CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Nikhil Arora

Project Number

S0301

Project Title

The Comparative Strengths of 3D Printed Microlattice Materials

Abstract

Objectives/Goals

The objective was to determine which material would be the best candidate to prevent against injuries when placed in football helmets.

Methods/Materials

1.27 cm tall 2.7 cm wide cylinder of Vinyl Nitryl foam obtained from UCLA
1.27 cm tall 2.7 cm wide cylinder of 3D printed Microlattice obtained from Architected Materials
1.27 cm tall 2.7 cm wide cylinder of 3D printed Microlattice obtained from Lawrence Livermore University
Cylindrical Stencil
Instron 5966 universal test machine
Bluehill Software
Freezer

Results

Two different micro-lattice materials were compared to vinyl nitryl foam in a compression test. The Architected Materials micro-lattice had the best absorbency.

Conclusions/Discussion

The Architected Materials 3D printed micro-lattice was able to most efficiently absorb force due to its lattice like structure that allowed it to compress easily but was stiff enough to resist impact. The commercial Vinyl Nitryl foam had the second most consistent stress experienced after compressing the material but was not as efficient as the Architected Materials micro-lattice at higher strains. Finally, the Lawrence Livermore University#s 3D printed micro-lattice compressed too easily and was not stiff enough to resist force. Therefore, the Architected Materials micro-lattice was the most efficient at compressing and resisting impact.

Summary Statement

Different 3D printed materials were compared to commercial foam to see which would best prevent concussions when placed in football helmets.

Help Received

Dr. Igor De Rosa from UCLA allowed me to come to his lab in UCLA to test my materials using the Instron 5966 machine in the lab. Dr. Bamidele Ali from Architected Materials provided the donation of micro-lattice. Dr. Christopher Spadaccini donated a sample of micro-lattice from Lawrence Livermore

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Ryan A. Barnes

Project Number

S0302

Project Title

Strength of 3D Printed Interlocking Designs

Abstract

Objectives/Goals

The purpose of this research project was to create interlocking joint designs using a simple, inexpensive 3D printer and materials to demonstrate the possibility of new and stronger designs that can be quickly and easily fabricated by typical household 3D printers. Having effective interlocks allows objects larger than a single build plate area to be printed, providing the ability to create even larger items by interlocking them together into an assembly.

Methods/Materials

The 3D printed specimens were created using a Flash Forge Creator Pro. Each specimen was designed to be 70 mm by 15 mm by 15 mm when connected. Each of the eight designs had five trials. The specimens were tested in tension using a home built system that included a ladder, weights, clamps, and carabiners.

Results

The results showed that the pin and hole type joints out-performed joint designs that depended on friction or the stiffness of the flanges to prevent displacement of the flange while under tensile load. With the exception of the circular joint design and the vertically printed pin design, the designs had low coefficient of variation.

Conclusions/Discussion

The testing demonstrated that the three part pin and hole design was the strongest. Testing also demonstrated and confirmed that parts built in the horizontal direction were stronger than those built in the vertical direction. This data confirms the result from others showing that FDM printing produces weaker properties between build layers (Z-direction) than in the direction of the layers (X-Y direction).

Summary Statement

I demonstrated that the three piece pin design was the strongest 3D printed interlock in tensile load created in this experiment.

Help Received

None. I designed, built, and tested the specimens on my own.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Sophia A. Brodish

Project Number

S0303

Project Title

An Exoskeleton of the Spinal Cord to Prevent Scoliosis

Abstract

Objectives/Goals

Spinal vertebrae come in a variety of shapes, but how do the angles of each vertebra change the shape of the corresponding plate. Can an exoskeleton following these angles be worn on the exterior of the body? The larger differences in the vertebrae, the larger differences in the shapes of each plate would be; therefore, looking into specifics on each vertebra with the use of around thirty cadavers would aid in the process of calculating the different angles of each vertebra. A designed model of the corresponding plate, was created using Creo Parametric and GeoGebra. As the angles generally increased from the C3 vertebra to the T7 vertebrae, they ranged from 118.9 degrees to 292 degrees, and near the lower region of the spinal cord, the angles spiked (319.7 degrees) due to their larger size and lesser necessity for movement. The original hypothesis was accepted, because the data shows large changes in each vertebra depending on the calculated angles; however, a trend noticed with the middle vertebrae section is that they are very similar in structure due to minimal differentiation in their angles and homogenous functions. The viability of the exoskeleton will be determined by the structures of each vertebrae and how they aid in the function of supporting the spinal cord.

Methods/Materials

The largest aspect of the this project was finding the angles of each vertebrae in order to make the corresponding plates. The software GeoGebra was used to find the specific angles of each vertebrae in the spinal cord. Then the software PTC Creo Parametric (a computer aided design software) was used to 3D model each plate to be made by a manufacturer.

Results

Depending on the angle of the vertebra, having some form of an angle upward to extend was very common. The Thoracic plates were greatly affected by these angles, because they had to accommodate angles as high as 292.48 degrees in T8. The larger the angles, the larger the cutout would be at the top of each plate.

Conclusions/Discussion

The hypothesis, if the spinal cord has minor differences in structure, then the angles will have minor differences was accepted. Some vertebrae had practically the same angles, or were only different by half a degree, and those plates appeared very similar. Most of the angles increased, but there were some points where there was an obvious decrease. Overall, the data and CAD model showed the hypothesis to be almost always accurate.

Summary Statement

A spinal cord exoskeleton was designed by using the different angles in each vertebrae in order to develope a CAD model of the exoskeleton.

Help Received

I received a book on the Biomechanics of the Spinal Cord from a local chiropractor; however, I calculated my data and designed the exoskeleton by myself.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Isabella J. Catanzaro

Project Number

S0304

Project Title

Tumbling Polygons: Using Angular Momentum to Flip Polygon Robots

Abstract

Objectives/Goals

The goal of this project was to explore how polygonal robots move. Engineers have created cube robots that flip by using flywheels that spin fast and stop abruptly. My project explores beyond a simple four sided square cross-section to polygons of several sides: 5, 6, 8, 10, and 12 sides. The specific objective of this study was to determine if increasing the number of sides will decrease the torque required to rotate a polygon.

Methods/Materials

I derived an equation of motion that relates the torque required to rotate a polygon, the number of sides of the polygon and the radius of the polygon. I tested my hypothesis by creating a series of polygons of various sides, made from foam core, whose radii were based on the parameters calculated by my equation. A motor was placed at the center of the polygon. I controlled the motor through a motor driver coupled to an Arduino. The starting torque of the motor was used to rotate the polygon. I tested my equation by building and rotating polygons with a variety of sides that were larger and smaller than the predicted maximum radii that could be rotated by the motor.

