

73rd Annual Fair



**Connecticut
Science &
Engineering
Fair**

March 8 - 20, 2021

Student Abstracts

Mathematics

Fair Categories

	Life Sciences	Physical Sciences
7th & 8th Grade Team	LT (1001 – 1999)	PT (4001 – 4999)
7th Grade	L7 (2001 – 2499)	P7 (5001 – 5499)
8th Grade	L8 (2501 – 2999)	P8 (5501 – 5999)
High School	LS (3001 – 3499)	PS (6001 – 6499)
High School Team	LST (3501 – 3999)	PST (6501 – 6999)

Special Categories

AT = Applied Technology	EE = Engineering: Electrical & Mechanical
AS = Animal Science	ET = Energy & Transportation
BE = Behavioral & Social Sciences	EV = Environmental Analysis
BI = Biochemistry	EM = Environmental Management
CB = Cellular & Molecular Biology	MA = Mathematical Sciences
CH = Chemistry	ME = Medicine & Health Sciences
CS = Computer Science	MI = Microbiology
EA = Earth Science	PH = Physics & Astronomy
EN = Engineering: Materials & Bioengineering	PS = Plant Science

Special Category Composites

Biotechnology	AS, BI, CB, EN, ME, MI, PS
Environmental	EV, EM
Engineering	EN, EE
Sustainability	EA, EN, EE, ET, EV, EM

CSEF Official Abstract and Certification

Word Count

198

Fair Category

LS

Project
Number

3079

Title: Investigating Interplay between Amyloid- β and Tau and its Contribution to Neuroinflammation in Alzheimer's Disease Progression

Student Name(s): A. Kabra

Abstract:

Alzheimer's Disease is classified as the most common neurodegenerative disease that triggers and furthers the onset of neuronal cell death as a consequence of hallmark pathological changes. Since there is yet no cure for dementias such as Alzheimer's Disease, there is a perpetual cognitive function and development decline in diseased patients. The hallmarks of Alzheimer's Disease include abnormal amyloid beta plaques, neurofibrillary tangles, and neuroinflammation. While these neuronal processes are interlinked, it is not entirely understood how they are related or regulate each other. I will focus on the relation of neuronal processes and Alzheimer's Disease pathology, more specifically the influence of amyloid beta peptide aggregation on the Tau protein, dysregulated inflammation, and defective degradation mechanisms. In this paper, I analyzed the interaction between amyloid beta and tau tangles and how this leads to proinflammatory patterns, which results in neuroinflammation observed in Alzheimer's Disease. In context, I observed evidence for induction and progression of MAPT and TREM2 through analysis of RNA-sequencing (RNA-seq) data. In examining and correlating the pathological hallmarks for Alzheimer's Disease, neuronal abnormalities and dysfunctions have been analyzed with the intent to uncover new potential therapeutic approaches for rescuing degenerative cell function and structure.

**Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)**

CB ME MA

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

- human subjects potentially hazardous biological agents
 vertebrate animals controlled substances

2. Student independently performed all procedures as outlined in this abstract. Yes No

3. This project was conducted at a Registered Research Institution. Yes No

4. Is this project a continuation? Yes No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

- Yes No

CSEF Official Abstract and Certification

Word Count

235

Fair Category

LS

Project Number

3081

Title: Impact of COVID-19 Pandemic on Swimming Athletic Performance

Student Name(s): E. Huang

Abstract:

It has already been shown that COVID-19 has had a big impact on student mental health and academic performance. The purpose of this study was to investigate whether COVID-19 impacts swimming athletic performance and whether it differs based on age groups, gender, and states. We hypothesized that there would be an increase in time for different swimming events from 2019-2020 to 2020-21, especially in females and younger children. Public available data was collected from 3 different states of Connecticut, South Dakota, and Maine. The top available times for 100 freestyle and 200 freestyle from the ending period of the short course season of 2019 to 2020 and 2020 to 2021 were collected for both male and female, ages 11-12 and 15-16. The time differences in each of the events for the 2020-2021 and 2019-2020 seasons were then calculated and compared between the groups. We found that there was a large increase in time for both events ($p < 0.01$). The increase was significantly greater in the 11-12 age group when compared to the 15-16 age group ($p < 0.01$). There was no significant difference in the change between the gender groups. Among the three states, Maine had a noticeably larger increase than the other 2 states ($p < 0.01$). This study suggests that COVID-19 had a great impact on swim performance, especially for younger swimmers. The effect it has on different states needs further investigation.

