CALIFORNIA STATE SCIENCE FAIR
2007 PROJECT SUMMARY

Name(s)
Christopher T. Barnum

Project Number
S1301

Project Title
Pascal's Triangle and Infinite Dimensions

Abstract

Objectives/Goals
The initial idea was to determine if Pascal's Triangle could be created in 3- dimensions, & if so, to discover the underlying formula, any specific patterns for the 3-D version, & any patterns between the versions.

Methods/Materials
Starting with a basic understanding of Pascal's Triangle, which is a series of numbers that represent the coefficients of the expression [X + Y]^N. A pyramid shaped three-dimensional version of Pascal's Triangle was built and tested. It was constructed using the idea that each variable created an "axis", or line of ones on an edge, along with a simple rule: Each axis has to have a non-intersecting plane or area connecting it to every combination of all other axis. If something of this magnitude could be made, then Dr. Kitto would help find the underlying formula for the pyramid. Possible patterns between the versions of Pascal's triangle were studied, & work began on a 4-d version, using time as a fourth dimension.

Results
The result of the experimentation was pyramid shaped string of numbers, which, interestingly, has Pascal's original triangle on each face. Dr. Kitto was able to locate a formula, [X+Y+Z]!/X!Y!Z!, which provided the underlying formula for the pyramid. No provable patterns were found between the levels constructed, but there were a few that appeared to exist & looked promising.

Conclusions/Discussion
Dr. Kitto was able to locate a formula, [X+Y+Z]!/X!Y!Z!, which also had an interesting pattern between itself & the other versions of the triangle. This pattern is that the other versions are always present just "not looked at," or equal to zero. In other words, they are all still there. So, the formula is REALLY [a(1)+a(2)+....+a(n-1)+a(n)]!/a(1)!*a(2)!*....*a(n-1)!*a(n)!, where any a(n) not used is equal to zero. For the original triangle, for example, the equation is [a(1)+a(2)+0(1)+0(2)+....+0(n)]!/a(1)1*a(2)!*0(1)!*...*0(n)!. It is important to note that 0!=1, so the equation would be totally & completely unchanged if one were to "add or remove" variables at will. Also, it appears that each variable one "adds in" will use a separate dimension than any of the other variables in order to have a unique line, plane, area, space, & set of simplexes with every (all) other variable(s).

Summary Statement
This project is about creating & expanding multi-dimensional versions of Pascal's Triangle.

Help Received
Dr. Kitto helped find formula, many applications for project found on internet

CALIFORNIA STATE SCIENCE FAIR
2007 PROJECT SUMMARY

Name(s)
Arkajit Dey

Project Number
S1302

Project Title
Tree-Realizability of a Distance Matrix

Abstract

Objectives/Goals
A fast algorithm for both testing the tree-realizability of a distance matrix and constructing the optimal realization is presented. The fastest existing algorithms are only designed to either test tree-realizability or construct a realization.

Methods/Materials
The presented algorithm's modifications over existing algorithms include a streamlined list of input parameters and maintaining a growing distance matrix.

Results
In addition to combining both testing and constructing algorithms, the improvements offer several other advantages: early halting upon detecting a non-tree-realizable distance matrix, a running time that is just as fast as existing construction algorithms on input that is realizable, and faster performance for input that is non-tree-realizable. The algorithm has a worst-case running time that is quadratic in the order of the input distance matrix and attains the subquadratic running times that are possible in existing algorithms that only construct the realization. For non-tree-realizable input, the algorithm needs to process, in expectation, at most three-quarters of the vertices to halt.

Conclusions/Discussion
Tree-realizations can make naturally difficult problems such as the traveling salesman problem more easily solvable optimally over a tree-metric. In addition to its implications in the study of graph theoretic algorithms, the proposed algorithm also has applications in many varied disciplines: phylogenetic tree reconstruction in molecular and evolutionary biology, prediction of physical properties of alkanes in organic chemistry, inference of Internet network topology, evaluation of Internet performance, and the analysis of memory and mental association in psychology.

Summary Statement
In my project, I design a more efficient, improved graph theory algorithm to solve the tree-realization problem that has applications in fields ranging from phylogenetics to internet tomography.

Help Received
Dr. Wasin So acted as my mentor and suggested the topic idea.