Results

The results confirmed my hypothesis and equation of motion for rotating polygons. Increasing the number of sides reduced the torque required to rotate the polygon. Decreasing the radius reduced the torque required to rotate the polygon. The configurations that were rotatable and non-rotatable were very consistent with the equation of motion for rotating the polygon. Only two out of fourteen tests produced results that were inconsistent with the equation of motion.

Conclusions/Discussion

The polygonal robots with more sides were able to flip more often than the polygonal robots with the same radius and one less sides. This meant the increase in sides led to the decrease in required torque and energy to flip the polygonal robot. However, since the polygonal robots with more sides required less torque, the polygon continued to roll. Polygons with more than four sides require less torque to flip which is advantageous. The ability to control these polygons is reduced when they require torque much smaller than the torque that the motor supplies. There is an optimum number of sides and radius for the motor in which the torque and control are balanced.

Summary Statement

I created and tested various polygonal robots to prove that an increase in the number of sides led to the decrease in required torque and energy to flip a polygonal robot.

Help Received

My father explained the details of how force and torque worked but I designed, built, and performed the experiments myself.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Shannon S.Y. Chen

Project Number

S0305

Project Title

Airship Hull Optimization Using Artificial Neural Network and Computational Fluid Dynamic Simulations

Abstract

Objectives/Goals

The Artificial Neural Network (ANN) has potential to help human brains solve complex computational problems. One example is the design optimization process that involves many cycles of performance simulations and design modifications. The design of airship hull belongs to this problem category. The hull shape must be optimized for low aerodynamic drag to reduce fuel consumption. Computational Fluid Dynamic (CFD) simulations provide accurate estimate of the drag. However, each CFD cycle may take hours to complete even for a simple hull shape that has rotational symmetry about its body axis. Direct hull optimization using CFD becomes computationally formidable. This project utilized the learning ability of the ANN to overcome this challenge.

Methods/Materials

A parametric representation was developed to represent the hull shape by a few parameters. Initial hull shapes and their corresponding drag coefficients obtained by CFD simulations were used to train the ANN. With the knowledge from the training set and the help of a nonlinear optimizer, the ANN then generated a hull shape that potentially had the lowest drag coefficient. CFD simulations were followed to obtain the drag coefficient of the ANN-generated hull. The new data set was added to the training set to retrain the ANN. This process was repeated until satisfactory hull shapes were obtained. The ANN code was written in Java. Open source programs OpenSCAD and OpenFOAM were used for 3D geometry generation and CFD simulations, respectively. All computations were performed on a Linux laptop computer.

Results

Four optimization trials were performed. The hull length and volume were 5 meters and 2.2 cubic meters, respectively. The free-stream air speed was 10 m/s, equivalent to a Reynolds number of 3.3 million. The first trial used nine unconstrained hull parameters for optimization and unrealistic hull shapes were produced. In the remaining trials, the hull shapes were represented by five constrained parameters. Low-drag hulls were produced by the ANN in less than 10 optimization cycles in each trial, and each optimization only required one CFD simulation.

Conclusions/Discussion

In conclusion, low-drag airship hulls were successfully obtained by the ANN-assisted optimization. Their drag coefficients were comparable to or lower than that of the NACA Model 111. This clearly demonstrated the potential of the ANN-assisted optimization method.

Summary Statement

The learning capability of the ANN was utilized to reduce the number of CFD simulations in airship hull optimization, and a number of low-drag hull shapes were successfully achieved.

Help Received

Dr. Bob Boyd of Lockheed Martin suggested directions for research and literature study, and answered my questions about airships. Mr. Peter Starodub provided guidance and monitored my progress.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Allen Cheung; David Hoang

Project Number

S0306

Project Title

Gravity Wheel Electric Generator: Harnessing Free Energy from Ocean Waves

Abstract

Objectives/Goals

The world is currently heavily dependent on fossil fuels for power generation, which has negative impacts on the environment. Our project objective is to design and build a functioning scale model of a buoy that generates electricity through the motion of ocean waves. Our design, if successful, will help to contribute to a greener environment.

Methods/Materials

Our design concept is based on the principle of electromagnetic induction. By converting the kinetic energy of ocean waves into motions that cause multiple strong magnets to move through copper coils as well as rotating a DC motor, we can generate a constant source of electricity. The design will be in the form of a buoy that, in real world, application, will be anchored to the ocean floor along the shore. Our prototype will be a small scale model made with easily available components. We expect the prototype to generate a minimum of 1.5 Watts of energy output with moderate wave motions. Since we cannot test out design in an actual ocean environment, the results will be based on simulated motions of ocean waves. As for our materials, we used a stopwatch, various plastic components, rectifiers, capacitor, magnets, digital multimeter, and various power tools. We tested our prototype by measuring voltage over time through hand-simulated motions. Multiple design revisions and improvements were done throughout testing.

Results

The finished prototype was able to generate electricity, however, not the the level we had originally expected. It generates enough power to drive multiple LEDs through continuous simulated motions. It was tested to generate about 0.18 Watts of power, which is way below our design goal of 1.5 Watts. This is due to the limited output of the DC motor. To improve this, a more efficient DC motor can be used to achieve a higher amount of output power. Our design shows that it is possible to harvest electricity from ocean waves through the use of electromagnetic induction.

Conclusions/Discussion

From our experiment, we can conclude that our design works as expected. With improved mechanical and electrical designs, a significantly larger buoy can definitely generate more power. The power multiplies with the deploying of more buoys along the shore. Through this project, we learned the valuable experiences in applying the theory of physics to real life applications that can help to improve our environment.

Summary Statement

We created a working prototype that converts mechanical movement from ocean waves into electricity via electromagnetic induction.

Help Received

We built, designed, and tested the prototypes ourselves. A parent assisted us in using power tools.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Julia V. Cote

Project Number

S0307

Project Title

The Comparison of Strength in Different Shapes When Used in Composite Sandwich Panels

Abstract

Objectives/Goals

For my project I tested what shape, octagon, hexagon, square, triangle, or circle, when used to make the core of a composite sandwich panel, would be the strongest/withstand the most weight. I knew that hexagons(in a honeycomb pattern) were widely used because they are extremely efficient to manufacture, but what I wanted to know was whether the hexagons were actually the strongest.

Methods/Materials

Kraft paper(used commonly to make cardboard), ruler, scissors, rubber cement(used due to flexibility when dry), sand(used as weight because it could be easily added incrementally). Used paper, ruler, scissors, and glue to make 15 composite sandwich panels, with five different shapes used in the core, with 3 panels of each shape. Then added weight to test weight threshold in order to determine which shape was strongest.

Results

Five shapes were tested in three trials to determine which one was stronger. After testing it was found that a composite sandwich panel with a core made from circles was the strongest.