Technical Disciplines Selected by the Student
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MA ME

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- Yes No

CSEF Official Abstract and Certification

Word Count

247

Fair Category

P7

Project Number

5009

Title: Using Snell's Law to Determine the Index of Refraction in Solutions

Student Name(s): S. Borst

Abstract:

The purpose of this project is to represent the concentration of sugar in a solution using the principle of light refraction. The scientific question is how does sugar in a solution affect the index of refraction? The hypothesis for this experiment is that the more sugar in a liquid the more laser light will bend or refract. A prism will be filled with different solutions containing known and unknown amounts of sugar. The prism will have a laser light passed through it. The prism will then be rotated so that the laser light inside of it is parallel to the bottom side of the prism resulting in a spot on a target board. This spot will be marked on the target board using colored pencils for each different solution. Based on these marks distance measurements in centimeters will be taken and used along with an understanding of trigonometry to calculate an angle theta. Knowing what theta is and plugging it into Snell's Law allows additional mathematical calculations and results in the index of refraction for each known and unknown solution. The results of my project showed that as the sugar concentration of the prepared solutions increased so did the index of refraction. That means the more sugar in a liquid the more the laser light bent or refracted resulting in a higher index of refraction. In conclusion, my hypothesis was supported by experimental data proving the more sugar in a solution the more the laser light refracted.

Technical Disciplines Selected by the Student
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MA PH

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- Yes No

CSEF Official Abstract and Certification

Word Count

89

Fair Category

P7

Project Number

5016

Title: The Algorithm of the Rubik's Cube

Student Name(s): M. Rosario

Abstract:

The Rubik's Cube is a 3-dimensional color based combination puzzle that was created in 1974 Ernó

Rubik. The original Rubik's Cube had six sides that were each covered by nine stickers, each side had

one solid color: white, red, blue, orange, green, and yellow. The goal of the Rubik's Cube is to mix it up and resolve it to its original form. I tested several algorithms and settled on two that solved the cube more frequently. In the end, both algorithms simultaneously were needed to solve the cube.

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MA

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- Yes No

CSEF Official Abstract and Certification

Word Count

249

Fair Category

PS

Project Number

6001

Title: Finding optimal size for pooled testing of SARS-CoV-2

Student Name(s): J. Li

Abstract:

The spread of COVID-19, kindled by a lack of mass testing in early stages, has affected hundreds of millions of lives. Even with recent vaccination developments, such testing is still critical. Thus, a timely, cost-efficient method for extensive testing is imperative for fighting the pandemic. One solution is pooling multiple samples into a single PCR test. This study aims to determine the optimal size of these pools based on prevalence rate. R was used to simulate pooling in a population with a prevalence rate of 0.05. This revealed a binomial distribution, where each positive case in a pool represents a “success.” The following formula (1) was derived: $F = ((1-P)^n) - (1/n)$, where F is the reduction factor, n is the pool size, and P is the prevalence. Plotting F vs n showed a single relative maximum in the first quadrant, thus the equation $(n^2)((1-P)^n) * (\ln(1-P)) + 1 = 0$ for optimal pool size was found by setting the derivative of equation (1) equal to 0. As prevalence increases, pooling efficiency decreases. For instance, at $P=0.005$, the optimal pool size of 15 can save 86% of tests that would be needed, but at $P=0.2$, the optimal pool size of 5 can only save 13%, and at $P=0.3$, reduction is negligible. Overall, the formulas allow for accurate estimation of reduction factor and optimal pool size, not only useful for COVID-19 but also for future situations that require mass testing.

Technical Disciplines Selected by the Student
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MA ME BE

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- Yes No

CSEF Official Abstract and Certification

Word Count

250

Fair Category

PS

Project Number

6005

Title: Accessible program and system to accurately align a star tracking mount using a DSLR camera.