CALIFORNIA STATE SCIENCE FAIR
2007 PROJECT SUMMARY

Name(s)
Scott M. Elder

Project Number
S1303

Project Title
Pseudorange Fit Algorithm

Abstract

Objectives/Goals
This is my third in a series of three science projects on GPS Multipath. This year, my research focused on multipath signals that are refracted from above the GPS antenna. My project objective was to create a pseudorange fit algorithm that would remove the corrupted pseudorange measurements caused by this multipath and eliminate GPS receiver position jumps.

Methods/Materials
I collected positioning data from the GPS constellation for every second using a special Garmin GPS receiver that supplied the #raw# pseudorange measurement data. This resulted in a very large volume of data. I then used my laptop and some special software supplied by Garmin for data analysis. My data collection area did have potential sources of multipath signals that I was able to take advantage of since my receiver supplied the azimuths of the GPS satellites.

Results
I collected GPS position data from seven satellites from 22:30:00 to 23:19:10 for every second. This resulted in about 190,000 points of data. Data analysis identified a potential multipath problem from 22:44:36 to 23:00:46 with 40,180 points of data. Further data analyzed determined that PRN 11 had pseudorange measurements corrupted by multipath and resulted in 971 data points. I then created a pseudorange fit algorithm based on least mean squares theory. This resulted in a best-fit line gradient to which I applied the corrupted PRN 11 data. With the correct fitted boundaries set into the algorithm, it did remove the corrupted data points and keep the uncorrupted pseudorange measurements.

Conclusions/Discussion
My hypothesis was proven valid and I was able to develop a pseudorange fit algorithm that eliminated the bad pseudorange measurement data that causes GPS position jumps. In addition, by knowing PRN 11#s elevation and azimuth in the sky and my receiver location, I was also able to identify the tower that had caused the diffracted multipath condition.

Summary Statement
My project developed a pseudorange fit algorithm to eliminate GPS receiver position jumps caused by a diffracted multipath condition.

Help Received
Dad helped with test set up.

CALIFORNIA STATE SCIENCE FAIR
2007 PROJECT SUMMARY

Name(s)

Dhruv Garg; Charles Xue

Project Number

S1304

Project Title

PrevCor: An Algorithm Using Amino Acid Properties and Protein Folding Patterns to Simulate the 3-D Folding of Proteins

Abstract

Objectives/Goals

The design and construction of a protein folding computer algorithm that maximizes accuracy for biotechnology researchers and scientists to perform flexible protein sequencing simulations based on genetic data.

Methods/Materials

We created a UI which converts user-inputted DNA sequences into an amino-acid sequence; this is stored in a lattice-modeled doubly-linked-list data structure, in which each node represents an amino acid. The structure between each node is part of a separate data structure overlaid on a wire frame, which provides the angular orientation and interaction type as enumerations. The interactions between individual nodes are based on probabilistic protein-folding equations derived from each amino acid's hydrophobic intensities, acidity properties, and relative frequencies of occurrence (alpha helixes, ß-sheets) in a polypeptide chain. We used Java and Java3D API in the Visual Studio Professional Edition development environment to construct this algorithm.

Results

The computer simulation was compared to the actual placement of amino acids in proteins such as insulin, hemoglobin, and pepsin. Our simulated proteins had an accuracy % of 98.039%, 87.805%, 81.308% respectively. Accuracy was determined by comparing the relative locations of amino acids to their actual lab-based models under a pH of 7.0. Under deviating pHs, due to the random instance algorithm used, accuracies ranged from between 2.0 x 1.9^|7.0-pH| - 4.0 x 1.9^|7.0-pH|. CPU usage and processing power in relation to the number of amino acids on a 2.0GHz Dual-Core processor are as follows (# of amino acids, CPU %): (10, 1.16%), (50, 2.11%), (100, 4.43%), (200, 19.64%), (300, 87.06%).

Conclusions/Discussion

As expected, larger protein sequences have a greater toll on the processor, which lowers accuracy. This is caused by the exponential increase in the number of interactions among the secondary and tertiary structures of the protein. An accuracy of >80% provides a protein with enough structural similarities to give a detailed analysis on its attributes, thus the simulation is effective up to 325 amino acids. Similarly, CPU usage is also based on an exponential curve and the CPU vs. # of amino acids curve closely fits the equation 1.015^A where A represents the # of amino acids. In the future, we plan to analyze much longer and data-intensive polypeptide chains by employing a supercomputer to manipulate data.

Summary Statement

A computer algorithm that predicts and simulates protein-folding using a lattice-model doubly-linked-list data structure and probabilistic equations derived from hydrophobic intensities, pK(a) data, and structural tendencies of amino acids.