Conclusions/Discussion

The performance of the circles shows that there is a stronger alternative to the widely used hexagons/honeycomb when dealing with the design of the core for composite sandwich panels.

Summary Statement

Composite sandwich panels are commonly made from a honeycomb core and are used widely in many fields; I tested wether hexagons(honeycomb) was actually the strongest shape that could be used, and found that circles were actually stronger.

Help Received

None. I designed, built, and performed the experiments myself.

Name(s)

Kyle J. Ettinger

Project Number

S0308

Project Title

Multirotor Disabling Net Launcher

Abstract

Objectives/Goals

My goal is to develop a multirotor mounted net launcher that can disable unwanted multirotors. The technology must be robust, light and cost effective for wide implementation. The net launcher should have a large effective capture volume. Currently there are no effective means of disabling multirotors that pose a threat to public safety, security, privacy, aviation and property.

Methods/Materials

I investigated several means of propelling the net. This included building and testing a vacuum and a CO2 cartridge powered launcher, before deciding on compressed air. The design uses 4 bullets that are fired at the same time and expands the net, propelling it forward. Component material and design for low weight was an area of focus. I built and tested several different manifold designs to investigate the effect of bullet size, weight, air pressure, bullet weight, net material and size on net deployment. The final design was mounted and integrated to a multirotor. A servo was added to provide additional aiming control. This design was field tested against another multirotor. A combination of line of sight and FPV (video camera mounted to multirotor) was used to pilot the multirotor and fire the net at the opposing multirotor.

Results

Field testing of the multirotor mounted net launcher showed net deployment was reliable and totally effective at downing the opposing multirotor provided the net made contact with it. The net launcher plus servo control mass is 802 grams making it very feasible to mount on a multirotor. It has a capture volume of up to 3 m^3 which is a useful size and makes precise aiming less critical. The low cost of this system of $264 makes mounting on a multirotor feasible for wide implementation.

Conclusions/Discussion

Multirotor mounted net launchers could provide an effective means of protecting the public from unwanted multirotors. Improved aiming would make this a compelling technology.

Summary Statement

I developed, built and tested a multirotor mounted net launcher that can disable unwanted multirotors.

Help Received

I designed, built and tested the multirotor net launcher. My dad supervised machining of the components.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
Mitchell T. Herbert

Project Number
S0309

Project Title
Mobile Device Activated Package Theft Preventing Lockbox

Abstract

Objectives/Goals
Design an intelligent, mechanical lockbox that can prevent package theft and allow multiple package deliveries. Existing lockboxes can only accept one package before the owner must come home and unlock the box manually.

Methods/Materials
My project included a Raspberry Pi computer and camera, a wifi USB dongle, custom electronic circuits (with various components), the Kicad PCB design tool, CircuitLab (online circuit schematic editor), sheet metal (varied sizes), plexiglass, rubber sheets (varying sizes), Twilio (cloud communications), Python, Bash, Apache, and various python packages. Used a Raspberry Pi to control various circuits that mechanically unlocked a package theft lockbox from a mobile device messaging service. The camera was used to take picture of delivery man as a prompt for the owner of the box to reply to.

Results
I designed a mechanically locking package theft lockbox. This lockbox can be opened multiple times from the messaging service on a mobile device such as a phone. The lockbox is locked with a thick metal bar and was constructed using sheet metal to prevent package theft.

Conclusions/Discussion
This package theft lockbox is a large improvement upon the existing lockboxes. This lockbox can be opened from nearly anywhere at any time. This allows people on vacations to accept multiple packages remotely without having to return home to unlock the box manually.

Summary Statement
I designed an intelligent lockbox that prevents package theft and allows the owner to accept multiple packages from anywhere at anytime.

Help Received

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Charles J. Huang

Project Number

S0310

Project Title

Crystallization of Calcium Carbonate into Chitin in Agaricus bisporus for Synthetic Bone Grafting and Prosthetics

Abstract

Objectives/Goals

The objective is to engineer a new material as a cheaper alternative for Synthetic Bone Grafts and a biodegradable alternative for short-term-use prosthetics.

Methods/Materials

Agaricus Bisporus, Lyophilisation Machine (from Shannel's Flowers), 1% Acetic Acid (Diluted Vinegar), 10mM Calcium Chloride Solution, 10 mM Sodium Carbonate Solution, Google Sketchup, 3d printer, Double Diffusion Chamber (I designed and 3d printed this apparatus)

Results

From the double diffusion, I ended up with 5 materials: a 3 hour, 6 hour, 24 hour, and two 48 hour crystallization periods. Then, I measured the maximum mass each material could hold and found that the six hour crystallization period was the strongest, as it was able to hold 1952 times its own mass. The lowest results came from the 48 hour crystallization period, where it was able to hold 1031.57 times its own mass. This shows that the materials are able to withstand a lot of weight before breaking.

Conclusions/Discussion

With the average male/female being only 60 kilograms and the maximum mass 1 kg of the material could hold being 1952 kilograms, the material is applicable (as of strength) in prosthetics. Due to its biodegradability, it will most effectively apply into short term prosthetics such as holding up an arm/wrist while it heals. Because the composition of this material is very similar to bone's composition and may yield a high osteocondictibility, it could provide a cheaper alternative for synthetic bone grafts because the Agaricus bisporus mushroom can be harvested in bulk.

Summary Statement

I engineered a new material as a cost effective alternative for synthetic bone grafts and a biodegradable alternative for prosthetics by crystallizing Calcium Carbonate into Chitin in the fungus, Agaricus Bisporus.

Help Received

I designed and constructed the double diffusion chamber myself. Mr. Lendy Dunnaway helped print and lazer cut the parts of the chamber. Melanie from Shanels Flowers offered me the opportunity to use her lyophilisation machine.

Name(s)
Garron W. Ireton

Project Number
S0311

Project Title
Shrapnel or Sorry: A Study of the Effects of Armor's Trajectories on the Effective Energy of a Projectile

Abstract

Objectives/Goals
The objective of this project is to determine the effects of sloped armor on the effective energy of a penetrating projectile.

Methods/Materials
Pellet gun, ballistic gel, stove, refrigerator, ruler, protractor, 1 cm thick particleboard armor squares. Shot thru armor squares oriented at various angles and into ballistic gel lying behind. Recorded subsequent penetration violence and distance into gel.

Results
The greater the slope of the armor in relation to the pellet's path, the less penetration was achieved at the cost of greater violence of penetration.

Conclusions/Discussion
It appears that while less penetration can be achieved with armor sloping, potentially worse damage can be caused by the more violent penetration associated with such sloping.

Summary Statement
By testing the effects of armor sloping on the effective energy of a penetrating projectile, I found that sloping is a trade-off, causing less penetration but more spauling and shrapnel to occur.