Student Name(s): S. Staubly

Abstract:

Astrophotography is a widely popular hobby involving taking pictures of faint star formations in the night sky. Most amateur astrophotographers purchase a star tracking mount for their DSLR camera so they can take longer exposures of these stars while minimizing star trails which form in the picture due to the Earth's rotation. The downside of these mounts is that the longer one wants to expose an image while eliminating star trails, the more accurately they must align their mount with the North Celestial Pole (NCP). The most accurate method is with the use of an electronic polar scope, which connects to a computer program allowing for very accurate alignment. The downside is the scope has no other uses besides polar alignment, so spending an additional \$300 on an extra camera for one single purpose is wasteful when one could seemingly use their DSLR camera for the same purpose. This project will investigate the ability to use a DSLR camera for polar aligning the star tracking mount. The goal is to achieve a similar accuracy and efficiency as an electronic polar scope, without requiring the purchase of extra equipment. A program will be written to receive images from a Nikon DSLR camera, perform necessary calculations, and provide a simple guide showing the user how to obtain a perfect alignment. Future applications of this project allow for a wider audience to utilize their DSLR cameras to obtain a precise alignment while saving money for future purchases to explore their hobby even further.

**Technical Disciplines Selected by the Student
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PH MA

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3. This project was conducted at a Registered Research Institution. Yes No

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- Yes No

CSEF Official Abstract and Certification

Word Count

242

Fair Category

PS

Project Number

6011

Title: Muscular Strength and Endurance Adaptations Following Resistance Training Using Higher Volume and Lower Intensity or Higher Intensity and Lower Volume

Student Name(s): C. Shea

Abstract:

When it comes to resistance training, whether or not one should prioritize training volume or training intensity when trying to optimize their muscular strength and endurance is relatively unclear. The literature on this topic comparing different training intensities either didn't take training volume into account at all or did but could have made more of a distinct difference in volume between both groups to better compare training intensity vs. training volume. Therefore, experiments were set-up so that there is more of a distinct difference in volume between both groups, with the higher intensity group training with half as much volume as the lower intensity group to give more of an honest evaluation for which one could be more beneficial to prioritize. A control group and two training groups were tested with their one rep maxes (1RM) and a max rep out of 50% of their 1RM on the barbell shoulder press and barbell row initially and then 8 weeks later. The total pounds of increase of the subjects 1RM will be measured along with the total reps of increase of half of the subjects initial 1RM and standard deviation of both measurable will be determined for each group. It is expected the higher intensity and lower volume group to show greater pounds of increase of their 1 rep maxes, but for the lower intensity and higher volume group to show greater reps of an increase of half of their initial 1RM.

Technical Disciplines Selected by the Student
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ME MA

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4. Is this project a continuation? Yes No

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- Yes No

CSEF Official Abstract and Certification

Word Count

187

Fair Category

PS

Project Number

6022

Title: Incorporating Pre-Game Rankings to Colley, Massey, and Elo Methods

Student Name(s): J. Liu

Abstract:

Colley, Massey, and Elo are three popular rating methods commonly used in the NFL and Major Division I NCAA sports where game results from the regular seasons can be used to seed major playoff brackets or create predictive rankings. As with most rating systems, an ample amount of game data is needed for the resulting rankings to be reflective of the competitors' strength relative to others. However, in situations such as a professional golf match play tournament, where there is a lack of available match play data, or initial weeks into regular NFL season, when it is too early to have the appropriate amount of needed data in hand, how can we produce rankings that meet the standard of accuracy? To address this problem, this project proposes two possible seeding methods, the dominance graph method and the weak dominance graph method, that both incorporate pre-game rankings to make up for the lack of relevant games that are adaptive to Colley, Massey, and Elo. In predicting the outcomes of the Dell Technologies Match Play and weekly NFL games outcomes, the effectiveness of the method can be tested.

Technical Disciplines Selected by the Student
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MA CS

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- Yes No

CSEF Official Abstract and Certification

Word Count

255

Fair Category

PS

Project Number

6035

Title: How Holidays Impacted the Spread of COVID-19 in the United States: An Exploratory Analysis

Student Name(s): J. Li

Abstract:

COVID-19 has become a national crisis in the U.S. Holidays could be a risk to cause super-spreading. However, the extent of the impact from holidays remains a question.

My research questions include: whether holidays triggered COVID-19 surges; whether different holidays impacted differently; whether different states were affected the same. Easter, Memorial Day, Independence Day, Labor Day, Halloween, Thanksgiving, and Christmas and New Year were selected for study. I used data from the Johns Hopkins Database on GitHub. I compared the weekly COVID-19 cases before and after each holiday using the absolute difference and ratio, for the entire country and for the top states with the most and least cases up to date.