Help Received

Mr. Bruce Kawanami (Monta Vista High School, Cupertino ROP Eng. Tech Teacher) was our project adviser. Everything else has been done by us independently. We also consulted various online resources and the details are provided in the bibliography of our documentation.

CALIFORNIA STATE SCIENCE FAIR
2007 PROJECT SUMMARY

Name(s)
Stephen C. Greenfield

Project Number
S1305

Project Title
Simulation Software of Prey and Predator Species in a Controlled Environment

Abstract

Objectives/Goals
The purpose of this project is to develop a simulation that correlates with the population models that biologists have created. My hypothesis is that it is possible to develop simulation software of species in a controlled environment that correlates with the population models in Biology while the species move, give births, and feed randomly.

Methods/Materials
The simulation employs parameters to control initial populations, average life spans, age range and chances to give birth, and food consumption. The experiments are performed by changing the values of the parameters and the simulation logs the populations of the species. Once the simulation runs long enough for analyses, the logged data is imported into spreadsheet software for graphing.

Results
According to the tests that I carried out with the program, the hypothesis is correct. The information that the program collected and graphed is almost like the graphs that where made by the math equations and biologists. The math equations that are made make a smooth graph and the graph that is made by the program is rigid because it runs randomly.

Conclusions/Discussion
The simulation takes place randomly based on the parameter settings. However, the results produced by the simulation display large similarities in correlation with population models developed by biologists. One of our findings is that the species by themselves make their own territories although it was not part of the simulation model.

Summary Statement
a computer simulation that correlates with the population models that biologists have created

Help Received
my programming teacher taught me how to program

CALIFORNIA STATE SCIENCE FAIR
2007 PROJECT SUMMARY

Name(s)
Ariana G. Haro

Project Number
S1306

Project Title
The Utilization of Empirical Math Modeling in a Predator-Prey Relationship

Abstract

Objectives/Goals
In Phase 1 of this project, utilizing real-time research data I was able to confirm that classic predator-prey mathematical models fail to include dynamics that influence population size. Based on this information I concluded a model cannot be created to accurately represent the predator-prey relationship in the presence of unpredictable environmental variables. In Phase 2 of this project I conducted a comparative study between migratory variables and a static (less dynamic) environment with these models using real-time data.

Methods/Materials
In this study it is my goal to determine that in an isolated population, the polynomial fit lines do not exhibit the behavior observed in the data, in relation to the classic predator-prey model. First, a classic predator-prey model was constructed for comparison purposes. Then data from Ngorongoro Crater (a relatively static non-migratory ecosystem) was converted into spread sheets. Using these spreadsheets graphs were made for each predator and prey. In addition, polynomial fit lines were constructed on the graphs. Then the classic and Serengeti models (a highly migratory ecosystem) were compared to the various Ngorongoro graphs to check for compliance.

Results
To analyze the predator-prey models a polynomial fit line was constructed on the graphs to show the most accurate depiction of the data. They were also used to assist in the comparing of the models made with the Ngorongoro Crater data (a non-migratory environment), Serengeti data (a migratory environment), and the classic mathematical predator-prey model.

Conclusions/Discussion
Utilizing data from the Ngorongoro Crater, I was able to confirm that polynomial fit lines do not exhibit predictable behavior observed in the data with migratory variables in predator-prey relationships essentially eliminated in comparative populations and ecosystems.

Summary Statement
This project is a mathematical analysis of predator-prey models and their interaction with uncontrollable dynamics.

Help Received

CALIFORNIA STATE SCIENCE FAIR
2007 PROJECT SUMMARY

Name(s)
Gregory A. Hirshman

Project Number
S1307

Project Title
Differential Cryptanalysis of MD5: Unscrambling the Hash Bit by Bit

Abstract

Objectives/Goals
The recent successful attack on the widely used hash function, the MD5 Message Digest Algorithm, was a breakthrough in cryptanalysis. Original papers, published in 2004 and 2005 by Wang and Yu and Liang and Lai, described this attack in an obscure and elliptical manner. Hawkes, Paddon, and Rose later presented the attack in more detail, but even their paper contained numerous unproven statements. This paper will prove assertions made by Hawkes, Paddon, and Rose, provide original corrections and illustrations, and explicate the two primary papers to make them more accessible to the mathematically-literate reader.