Help Received
I designed and carried out the project myself. I received help with statistical analysis and some woodworking from Collin Ireton, an engineering sciences major.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Holly M. Jackson

Project Number

S0312

Project Title

CUBOCTimization: Topological Optimization of a Cuboct Truss Bridge Using a Genetic Algorithm

Abstract

Objectives/Goals

Any structure carried into space must be lightweight due to the high cost of space travel. Structures made from cuboct trusses are actively studied by NASA due to their easy modular assembly and extremely high stiffness to mass ratio. A cuboct truss is composed of repeating octahedrons called voxels. The goal for my project was to create lightweight cuboct truss bridges with programmable stiffness properties. My inspiration for the project was the lightweight lattices found in natural bird bones.

Methods/Materials

I created a genetic algorithm in Java that replicated the process of evolution. To begin, the algorithm generated a virtual population of 50 cuboct bridges with random variations (i.e. missing voxels). Children were bred from random pairs of parents from this population. To create a child, voxels (like genes) were randomly selected from either the mother or the father's structure array (or genetic code). Small random mutations were also inserted. Each child's fitness was calculated, and, if the child had a better fitness than its most similar parent, it replaced the parent in the population. This process was repeated until all of the fitness scores of the population members converged. I ran my algorithm four times with varying parameters. Each run took approximately 7800 generations over 72 hours on a 12-core computer. I created 30 real 3D-printed models of the four optimal bridges generated from my algorithm (along with a full envelope and standard bridge) using two different printers at 100% and 50% scale. I stress tested each using an Instron load testing system.

Results

After stress testing five copies of each bridge type, I compared my stiffness predictions from my algorithm to the actual Instron results. I correctly predicted the relative ranking on 4 out of 6 bridges. The error between my measured and predicted displacements averaged 38%, with the best and worst cases being 0% and 127%.

Conclusions/Discussion

I accomplished the first part of my hypothesis by evolving bridges that had a more optimal fitness than the standard and full envelope bridges. The second part of my hypothesis was that the results of real 3D tests would match my algorithm's predictions. Taking measurement error into account, I conclude that my predictions were reasonably accurate in half of the cases.

Summary Statement

I created a genetic algorithm to optimize the fitness of cuboct truss bridges and verified the results with real 3D test samples.

Help Received

I worked in the NASA Ames Coded Structures Lab under the guidance of Dr. Kenneth Cheung and Ph.D. student Daniel Cellucci. Although my project was independent, my mentors helped answer any questions. In addition, they provided lab equipment, 3D printers, and the Instron load testing system.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Patrick D. Kao

Project Number

S0313

Project Title

Stabilizing a High-Power Quadcopter

Abstract

Objectives/Goals

I was a member of a Stanford UAV club project that built an ultra-high-powered quadcopter with a thrust-to-weight ratio of 8:1 (0 to 60 mph in 0.34 seconds). We hoped to break a world record for fastest quadcopter. Because the quad was constructed from off-the-shelf parts that were known to work well, we expected it to just fly. But instead it just crashed immediately.

I was responsible for getting the quad to fly. I had to modify the stock firmware of the flight controller and the electronic speed controls (ESCs) in order to stabilize such a high-powered quadcopter.

Methods/Materials

I came up with the following procedure for determining and fixing the cause of the crashes. First, I lowered the power of the quad (by modifying the ESC firmware) until the quad flew stably. Then, in successive flights, I gradually increased the power until I observed a problem with the quad's flight behavior. Once I identified a problem, I modified the flight controller firmware to eliminate it. Then I continued to increase the power so I could observe any more problems.

Results

I identified and repaired the following problems with the flight controller's firmware. First, I had to fix a bug that caused an uncontrollable throttle increase during a hover. Second, I had change the firmware to allow PID constants less than 0.001.

The third problem required a particularly involved solution. The flight control firmware used a single set of PID gains for the entire throttle range. Unfortunately, my flight testing showed that a single set was insufficient for a high-power quadcopter. So I modified the firmware to implement a 10-segment piecewise-linear gain curve. I devised a novel procedure for determining the required gains at 10 points in the throttle range.

Conclusions/Discussion

I concluded that conventional flight control software can't be used to fly a high-power quad stably, without modifications. The methodology I devised: starting with conventional power levels and gradually increasing the power, allowed me to identify and fix problems in the flight control firmware. I showed that PID gains need to vary with the throttle, and a piecewise-linear curve can implement this variation. My experiments for determining the shape of this curve yielded a surprising result: the piecewise-linear curve is U-shaped rather than monotonically decreasing as is widely believed.

Summary Statement

I stabilized an ultra-high-power quadcopter through firmware modifications.

Help Received

Dmitry Turbiner, Eli Wu, Gordon Sun, and Russell Kao collaborated with me on the design and construction of the quadcopter. Eli recommended using BLHeli flight controller. Dmitry suggested scaling PID gains based on throttle.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Zaid A. Khan

Project Number

S0314

Project Title

A Study of the UV Blocking Ability of UPF Rated Shirts

Abstract

Objectives/Goals

The objective of this study is to test the integrity of these UPF rated shirts which claim to help prevent skin cancer, and block UV rays from penetrating the skin to a certain extent.

Methods/Materials

Tested the quantity of UVA and UVB rays penetrating the shirt with UVA and UVB probes held up by a ringstand. Data from UVA and UVB probes was collected by a LabQuest2.

Results

I tested the UPF rated shirts against standards set by the ASTM (american society for testing and materials) and they exceeded the standards. However, when i tested a regular cotton t-shirt it blocked exactly the same amount of UV rays as the UPF rated t-shirts, even though the UPF rated t-shirts were much more expensive.

Conclusions/Discussion

My results show that the standards set for these UPF rated t-shirts are skewed because these shirts do no better than regular cotton t-shirts. This means that the companies manufacturing these t-shirts are essentially selling over-priced shirts while claiming that they prevent skin cancer and block out UV rays.

Summary Statement

I tested shirts with an Ultraviolet Protection Factor Rating for their effectiveness in blocking UV rays, compared to what they claimed the shirts did.

Help Received

Riccardo Magni (mentor), The Summer Science Institute at Allan Hancock college, Dr.Murphy

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Benjamin T. Kolland

Project Number

S0315

Project Title

Project ARROW: Autonomous Rocket Return on Wings

Abstract

Objectives/Goals

To decrease the distance required to recover model rockets-which can drift several miles after deploying a recovery system-the project goal was to develop a low-cost guided recovery system that would bring a rocket directly back to the launch area.

Methods/Materials

After considering several recovery options based on previous large-scale NASA work, a 98mm diameter rocket was constructed to test a guided parafoil system. I built a small gondola module to drop test the parafoil off buildings. For the rocket, an internal avionics bay initiallly used a radio-controlled servo to steer a 0.5 square meter parafoil. To ease deployment difficulties, the final design uses a larger 2.5 square meter wing and a 140mm diameter rocket, combined with an Arduino-based guidance computer for autonomous control.