Results show the most influential holidays nationwide were Independence Day, Halloween, and Thanksgiving. The second week after the holiday was worsening than the first week. The greatest surge was from the second week after Halloween, where cases nearly doubled with an increase of half million from before. Furthermore, Halloween was the only holiday after which every state increased, even including the five states with the least cumulative cases.

Different states were impacted differently. California was hit most heavily during Independence Day, where cases increased by about 150%, and Thanksgiving, where cases increased by 233% 2 weeks after. Florida showed the greatest relative change during the second week after Memorial Day when cases increased by 1.5 times.

Results show that not every holiday has the same impact on outbreaks of COVID-19. My findings provide insights to guide holidays restrictions.

**Technical Disciplines Selected by the Student
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MA BE ME

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4. Is this project a continuation? Yes No

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- Yes No

CSEF Official Abstract and Certification

Word Count

199

Fair Category

PS

Project Number

6044

Title: Towards Clean Energy via Radioactivity: An Investigation of the Dissipation of Electrons in an Ultra High Vacuum Environment

Student Name(s): L. Apostolides

Abstract:

The purpose of this project was to study the dissipation of electrons in an electric field. The analysis of this phenomenon will help study the applicability of free electrons in a vacuum in new fields of clean energy and will help further advance high-energy particle physics research. The project was completed in two main phases. The first step was to find the desirable simulation software and to develop a program written in Python to run the simulation. Pyboltz was selected as a Monte Carlo Simulation, calculating electron transport properties in gas. The software is a cython translation of MagBoltz, a common simulation used at world-renowned facilities such as CERN. The second step of this project involved the implementation of a program written in Python to save and analyze the data, extrapolating results at physically achievable pressures. The velocity as a function of time was calculated by solving a differential equation. By integrating the velocity as a function of time, the distance traveled for a given time can be calculated. Independent of the electric field, the electrons will travel extremely long distances at extremely low pressures that are very difficult to achieve and maintain within a closed system.

**Technical Disciplines Selected by the Student
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PH MA EE

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 vertebrate animals controlled substances

2. Student independently performed all procedures as outlined in this abstract. Yes No

3. This project was conducted at a Registered Research Institution. Yes No

4. Is this project a continuation? Yes No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

- Yes No

CSEF Official Abstract and Certification

Word Count

258

Fair Category

PS

Project Number

6065

Title: Examining the Relationship Between Labor Cost and Firm Strategy Through Mixed Methods Content Analysis on Panel Data and SEC Filings

Student Name(s): A. Kabra

Abstract:

With a desire for growth and longevity, corporations have looked to analyze labor cost, a proven indicator for capital success, to recognize which components of firms ensure maximal revenue. Interpreting such indicators help make vital managerial decisions regarding production cost adjustment and workforce investment. In recent years, it has been hypothesized that firm strategy also impacts corporate success but could not be evaluated due to the data's qualitative nature. In this study, I analyzed labor cost and its variability in relation to five prominent firm strategies through the creation of a novel mixed-methods methodology using tokenization and root-word identification. I examined a cross-sectional dataset spanning over 30 years with 3300 observations, performing content analyses on qualitative SEC 10-K filings and multivariate regression analyses for quantitatively extracted frequencies. Multivariable statistical models were analyzed via R and SPSS and organizational control variables, such as capital expenditure, were selected due to their high correlation with labor cost, acting as a way to avoid multicollinearity. Results showed that innovation, human resources, and consumer-focused strategies had a strong association with labor cost while growth, restructuring, and human resources shared strong correlations with labor cost variability ($p < 0.01$). Such results led to conclusions on the implementation, advantages, and drawbacks of each strategy and their magnitude of significance in relation to capital success. Firms can use this novel mixed-methods approach to draw conclusions and make critical organizational decisions referring to cost allocation and strategy identification. Future studies should include content analysis using multi-layered analytical techniques and big data.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

MA CS AT

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- Yes No

CSEF Official Abstract and Certification

Word Count

155

Fair Category

PS

Project Number

6066

Title: Natural Function Restrictions, Identities, and Properties to Determine Finite Cardinalities of Solutions for Real-Valued Functions Projected onto Natural Space

Student Name(s): P. Chitirala

Abstract:

The aspects of the natural function $\text{nat}(f(x))$ and the natural solutions function $\text{nats}(f(x))$, which involves a compilation of definitions, properties, restrictions, identities, theorems, and relations are analyzed and developed for real-valued functions and determining the number of natural solutions $(c_k, f(c_k))$ of general functions such that the property $c_k, f(c_k) \in \mathbb{N}$ holds, where the x-values and the y-values of the points are both natural. These solutions are founded upon the equation $[f(x)] - f(x) = 0$ in which the natural solutions to this equation satisfy the natural solutions function, and thus the natural function, of $f(x)$. The definition of the natural solutions function is formed in terms of the natural function, and the relations between the natural solutions functions of different real-valued functions are determined in terms of the mapping and organizations of the sets including unions, intersections, and morphisms.

Technical Disciplines Selected by the Student
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MA AT

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- Yes No

CSEF Official Abstract and Certification

Word Count

255

Fair Category

PS

Project Number

6069

Title: Comparing Algorithms to Solve the Exact Cover Problem with Sudoku

Student Name(s): A. Pourkavoos

Abstract:

The exact cover problem is an NP-complete problem in computer science with practical applications in coordinating schedules. This project compared the efficiency of C implementations of the backtracking algorithm to solve Sudoku, a special case of the exact cover problem. Each program stored not only the board but also a 9x9x9 array containing which digits were possible for each cell. This allowed the program to backtrack if a cell had zero possible digits remaining, or to immediately fill in cells with exactly one digit remaining. Three backtracking variations were compared. The first was the naive approach, storing only the above arrays. The second variation also stored how many digits remained possible for each cell, updating the count as necessary. The third variation stored, in addition to the above, a doubly linked list of all possible digits for each cell, implementing Knuth's Dancing Links algorithm. Each variation has faster asymptotic behavior than the previous but also requires more operations per individual action, such as eliminating a digit. Each variation was implemented in two ways: single-threaded and multi-threaded, the latter using the POSIX Threads (pthreads) library, for a total of six programs. Of the three variations, the naive approach was the slowest, and Dancing Links was the fastest. The multi-threaded programs ran approximately 20 times more slowly than their single-threaded counterparts (1.49 vs 33.1 ms per puzzle on average), likely because the overhead of creating and terminating threads outweighed the benefits of running an already-efficient program on four cores vs one.

Technical Disciplines Selected by the Student
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CS MA AT

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4. Is this project a continuation? Yes No

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- Yes No

CSEF Official Abstract and Certification

Word Count

256

Fair Category

PS

Project
Number

6071

Title: Robotic Pancreatoduodenectomy (PD) vs. Open PD: A Meta-analysis-driven Algorithm to Enhance Surgical Decision Making

Student Name(s): E. Zhang

Abstract:

The Centers for Medicare & Medicaid Services estimates that health care expenditures will account for 19.7% of the GDP by 2028; therefore, medical resources must be prudently managed. Besides the \$3000-6000 difference between robotic and open surgery, past studies have shown the inferiority of robotic pancreaticoduodenectomy (PD) as compared to open PD. However, given the rarity of operable pancreatic tumors, a study with an adequate sample size and a sufficient assessment of bias/heterogeneity remains unperformed. To accomplish this, a meta-analysis was conducted. The present study seeks to fulfill two objectives: (1) to determine if the efficacy and feasibility of robotic PD are comparable to those of open PD, and if so, (2) to provide surgeons and patients with a data-driven algorithm to facilitate the selection of optimal PD approach in a clinical setting.

Five databases were systematically searched for studies. Twenty-four studies totaling 12,579 patients were included in the final quantitative analysis. Six primary endpoints and four secondary endpoints were selected. The Mantel-Haenszel-Cochrane odds ratio and the Inverse Variance weighted average for categorical and continuous variables, respectively, were utilized. This meta-analysis concluded that robotic PD is at least comparable to its open counterpart: Five primary endpoints favored robotic PD and one favored open PD. The second conclusion comes in the form of an algorithm that offers insight into the favorable PD approach on a case-by-case basis. These findings will improve postoperative qualities of life for patients undergoing PDs and identify situations in which expensive robotic equipment is unnecessary.