Methods/Materials
This paper provides background information on cryptography, hash functions, the MD4 and MD5 Message Digest Algorithms, a substitution-permutation network (SPN), differential cryptanalysis, and the differential attack on MD5 as originally presented. Then, it explicates this attack. Two blocks are treated. For the first block, it adds calculational details, examples, and original proofs to elucidate the step by step analysis presented by Hawkes, Paddon, and Rose. For the second block, it develops a step by step analysis based on a few tables that they provide. Finally, it presents an original comparison between the structures and cryptanalyses of the SPN and MD5 algorithms, providing insight into the attack on MD5.

Results
This paper makes four important contributions. First, it provides an example for each of the three conditions at the beginning of the description of the first block differential, demonstrating why certain conditions had been placed on the Tt. Second, it proves conditions specified by Hawkes, Paddon, and Rose for the first block. Third, it provides for the second block a completely original step by step analysis of both the description of the differential and of the propagation of the differences through the ft functions. Finally, it reveals several mistakes in the work of Hawkes, Paddon, and Rose. Most are trivial, but one is of special importance since implies that their attack is actually about twice as fast as they believed.

Conclusions/Discussion
The goal of this paper is to use original analysis to provide a more detailed, accurate, and closely reasoned account of current research, making it more accessible to a wider audience. Further research could include similar treatment of Klima#s tunnels, which have provided the fastest known attack on MD5.

Summary Statement
This paper expands on one of the most comprehensive papers on the differential attack on MD5 by providing original proofs, corrections, and illustrations to make the attack more accessible to the mathematically-literate reader.

Help Received
Qualcomm employee helped with concepts; father helped edit the report.

CALIFORNIA STATE SCIENCE FAIR
2007 PROJECT SUMMARY

Name(s)
Nicholas Kotsianas

Project Number
S1308

Project Title
ALife 101: Computer Simulation of Artificial Life Organisms

Abstract

Objectives/Goals
The objective of this research is to design, implement, simulate, study, and improve a life-cycle model of Artificial Life agents. Artificial Life, or ALife, is the most recent and promising topic of Artificial Intelligence, covering the bottom-up approach of AI versus the top-down approach of earlier methods. The short-term objective of this project is to synthesize, validate, and calibrate a family of customizable agent models resulting in stable, sustainable populations under varying environmental conditions.

Methods/Materials
Life is simulated in a configurable, closed Universe populated by Agents, which are organized in Orders. Agents are the basic units of life, possessing mobility and metabolic characteristics: Health and Energy levels, Food Conversion Efficiency (FCE), maximum Lifespan, and Reproductive cost. Agent AI consists of local environment comprehension, goal identification, path planning, and obstacle avoidance algorithms. The Universe consists of a square cell grid, includes walk-able and Barrier cells, and has a supply of renewable localized and distributed nutritional resources. The Agent#s goal is to identify nutritional resources, navigate and move, consume, metabolize, and reproduce. In order to survive, Agents must compete with others for resources, and make efficient use of space and time. This project was implemented in C#, using Microsoft Visual Studio.

Results
An Agent life-cycle model was implemented successfully, leading to an energy balanced Universe and population stability over time. Lower population sizes at equilibrium were observed for Orders with less efficient food metabolism and for higher Reproductive costs. Also, Orders with more efficient metabolism may lead to dominance and cause extinction of less efficient Orders. The A* algorithm was found effective in guiding Agents along the optimum path to food while avoiding collisions.

Conclusions/Discussion
The ALife model implemented leads to realistic simulated behavior of Agent populations and exhibits an inverse relationship between FCE and population size and between Reproduction cost and population size.

Summary Statement
An Artificial Life Agent model is synthesized, validated, and implemented, and is utilized to study the relationship between metabolic rate, reproductive cost and population size during time simulation of artificial organism colonies.

Help Received
Mentor helped in comprehnsion of programming language and board assembly.

CALIFORNIA STATE SCIENCE FAIR
2007 PROJECT SUMMARY

Name(s)
Brian S. Lee

Project Number
S1309

Project Title
A Comparison of Numerical Integration Approximations: Midpoint, Trapezoidal, and Simpson's

Abstract

Objectives/Goals
The objective of this project is to determine if the Midpoint Approximation, the Trapezoidal Approximation, or the Simpsons Approximation would give the most accurate result for the area under the curve.

Methods/Materials
1.Take the following functions: y=2x-1, y=-3x+2, y=1/2(x-2)^2+1, y=-(x+1)^2+4, y=cos(x), y=sin(x), y=2e^(0.5x), y=0.5e^(-0.5x), y=1+log(x), and y=ln(2-x).
2.Calculate the actual area under the curve for each function using integration.
3.Divide each curve into 2, 4, 8, 16, and 32 equal subintervals.
4.Using the Midpoint, find the approximate area under the curve for each subinterval.
5.Using the Trapezoidal, find the approximate area under the curve for each subinterval.
6.Using the Simpsons, find the approximate area under the curve for each subinterval.
7.Record the results and compare them to the actual area under each curve.
Note: Programs on TI-89 calculator and Java programs are used to compute the area.