Results

Eighteen drop tests of the guidance module from buildings (6.5m to 16m height) showed that very small control inputs were adequate to steer the parafoil. Although tangling of lines was an issue in 5 of 18 drop tests, only a <5cm rotational arm was needed to provide control of the parafoil. After ground testing, a serendipitous design improvement showed an internal avionics bay could double as both a guidance module and a piston to deploy the recovery system. However, half of the launch vehicle tests still failed due to parafoil line tangling after deployment. Simultaneous to launch vehicle tests, navigational algorithms were simulated in MATLAB and ported to the Arduino guidance computer for autonomous recovery control. The Arduino GPS module was launch tested and collected data successfully and servo control worked correctly. The larger rocket design flew with two nominal recovery deployments at 281m and 615m.

Conclusions/Discussion

After my ground testing provided a serendipitous design improvement, subsequent ground testing revealed several major changes needed for complete recovery deployment. Drop testing proved parafoil guidance worked, and Arduino flight computer testing proved that autonomous guidance was possible. Additional testing is underway to optimize a reliable steering configuration for Project ARROW. This low-cost autonomous recovery system could have useful applications beyond model rocketry for small-scale payload delivery applications.

Summary Statement

Drift from wind is a challenge for model rocket recovery, so this project focused on controlling the rocket to autonomously fly back to a target area after launch.

Help Received

Supervised rocketry testing at TCC & LUNAR (J. Dougherty, D. Raimondi, J. Friedland). Aircraft testing at RC Bees with support of D. Morris, J. Boracca, S. Boracca. Drop testing support from J. Gerer. Design assistance from G. DeVault and L. Workman. Participant - Tripoli Mentoring Program.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
Maya Kumar; Anooshree Sengupta

Project Number
S0316

Project Title
A Map-Building, Self-Driving, Voice-Controlled Service Robot for the Visually Impaired

Abstract

Objectives/Goals
The objective of this project was to build a robot that can guide the visually impaired in an indoor environment. Design goals of the robot include the ability to create a map of its environment, localize itself in the map, plan a route to a specified destination, and drive there while avoiding any obstacles along the way. The robot should be directed using voice commands respond with synthesized speech.

Methods/Materials
The robot was built using an iRobot Create Educational chassis and 3D printed custom parts, and equipped with a LIDAR rangefinder, 3D camera and inertial measurement unit. The onboard computer is an Intel NUC mini-PC running Robot Operating System (ROS) on Ubuntu Linux. Each layer of the ROS navigation stack was customized for accuracy and dynamic behavior. Data filters were developed for sensor integration. An executive process was written for robot control and voice/speech interaction. Development was done on an iMac running Ubuntu Linux and communicating with the NUC over Wi-Fi.

Results
Our robot could successfully create a map of an indoor environment, determine its position in the map, plan a path to a destination and drive to it while navigating around temporary obstacles. It accepted voice commands and responded with context-aware spoken answers. The map was accurate to within 0.3m for every 10m of linear distance. Self-driving was accurate to within 0.5m from the center of the robot to the actual destination. Voice command processing recognized key phrases 82% of the time, and rejected non-test phrases with 96% accuracy.

Conclusions/Discussion
We achieved our goal of building a robot that can guide visually-impaired persons in an indoor environment. Mapping and localization accuracy were excellent and voice/speech interaction was adequate for the task. While purpose-built guide robots have been reported in the literature, they tend to be large, expensive unitaskers. Our robot can be built inexpensively using commercial parts. With a powerful, general-purpose PC on board, it is a versatile, modular and upgradeable platform for future applications such as health monitoring and social interaction for the visually impaired.

Summary Statement
We built a robot that can autonomously guide a visually impaired person in an environment by first creating a map of an environment and then using voice commands to drive to a specified destination in the map while avoiding obstacles.

Help Received
We designed, built and programmed our prototype and final design ourselves. After the completion of our prototype, we met with Professor Stefano Carpin of UC Merced, who advised us to consider developing on ROS running on a more powerful onboard computer.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Benjamin C. Liu

Project Number

S0317

Project Title

A Lab-on-a-Chip Device Incorporating Novel Micropumps, Microvalves, and an Acoustic Micromixer for Disease Diagnostics

Abstract

Objectives/Goals

Normal RNA analysis requires multiple lab processes and manual handling that is tedious and prone to human error. The goal of this project is to develop an integrated lab-on-chip device that utilizes novel, but simple microvalves, micropumps, and micromixers, to carry out raw sample-to-answer biological analysis for disease diagnostics.

Methods/Materials

Individual microfluidic technologies were developed first: 1) Acoustic micromixing was tested in a plastic chamber consisting of tiny air pockets. The chamber was machined using CNC and attached with a PZT disk, and a function generator was used to create acoustic energy for micromixing. Relationships between design elements and mixing efficiency were studied through several designs 2) A micropump involving water electrolysis was tested using a DC power supply, NACl solution, and paper clips. 3) Simple microvalves were successfully developed to simplify fluid control using candle-wax and resistive heaters. An integrated microfluidic device consisting of the above components was developed and tested on human urine samples for detection of Chlamydia Trachomatis.

Results

The fully-integrated device demonstrated significant advances to current technology. The acoustic micromixing reduced normal mixing times from 6-8 hours to 6-8 seconds. The inexpensive electrochemical micropump generated only H2 gas for liquid pumping. The relationship between pumping rate and DC current was also established. Furthermore, both normally open and closed wax microvalves for fluidic manipulation were successfully demonstrated. The integrated, self-contained device took raw samples and performed cell lysis, RNA capture/separation, RNA isothermal amplification, and real-time RNA detection for Chlamydia Trachomatis analysis. The device produced diagnostic results comparable to those generated from current technologies.

Conclusions/Discussion

An integrated microfluidic device was successfully developed for RNA analysis-based disease diagnostics. This is the first demonstration of lab-on-chip technology for RNA sample preparation and isothermal amplification on a single chip. With successful diagnostic performances testing Chlamydia Trachomatis, the device yields high potential in diagnosing thousands of other RNA-based diseases. RNA analysis can now be transformed from reliance on bulky, expensive lab equipment to a portable, integrated platform that is more accessible and affordable.

Summary Statement

My project is about the development of a lab-on-a-chip microfluidic device that integrates all lab functions for infectious disease diagnostics into a simple, inexpensive, and effective chip for sample-to-answer biological analysis.