**Technical Disciplines Selected by the Student
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MA ME AT

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- Yes No

CSEF Official Abstract and Certification

Word Count

254

Fair Category

PS

Project Number

6076

Title: Developing Tetherless Motion Tracking of Wandering Insects with an Omni-directional Servosphere Robot

Student Name(s): N. Lee

Abstract:

This project is the development of a servosphere robot capable of treadmill-style operation and tetherless motion tracking. Wandering insects are model organisms for researching motion patterns and how they are affected by certain genetic factors. However, conventional methods of motion tracking, such as tethers or markers, interfere with insects' natural behavior, yielding inaccurate results. An omni-directional sphere, or servosphere, can rotate in any direction around any axis, such as with "Hamster ball" robots. A servosphere could be used as a treadmill for an insect, counteracting and recording its movements.

The procedure follows three sections: designing and constructing a servosphere robot using servo-powered omni-wheels, deriving theoretical methods of servosphere operation, i.e., an inverse-Jacobian transformation matrix, and implementing operation into the robot using Python-based motion tracking and computer vision.

The servosphere robot was evaluated based on two criteria: consistency of operation as a treadmill, and pathing error. Consistency is the frequency of successfully moving the silhouette from an arbitrary position to the sphere's center, and pathing error is the divergence of the silhouette's motion from the ideal path, measured as the trajectory's standard deviation. The results were promising, with 100% consistency and an average error of 0.484cm across all angular positions.

In this project, a servosphere robot was successfully constructed and operated by implementing theoretical models, and the viability of the servosphere robot as a motion tracking system was demonstrated. It can be used in research with genetically edited insects to isolate the effects certain genes have on motion behavior.

Technical Disciplines Selected by the Student
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EE MA CS

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- Yes No

CSEF Official Abstract and Certification

Word Count

158

Fair Category

PS

Project Number

6083

Title: Comparing the Efficiency of Autonomous and Regular Vehicles With New Requests

Student Name(s): D. Luo

Abstract:

Autonomous vehicles will become prevalent among the public within a few years, aiding in the reduction of traffic through communication between vehicles. However, properly planning the routes of these vehicles and testing their efficiency has been recently subjected to research. This experiment compares the efficiency of autonomous and regular vehicles with the appearance of new requests with total time traveled as the measure. Using Python, a computer model records the total time a regular and autonomous vehicle needs to pick up every location and fulfill new requests. The autonomous vehicle can change its route with the appearance of the new requests while the regular vehicle must make a second trip. An 8x8 grid is used for simplicity. This experiment comparing the efficiency of autonomous cars and exploring the potential of rerouting can inspire scientists to pursue the development of a smarter car. The results will help the public understand the potential increase in the efficiency of autonomous vehicles.

Technical Disciplines Selected by the Student
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AT MA CS

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- Yes No

CSEF Official Abstract and Certification

Word Count

254

Fair Category

PS

Project Number

6086

Title: Generalized Correction of Spatially and X-Z Correlated Errors through Adaptive Minimum-Weight Perfect Matching Topological Algorithms

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Abstract:

Topological quantum error correction uses the topology of surfaces like the plane or torus to correct quantum errors, helping quantum computing to be successful. However, topological quantum error correction assumes that errors occur independently, whereas real errors are often correlated. This project considers both spatial and X-Z correlation. The error model uses fixed-length random walks of errors, providing the spatial correlation. Also, chains are made up entirely of either Pauli X, Y, or Z errors, each with independent fixed probabilities. This forces the decoder to consider X-Z correlation. The decoder is a variation of the minimum-weight perfect matching (MWPM) algorithm. Instead of the weight of an edge being the taxicab distance, it is defined using a combination of functions on distance and chain syndrome overlap. The distance function combines models of the fixed length of the walk and partitions of the walk into staircase-shaped chains. The overlap function peaks at zero and complete overlap to account for Y chains. The structural changes to the algorithm reduce errors by >90% when compared to the error model and algorithm from the initial research. The new decoder accounts for a variety of parameters so that errors are more realistic, including error type distribution and the probability that the type of walk aligns with syndromes. Independent of these parameters, this revised algorithm provides at least a 30% reduction in errors as compared to the traditional MWPM algorithm. This shows this algorithm can successfully adapt to these random walk errors and improve quantum computations.

**Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)**

CS PH MA

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

- human subjects potentially hazardous biological agents
 vertebrate animals controlled substances

2. Student independently performed all procedures as outlined in this abstract. Yes No

3. This project was conducted at a Registered Research Institution. Yes No

4. Is this project a continuation? Yes No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

- Yes No