Results
For the linear functions, the areas were always exact regardless of the methods used. In the case of quadratic functions, the Simpsons method gave the best approximation and the Trapezoidal provided the worst. Next, for the trigonometric functions, the Simpsons gave the most accurate approximation while the Trapezoidal gave the least accurate approximation. Then in the case of exponential functions, again the Simpsons gave the best approximation and the Trapezoidal yielded the worst approximation. Finally, for the logarithmic functions, the result was the same; the Simpsons offered the closest value to the actual area and the Trapezoidal gave the least accurate result.

Conclusions/Discussion
In most cases I was correct that the Simpsons gave the most accurate approximation. However, I incorrectly predicted that the Trapezoidal would do better than the Midpoint. The Midpoint gave more accuracy than the Trapezoidal. Next, I verified my intuition that as the number of subintervals increases, the approximations get better. In fact, the Midpoint can achieve the accuracy of the Simpsons at very large n. Also, I found that error in the Trapezoidal is almost twice the error in the Midpoint, bur in opposite direction. Another interesting thing with the Simpsons is that its accuracy improves dramatically over n. Finally, I conclude that, regardless of the function, the approximation techniques work better if the curvature of a function is not too high.

Summary Statement
My project explores to find if the Midpoint, Trapezoidal, or the Simpsons would give the most accurate result and analyze the data for comparison between the three methods.

Help Received
My father introduced me to the analytic method of evaluating definite integrals in calculus and showed me how to calculate the area under a curve using integration. He also helped me with the programming on the TI-89 calculator.

CALIFORNIA STATE SCIENCE FAIR
2007 PROJECT SUMMARY

Name(s)

George Liaw; Bryan Lin

Project Number

S1310

Project Title

Modeling and Analysis of Human Binocular Perception of Position and Velocity in the Visual Cortex

Abstract

Objectives/Goals

This research focuses on developing a mathematical representation for human binocular visual perception from the visual field to the primary visual cortex based on spatial and physiological characteristics of the visual pathway.

Methods/Materials

First, a spatial relationship between single visible spot in the visual field and its retinal projection on the spherical surface for a monocular vision system was established. A novel approach, called ~{!0~}peel-off~{!1~} mapping, was then formulated in dealing with flattening the spherical retina to a 2-dimensional (2-D) plane before being mapped to the visual cortex. Velocity level mapping that described how a visible moving spot was projected from visual field to the spherical retinal surface was developed and then mapped onto the visual cortex. More importantly, all the kinematical relationships established for monocular system were extended to binocular vision. Finally, a complete model was developed that allows for quantitative computation of binocular disparity as well as disparity due to stereo-motion in the primary visual cortex.

Results

Computer simulations were carried out and simulation results not only show the validity of the proposed model but also provide a platform for better understanding about some of the visual perception processes and interpreting some of the experimental results conducted on human.

Conclusions/Discussion

A quantitative modeling for human visual perception has been established based on spatial and physiological characteristics the first time. Considering highly nonlinear mappings involved in the visual image propagation in the human visual pathway, the model can help visualize the representations of images or visual information at different stages in the visual pathway by providing rich 2-D and 3-D simulation results. The proposed model also provides a platform to compute binocular disparity and disparity due to stereo-motion at the primary visual cortex level. The formations of these input signals help further explore subsequent brain activities in the higher level cortexes.

Summary Statement

This project provides a mathematical representation of a fairly complex biological/physiological system, human binocular visual perception from the visual field to the primary visual cortex mapping.

Help Received

Professor Ou Ma at University of New Mexico answered email questions.

CALIFORNIA STATE SCIENCE FAIR
2007 PROJECT SUMMARY

Name(s)
David C. Liu

Project Number
S1311

Project Title
Acoustic Music Similarity Analysis

Abstract

Objectives/Goals
The popularization of digital music presents the problem of quickly finding music to suit individual users' tastes and moods. The collaborative user feedback (e.g. iTunes' "Listeners Also Bought...") used presently is often skewed due to extremely popular songs and fails to account for music without much customer feedback, such as undiscovered independent ("indie") artists.