Help Received

I designed, tested, and optimized the device design and individual components on my own. Dr. Robin Liu mentored me and gave me advice on improving my research. RD Bio Sciences Inc. gave me access to their lab equipment to conduct research.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Peter Y. Liu

Project Number

S0318

Project Title

Comparison of the Effect of Fixed and Natural Boundary Layer Transition on Airfoil Drag at Low Reynolds Numbers

Abstract

Objectives/Goals

This project is on testing whether or not a turbulent boundary layer can be beneficial in reducing overall drag on an airfoil at low Reynolds numbers.

Methods/Materials

Desktop/Laptop (Windows) computer with a fluid simulator XFOIL installed from the original MIT site. The code itself is developed by Mark Drela. XFOIL was used to modify or trip the boundary layer on an e222 airfoil (downloaded from Airfoil Tools) and the resulting output polar file analyzed by a text editor and Office Excel. This was done in six total configurations: 3 low Reynolds numbers (Re) and two trip types (Re = 200000, 300000, 400000, and tripped top & bottom surface or just top).

A wind tunnel was also made out of garage materials for visualization. These included a ShopVac, 3/4 inch plywood, two 2x4s, black spray paint, pipe clamps, flexible hose, and a valve. Dry ice was put inside the vacuum for airflow visualization.

Results

At Re = 200000 and 300000, drag was reduced for both the top & bottom and just top surface transitions. The LSB was also qualitatively noted to be reduced by looking at the pressure outputs. Drag was not reduced at Re = 400000 because of excess friction drag, which XFOIL can also predict.

Conclusions/Discussion

Since at 2 out of 3 Reynolds numbers the drag was still reduced using a turbulent boundary layer, the project concludes that a turbulent boundary layer can reduce drag by eliminating LSBs at certain Reynolds numbers. Friction drag is too high at higher Reynolds numbers so the turbulent boundary layer then becomes detrimental and increases overall drag.

Summary Statement

I showed how modifying fluid flow over an airfoil (2D section of a wing) could be beneficial in reducing drag on drones or airplanes in certain conditions.

Help Received

I received help from Dr. Raymond Chow from the Department of Mechanical and Aeronautical Engineering at UC Davis and Capt. John Rousseau of the Navy in understanding basic aerodynamics and how to use XFOIL. My AP Research teacher Dr. Nikki Malhotra helped me to access research papers. I

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Henry A. Mason

Project Number

S0319

Project Title

Make It or Break It, Now in Color: The Effects of Colorant on the Strength of PLA Polymer 3D Printed Objects

Abstract

Objectives/Goals

This study examines the effect of colorant on the strength of objects printed with polylactic acid (PLA), a biodegradable plastic. Colored filament is made of this PLA blended with pigments such as organic azine dyes. Considering that pigment is an additive and can therefore make a difference in the mechanical properties of plastic, I chose to study the behaviors of different color plastics under stress and to note the differences.

Question: Does color affect filament strength? What effect does colorant have on the structure of plastic? Of colors used for PLA 3D printer filament, which color is strongest?

Hypothesis: Filament with no dye or added color (natural) will outperform the plastics with color in stress tests.

Methods/Materials

Using basic hardware from the hardware store, I built my test equipment at home for all but the compression tests. The equipment I built allowed me to test flexure, tension, torsion, and shear; while I ran my compression tests using the leg press machine at a local gym.

I used a fish scale to measure the amount of weight being applied to each object up to its point of breaking (again, apart from the compression test, which was a matter of stacking weights on top of each test object).

Results

The study found that, contrary to my hypothesis, the natural or uncolored PLA was not the strongest in any of the tests, but rather the yellow was consistently the strongest. This does indicate that the colorant makes a difference in the strength of printed objects, as I discovered that each color of PLA behaved differently.

Conclusions/Discussion

The additives in filaments include more than just color and affect the mechanical structure of a 3D-printed object. My findings confirmed that color makes a difference in the mechanical properties of the printed objects.

This research proved that color causes differences in the mechanical structure of the plastics; in fact the

Summary Statement

This study tests for the effects of colorants on objects 3d printed using PLA plastic.

Help Received

My father for assisting in 3d printing and testing; Dr. Daniel Fernandez (CSUMB) for proposing the idea; Dr. Paul Stivers for hints about polymer chemistry; Mr. Thomas Shelby for reviewing my display and chemistry; Mr. James Arao for presentation coaching

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
Shaunak Modak

Project Number
S0320

Project Title
A Novel Method for Diagnosing Mechanical Component Failure Using Sound

Abstract

Objectives/Goals
Effective mechanical component failure diagnosis for consumer applications is an ongoing need in the automotive industry. The goal of my project is to prove the effectiveness of a system that is able to detect and categorize various mechanical component failures through audio analysis and serve as a simple early diagnostic tool for consumers and mechanics.

Methods/Materials
The apparatus consists of a commercially available USB microphone and a sound-card oscilloscope program, Soundcard Scope, built by National Instruments and accessed using an educational license, operating on a laptop computer. Readings are taken using the microphone, and the audio waveform is then transferred to the frequency domain using the oscilloscope analysis software. The failure signature is isolated by subtracting the Fourier Transform of the waveform of the correctly functioning component from a transform of the waveform collected for a failing component, and the signature is compared to previously collected signatures to diagnose the failure.

Results
The distinct frequency signatures of mechanical failures including worn brake pads, ruptured vacuum hoses, worn serpentine belts, and loose dust covers were successfully characterized. The apparatus was able to accurately detect and isolate frequency peaks across the entire frequency range corresponding to each mechanical failure, and spectrum broadening in a revving engine's sound profile was also characterized.

Conclusions/Discussion
The study validated the potential for this audio signature analysis method in automobile failures. A similar technique can be extended to various other mechanical systems in consumer applications as well as industrial settings. Basic audio diagnosis can be accomplished by ordinary consumers through a smartphone application. In more sophisticated industrial settings, the technique can be applied for early detection of failures and system monitoring.

Summary Statement
A novel sound-based method for diagnosing mechanical component failure using a simple microphone # oscilloscope apparatus was developed and successfully used to categorize mechanical failures based on audio frequency signatures.

Help Received
Guidance in understanding mathematical and physical principles of the project was provided by Mr. Greg Burroughs, my calculus teacher and the mentor of the Homestead FIRST Robotics Team, of which I am a member.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Labanya Mukhopadhyay

Project Number

S0321

Project Title

A Study of Micro-robotic Motions with Helical Flagella in Low Reynolds Number Liquids

Abstract

Objectives/Goals

In fluid mechanics, a unit less ratio known as Reynolds number quantifies the relative importance of viscous forces over inertial forces. My hypothesis is that the speed of the micro-robots through high viscous liquids at room temperature will decrease with increasing viscosity. Also the helical flagella which has larger length will generate more thrust on the liquid, move faster and have more stable motions through the liquids. Speed through a given liquid medium will increase with larger flagella diameter for a given length and pitch of the flagella.

