on a circle with n2 equally spaced points. Furthermore, this visual representation can be used to classify the squares by the symmetries they produce. Unlike previously used visual aids, this method of classification extends to all orders of magic squares. Using this method of circular graphing, generalized theorems about the reflection and rotational symmetries of magic squares were developed as well. It was also proven using these tools that the maximum number of possible axes of symmetry of a given n x n magic square is precisely n/2. Finally, inconsistencies found in prior work by other authors on classification of 4x4 magic squares using permutation matrices were discovered, and further relations to this theory were developed.

Awards Won:
Intel ISEF Best of Category Award of $5,000
First Award of $3,000
Mu Alpha Theta, National High School and Two-Year College Mathematics Honor Society: First Award of $ 1,500
National Security Agency Research Directorate : Second Place Award "Mathematics"$750
American Mathematical Society: Certificate of Honorable Mention