This project investigated methods of improving audio-based music analysis to find songs similar to given query songs. A new method of improving similarity results using spectral graph theory and the eigenspace transformation has been presented.

Methods/Materials
A collection of 800 songs from 8 different genres was analyzed. The statistical characteristics of the frequency distribution were used to capture the perceived texture of the music as signatures. Distances between songs were calculated using the Earth Mover's Distance (EMD), an algorithm for comparing song signatures.

These distances were represented as a connected graph. The eigenspace transformation was used to rearrange the points based on a random walk of this graph. This was a novel approach that separated songs into distinct groups.

Playlists of 10 similar songs were generated using each song in the collection as a query. The percentage of songs in the same genre as the query was defined as the genre matching accuracy.

A 3-D music navigation system was also developed as a visualization of the song collection in eigenspace, where similar songs are shown near each other.

Results
It was found that applying the eigenspace transformation on the EMD distances used in other research improved genre matching accuracy by 13.5% over the EMD alone, which is statistically significant.

Conclusions/Discussion
Music similarity analysis has the potential to change the way consumers listen to music. This project contributes an algorithm that improves similarity results considerably.

Summary Statement
This project explored ways to automatically find pieces of music that sound similar to each other, which enables people to quickly find music similar to their tastes.

Help Received
Dr. Beth Logan at Intel and Professor George Tzanetakis at the University of Victoria answered my questions by email, and George Tzanetakis also provided the music collection.

CALIFORNIA STATE SCIENCE FAIR
2007 PROJECT SUMMARY

Name(s)
Ishan S. Puri

Project Number
S1312

Project Title
The Magic of Math: Phi, Pi, and the Fibonacci Sequence

Abstract

Objectives/Goals
My science fair relates to mathematics. It deals with the terms of phi, pi, and the Fibonacci Sequence, all of which have very interesting properties. These values appear everywhere: in nature, space, the Bible, even in flowers. I plan to show people that math does have an effect on our lives. My goal is to instill inspiration in others for math, and to set out a challenge to solve the mysteries of these terms. I want to show others that math isn't just a bunch of numbers, and everything has meaning.

Methods/Materials
For this project I needed a TI 83 graphing calculator, pencil, rough workbook, and the internet. There are three main aspects I covered on each of these terms. I derived them, showed how each is related to the other, and showed how the terms are in real life.

Results
I found that phi can be derived using limits, trigonometry, and geometric constructions, while pi can be derived using the Monte Carlo Pi Method, the Pythagorean Theorem, and the Gregory-Leibniz Series. The Fibonacci Sequence can be determined by creating a formula and using Pascal's Triangle. Pi is related to phi in the golden circle, a circle with radius phi, and through trigonometry. Pi is related to the Fibonacci Series through Euler's formula. The Fibonacci Series relates to phi through a function involving term number and f(n). Now for the main importance of the project: these terms all appear in real life and nature. Pi is used in the cosmological constant, general relativity, and Heinsberg's uncertainty principle. Phi is used to predict changes in the stock market and is involved in the orbits of some of our own planets. Almost every flower has a Fibonacci number of petals, and the human body has 2 hands, 1 face, 2 eyes, and 5 knuckles per hand, all Fibonacci numbers.

Conclusions/Discussion
Now my point is here: why? With my project I want to motivate myself and others to action on math. I believe there lays a deeper and greater meaning to these relationships. Something great will come out of analysis.
I have given you a brief overview of my project. If it is analyzed in depth, it can be very interesting and bring up many unusual things about math. I hope to give you a comprehensive look at math and its applications to the real world, which is very important. We do use math in our lives, and with my project, I hope to give people a sense of motivation.

Summary Statement
My project focuses on three unusual mathematical terms and shows people through mathematics that math is important, with a goal to inspire others to investigate mathematics and show how math is related to real life.

Help Received
I want to thank Oak Park for allowing me to participate, my family for their support and my science and math teacher for help.

CALIFORNIA STATE SCIENCE FAIR
2007 PROJECT SUMMARY

Name(s)
Hannah B. Sarver

Project Number
S1313

Project Title
Advance to Go: Monopoly: A Mathematical Model

Abstract

Objectives/Goals
This project aimed to find the best property to buy in the game of Monopoly based on its probability of being landed upon, by mathematical calculation and actual game play. Other factors were taken into account, such as cost-to-rent ratio.