Methods/Materials

The micro-robot was made using the dc motor from the electronic flosser, two coin batteries, and push button latching switch. The viscosity of three liquids, corn oil, motor oil, and car washing detergent, were first measured based on Stokes' law and compared against the known values. Then the speed of the robot was recorded through these mediums.

Results

The viscosity value measured for corn oil, motor oil and car detergent are 300, 600 and 7000 centipoise respectively, which is close to expected values. The experiments showed that speed of the robot decreased with increasing viscosity of the medium. Also the micro-robots with larger flagella length moved slower with decreasing speed. Velocity also decreased with larger helical flagella diameter for a given liquid, length and pitch of the flagella.

The calculated Reynolds number for corn oil, motor oil, and car detergent are 3.5, 0.33, and 0.006 respectively.

Conclusions/Discussion

The experimental data about the speed of the robot for different parameters of the flagella partially contrasted my hypothesis. I found out the reason for the anomaly is due to greater drag force and load on the motor due to increasing length and diameter of flagella. The Reynolds number for all three test liquids are much less than 2000, which conforms to laminar flow. The measured value of the Gray and Hancock coefficients also matched Resistive Force Theory(RFT), the ratio of the normal and tangential force coefficients being under 2.

The study has numerous applications in real world. These micro-robots in nano-scale could be propelled through arteries and veins for targeted drug delivery, minimally invasive surgical procedures, removal of arterial blockage and many more. These micro-bots can also be useful in detecting and repairing cracks and other internal damages in the oil pipelines.

Summary Statement

A novel approach to the design of swimming micro-robots with helical flagella and studying the effects of flagella characteristics on its propulsion through different low Reynolds number liquids.

Help Received

Received help from my dad in soldering the electronic circuits for making the micro-robot, and for taking pictures during the experiments.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Mia B. Pardo

Project Number

S0322

Project Title

Gamma Radiation: The Effects of Shielding

Abstract

Objectives/Goals

In todays society, the current standard for radiation shielding protection is the use for large lead and concrete blocks to shield against radioactive sources. Examples of this are particle accelerator facilities in nuclear power plants. However, lead and concrete are very heavy and difficult to install in smaller devices like robots. Currently, at the Fukushima plant in Japan they are having trouble sending in robots to explore inside the damaged plant. The radiation inside is so strong that it short circuits the robot wires and essentially disables the robot immediately. This project aims to explore new shielding combinations that are much lighter than lead, but provide the same level of protection against radiation. The goal is to have a material light in weight and can have the robot incased in it, in order to protect it against the intense level of radiation found inside a nuclear power plants core.

Methods/Materials

First, I placed a radioactive Co-60, isotope sample (1 uCi) in a tray stand. Next, I took the probe of a Digital Geiger counter and placed it on top of the stand. Once I took 20 CPS, I placed one layer of shielding material between the isotope sample and the probe, then repeated this process until I got to 4 layers of shielding. I did this until I got 10 different combinations of 4-layered shielding materials. I also used water as a shielding material as well as different alloys I created.

Results

My results show that certain combinations of aluminum serve just as well, if not even better, than lead radiation absorbers, as well as being much lighter. Further investigation should be carried out to test these results more.

Conclusions/Discussion

In conclusion, if my results are correct, there is a chance that the robots and different equipment in Fukushima could potentially be covered with a much lighter material, that could also be just as effective as layers of thick lead and concrete.

Summary Statement

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Help Received

Mr. Levon Dovlatyan

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Aaron E. Parker

Project Number

S0323

Project Title

Hyperloop Beta: A New Method of Transportation

Abstract

Objectives/Goals

My project was to prove which method could propel a cart the fastest through a levitational tube. It was also to prove if the hyperloop could be built. I believe that the hyperloop can be built, and that the vacuum or suction of air will propel a capsule fastest through a levitational tube.

Methods/Materials

90 degree angle plastic visible corner guard, magnetic strips (double polarity, one side lengthwise south opposite side north), miniature plastic hollow box, tiny magnetic strips, clear tape, tape measure, plastic cutter, Plastic support blocks, gliders, small funnel, balloon , 20V Vacuum, stopwatch, DC motor, battery, coil, nail, labeling tape.

The project's intent was to build the tube and capsule, test for levitation and run a pretest to find out which method of propelling the capsule would work best. Pretest was run using magnets, electromagnets and air.

First, I figured out which propelling method propelled the cart fastest. Then, I tested 3 different ways of using the air method to propel capsule in the most optimal way: Balloon. vacuum and fan.

Results

The suction of air propelled the cart the fastest through a levitational tube. The vacuum system achieved the fastest rate of speed and fastest time to travel the distance of the tube. The pressurized balloon of air came in close behind. The fan had the slowest rate of speed. Therefore, the vacuum is the fastest method to propel a capsule through a levitational tube.

Conclusions/Discussion

The Hyperloop is a theoretic, idealistic, yet planned high-speed American technologically based transport. It is currently being viewed for development by a series of companies. This system involves the use of pressurized capsules riding on a cushion of air in reduced- pressure tubes propelled by air compressors and linear induction motors. The idea was originally put forth by entrepreneur Elon Musk, calling it the 5th mode of transportation.

My project was to prove if Elon#s idea could come to fruition. I proved my hypothesis correct. The hyperloop can be built and a vacuum/suction of air does propel a capsule throughout a levitational tube the fastest. Therefore, Musk#s idea is possible and utilizing air as a method of propulsion for the Hyperloop would be a success.

Summary Statement

I built a levitating transport system (capsule and tube) and successfully demonstrated that air propulsion is the most effective method to propell this new transport system.

Help Received

I designed and build the levitating capsule and track by myself. My parents, both electrical engineers, assisted me in understanding the dynamics of levitating systems.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Tyler E. Robertson

Project Number

S0324

Project Title

Improving Residential Solar Panel Efficiency in a Drought: A New Method to Clean Solar Panels without Water or Manpower

Abstract

Objectives/Goals

Thanks to falling prices and legal mandates, residential solar panel installations increased 70% in 2015, with California leading the way. In the Central Valley, there is plenty of sunshine to support solar energy projects. However, the prolonged drought has produced dry, dusty conditions in the surrounding agricultural areas and poor air quality with high particulate and ozone levels. These conditions result in the buildup of material on solar panels, reducing their efficiency. Currently, residential solar panel cleaning options are limited to hand cleaning with water or very expensive machines. The goal of this project was to design and build a cost-effective robot that would clean residential solar panels without the use of water or manpower.

Methods/Materials

Lego NXT, Arduino microcontroller, paintbrush roller, IR remote, Bluetooth receiver, ultrasonic sensor, CO2 inflator. Three different robot prototypes were designed and built. Each prototype was tested for effectiveness at driving straight and turning on a solar panel placed at an increasing angles (0-40 degrees). The ultrasonic sensor provided distance feedback to keep the robot from running off the edge of the solar panel. Prototypes were programmed to be autonomous or remotely controlled with either infrared or Bluetooth technology.