Methods/Materials
Calculate the probability of landing on each space on the Monopoly board from any other space by dice roll and action cards. Create a matrix of board space probabilities in Microsoft Excel, then repeat process with weighted probabilities from the first matrix. Assess the cost to rent ratio of each ownable property on the board and combine with the probability of landing on each to decide on the most practical property purchase. Play several games (15 hours) to identify trends in landing point frequency. Have each player record his dice roll outcomes and landing points. Compile collected data and compare to calculated probabilities.

Results
According to my mathematical calculations, New York Avenue is the most probable property landing point, and the In Jail space is by far the most probable board space. In actual games played, the most landed-on properties were B & O and Reading Railroads, tied with the In Jail space.

Conclusions/Discussion
Considering cost to rent ratios as well as landing probabilities, the Utilities, followed by the Pennsylvania, B & O, and Reading Railroads are the best properties to buy. However, in a short game of Monopoly, many factors affect which properties a player has the opportunity to buy, and landing probabilities do not always even out.

Summary Statement
This project was an exploration of the mathematical probabilities associated with the game of Monopoly, and how they should affect the property purchase decisions of players.

Help Received
I referred to my Math teacher, Mr. Tsuchiyama, for verification that my mathematical procedure was accurate and effective; my mother assisted me in learning how to use Microsoft Excel for mathematical calculations.

CALIFORNIA STATE SCIENCE FAIR
2007 PROJECT SUMMARY

Name(s)
Amandip Singh

Project Number
S1314

Project Title
Autonomous Rescue Chopper

Abstract

Objectives/Goals
Achieve the following: 1. 2D Image Capture; 2. 2D Image Recognition; 3. Stereo 2D to 3D Mapping (Trig); 4. XYZ Potion Tracking; 5. Navigation; 6. Autopilot; 7. Computer USB Digital Interface; 8. Digital USB to Analog converter; 9. 4 Channel Analog Converter to Radio Remote Interface; 10. Equations of Motion; 11. 2D to 3D Mapping Trig; 12. 3D Rotation; 13. Graphic User Interface.

Methods/Materials
How:
A model electronic helicopter that will be modified with a magnet to be able to pick up the item needed to be saved, in this case the rescue button. The rescue button will be a LED circuit board. An analog to a digital converter will make it possible to for the computer to control the helicopter. The converter will connect from the inside of the controller to the computer. In order to view the helicopter a camera will be needed will a mirror image split, this is where the LED come into play. Once you have a perfect split then use trigonometry to calculate the distances from LED to the camera, from the camera to the helicopter, then from the helicopter to the camera.

Materials: 1. Helicopter; 2. Receiver ; 3. Camera; 4. Computer (1.5GHz, 2 USB ports); 5. 2 LED Flashers (Person); 6. Magnet; 7. Software; 8. Cable for Converter; 9. Circuit Board; 10. Digital to Analog Converter; 11. Interface; 12. Controller; 13. Wood.

Results
1. 2D Image Capture: Success; 2. 2D Image Recognition: Success; 3. Stereo 2D to 3D Mapping (Trig): Success; 4. XYZ Potion Tracking: Success; 5. Navigation: Success; 6. Autopilot: Success; 7. Computer USB Digital Interface: Success; 8. Digital USB to Analog converter: Success; 9. 4 Channel Analog Converter to Radio Remote Interface: Success; 10. Equations of Motion: Success; 11. 2D to 3D Mapping Trig: Success; 12. 3D Rotation: Success; 13. Graphic User Interface.

Summary Statement
My Project allows a helicopter to opertae on its own and ppick up an item.

Help Received
step father helped buil;d curcuit board

CALIFORNIA STATE SCIENCE FAIR
2007 PROJECT SUMMARY

Name(s)
George L. Yang

Project Number
S1315

Project Title
Cracking the Case: Investigating the Fracture Patterns of Glass

Abstract

Objectives/Goals
The objective of this project is to observe and record properties of glass fracturing in order to create a model and program, using mathematics, which can simulate fractured glass. My hypothesis is that there is a direct relationship between the number of fractures and the types of fractures that form and the force that is used to fracture the glass.

Methods/Materials
Materials used in this project included 3/32 inches thick window pane glass, a weight, a scanner, and a computer. The data collection stage of the project involved fracturing glass by hanging a wrench at a controlled height and then releasing it. Once that was completed, the glass was taped back together to be scanned into a computer for data analysis. By using a spreadsheet program, all of this data could be recorded and a system for arranging this data into a simulation could be created. This system included uses of linear interpolation and trigonometric equations.

Results
When the project was completed, a fully functional glass simulation program was created. Also, my hypothesis about a direct relationship between the number of cracks and the impact force was confirmed. I also found that even though glass may look identical with the human eye, deep down on a lower level, there are differences that affect the force required to fracture glass, otherwise known as critical stress.

Conclusions/Discussion
My results confirmed my hypothesis that there is linear interpolation between the number of fractures and the types of fractures that form and the force that is used to fracture the glass. I hypothesized that for a given force, there would be a certain number of cracks and certain types of cracks. Once the program was completed, simulations using a certain force did indeed match up with real world images that used the same force. These results and this program are small steps towards a greater understanding of glass fractures. Also, ideas such as the ones presented through this project can be used in programs to create more realistic simulations at a professional level. This project also presents a process for incorporating mathematics into creating simulations, thus allowing for more simulations based on real world data instead of the imagination of an artist.

Summary Statement
This project's objective was to create a model and program using mathematics to simulate glass fractures.

Help Received
My mother gave lessons on using Microsoft Excel. Both of my parents took me out to pick up materials. My teacher sponsor supported me along the way and told me about the science fair.

CALIFORNIA STATE SCIENCE FAIR
2007 PROJECT SUMMARY

Name(s)
Noah P. Young

Project Number
S1316

Project Title
Intelligent Intersections in Various Vehicle Traffic Networks and the Resulting Changes in Network Efficiency

Abstract

Objectives/Goals
This experiment is designed to determine if street intersections can learn to increase the efficiency vehicle transport in a network over time.

Methods/Materials
A laptop and Visual Studio for the C# language were used to create a computer simulation from scratch. The simulation allows the user to #draw# a road network where vehicles are added to the network according to a pattern that models real life. The intersections store data about how many cars are waiting in each direction every time the configuration of the traffic lights changes. Intersections use this data to determine if certain lights should stay green for more or less time in future cycles. In each test, a percentage value is set which determines how drastically the intersections respond to the data they record. Tests were applied in simple road networks with both four-way and three-way intersections.

Results
Due to favorable values for deviation between trials, the experiment has yielded relatively firm results. The experiment demonstrated that the intersection logic and learning capabilities initially benefited intersections by increasing the number of cars they could process in a one-hour interval. As the #learning# percentage and the time over which the simulation was run increased, intersections actually lost efficiency.

Conclusions/Discussion
It was concluded that agents which learn slowly over time, rather than responding very rapidly to their environments, are able to execute their tasks most efficiently over time. This behavior - learning best at a modest pace - demonstrates that simulated intersections were learning much like humans do. These results have implications for urban planning and artificial intelligence in computer programs.

Summary Statement
This experiment uses a computer simulation and the principles of artificial intellegence to determine if road networks can be made more efficient if intersection control systems learn and adapt to traffic patterns automatically.

Help Received

CALIFORNIA STATE SCIENCE FAIR
2007 PROJECT SUMMARY

Name(s)
Christina Zhu

Project Number
S1317

Project Title
Investigation of Auditory Nerve Intraneural Implant Designs with Finite-Element Analyses

Abstract

Objectives/Goals
Intraneural implants aim to provide a sense of hearing to the deaf and hard of hearing. By using computer simulations to model the potential distribution and electrical fields in a material with electrodes, this project aims to understand the path of electrons in the auditory nerve. This project investigates several designs with the purpose of creating the optimal design for an intraneural implant.

Methods/Materials
I used COMSOL Multiphysics, a finite-element analysis program, to model the electrical field distributions and the potential distributions of different electrode array designs for an intraneural implant.

Results
The potential and electric field distribution plots showed that stimulating two electrodes further apart decreased the density of the electric field lines and decreased the likelihood that nerve bundles other than the one right above the tip will be stimulated. Setting the ground to be all around the tissue created a similar effect, so pure tones would be heard. Insulating the electrodes with a thin layer of silicon dioxide allows the implant to be more efficient, preventing the loss electrons to surrounding tissue and minimizing damage to the tissue.

Conclusions/Discussion
Signal transmission in an intraneural implant carries significance for the scientific community, not to mention the deaf and hard of hearing community. With intraneural implants that accurately transmit sound waves, patients with damaged cochleas # those who cannot benefit from cochlear implants # are able to process sounds. Through lab experiments and computer simulations, it is possible to design an optimal intraneural implant that will give those who are deaf or hard of hearing the ability to hear fully.

Summary Statement
I used computer simulations to develop and investigate several different designs for intraneural implants for the deaf and hard of hearing.

Help Received
Used lab equipment at the University of California, Irvine under the supervision of Dr. Tang.