Results

Prototype #3 was the most effective using four wheel drive and Bluetooth control. It was able to move in all directions on solar panels at 20 degree angles and travel straight across panels sloped up to a maximum of 40 degrees. The ultrasonic sensor provided consistent edge detection during autonomous running of the robot. Wheel traction was the limiting factor in the robot's effectiveness as roof slope increased.

Conclusions/Discussion

The prototype robots demonstrate the ability to clean residential solar panels on sloped roofs without the use of water to allow improved solar panel efficiency in high particulate regions. The robot was designed to be portable, cost-effective, and easily controlled with a remote, reducing the need for physically washing solar panels on a roof. I believe that my project has a lot of potential on the market, especially for homeowners in areas of high dust or pollution.

Summary Statement

I designed and built a cost-effective robot that cleans residential solar panels without the use of water or manpower.

Help Received

The RobotShop at Fresno IDEAWorks provided mentoring with robot programming. My parents supervised operation of power tools required during build.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Manjit Ruprem

Project Number

S0325

Project Title

A New Mechatronic Platform for Neuromuscular and Joint System Rehabilitation: Tested for Parsonage Turner Syndrome

Abstract

Objectives/Goals

This project designs and fabricates a programmable mechatronic platform for universal neuromuscular and joint systems rehabilitation through interchangeable end-effectors. The objective includes testing of rehabilitation motion profiles.

Methods/Materials

The design and fabrication includes (a) mechanical design specification and material selection, (b) interfacing of electronic control systems, and (c) development of motion profile algorithm. The mechanical structure was developed in CAD software (PTC CREO). After structural analysis, the model was fabricated. Required components and mechanisms such as hex shaft, bearings, shaft collars, chains, sprockets, couplers, etc., were purchased to integrate with the structure. Distributed automation scheme using CAN Bus was implemented. The important electronic and electrical components are motors, Talon speed controllers, NI roboRIO microprocessor, quadrature encoders, sealed lead-acid battery, power distribution panel, and wires. A software backend was developed in MATLAB to generate motion profiles in 3D space using Bezier curves. A LabVIEW GUI was developed to drive the motors in the assembled structure to follow the desired motion profiles.

Results

This project directly applies scientific principles to manufacturing and practical uses. The designed universal mechatronic platform works as per the objective. The end-effector movement mechanism performs user-defined movements with precision and accuracy of 5% and 10%, respectively. The dynamic response is improved through PID loop tuning. Through active position control, the prototype is capable of generating the required complex motion profiles in 2D and 3D using Bezier equations and Hobby splines. For validation, the platform was tested to generate and execute motion profiles for Parsonage Turner Syndrome.

Conclusions/Discussion

The design and development includes mechanical design and fabrication, electronic control systems, and software development for automating the platform. The design is universal in that it can accommodate several types of neuromuscular and joint-system rehabilitation, in contrast to available, dedicated types. The design is original.

Summary Statement

The new universal mechatronic system with interchangeable end-effectors is capable of generating complex 3D motion profiles with Bezier curves and executing them for neuromuscular and joint-system rehabilitation.

Help Received

(1) Mr. Bob Cain from Harris Manufacturing (Fresno), (2) Mr. Le from ADCO for inspecting standards, and (3) Abhijit Suprem from Fresno State for mentoring.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Julienne I. Sauer

Project Number

S0326

Project Title

HeadSentry: A Real Time System for Preventing Second Impact Syndrome from an Overlooked Concussion in Aquatic Sports

Abstract

Objectives/Goals

Concussions and other head injuries are very common in a wide variety of contact sports. However, a concussion that goes undetected can be severely life threatening to athletes through what is known as Second Impact Syndrome (SIS). As a result, this research project presents HeadSentry, a real-time monitoring system that can help identify whether an athlete has suffered an impact that could potentially cause a concussion, and initially focuses on the sport of water polo.

Methods/Materials

This project employed a multifaceted approach through the following steps. First, an online survey was conducted to substantiate the need for more effective concussion detection in water polo. Next, the biomechanics of concussions were investigated. Then, a sensor using accelerometers was constructed into existing water polo caps to measure the acceleration of a head during an impact. Tests were conducted using a crash test dummy head and neck system to measure the severity of ball impacts.

Results

It was found that impacts towards the front of the head were more dangerous than towards the side and that reducing the air pressure of the water polo ball could potentially reduce the prevalence of concussions. Lastly, a real-time monitoring system and web application was developed to notify coaches when a player is struck, identify potential symptoms, and propose diagnostic tests based on the direction and severity of the hit.

Conclusions/Discussion

As HeadSentry continues through the development process, it will expand into a more elaborate concussion detection and diagnostic system to revolutionize player safety in a multitude of sports.

Summary Statement

This research project presents an innovative system designed to improve the current methods of concussion detection and to prevent the potentially fatal Second Impact Syndrome (SIS).

Help Received

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
Alex C. Tacescu

Project Number
S0327

Project Title
Project Maverick: An Omni-Directional Robotic Mobility System

Abstract

Objectives/Goals
Nearly 40% of people age 65 and older have at least one disability; of those, two-thirds have difficulty walking. Wheelchairs can help people who have a hard time walking, but they are difficult to operate in tight spaces and, although they can provide physical respite, their users can develop muscular atrophy over time. Project Maverick is an omni-directional robotic system designed to offer a mobility solution for people with disabilities. By having the capability to move in any direction, Project Maverick mimics the movement patterns of humans.

Methods/Materials
I used Autodesk Inventor Professional 2015 to design my whole project in 3D. Developed assembly and manufacturing drawings and selected gears, pulleys, belts, bearings, gearboxes, and motors. Selected the control system: BeagleBone Black- a Linux-based single board computer, motor controllers, and sensors. Developed software using Java to electronically synchronize all 8 motors using input from the 3D mouse and analog and digital sensors.

Results
To demonstrate the feasibility of the robotic system, I designed, built and tested a full size prototype, demonstrating the functionality of the drive and control systems as well as the collision detection and autopilot systems. The drive system uses 4 wheels and 8 motors. Each wheel module has 2 independently-controlled motors - one for steering and one for driving - to provide maximum maneuverability. The system is simple and modular, built out of 4 identical wheels, and feasible to be mass produced. All 8 motors are controlled using a Linux-based controller programmed in Java. The main user input device is a 6-axis 3D controller, providing a simple and intuitive driving system.
The robot is also equipped with 2 intelligent safety features: collision detection and autopilot through doorways and narrow hallways. To detect possible collisions the system is using an array of infrared distance sensors (single beam and 2 dimensional).

Conclusions/Discussion
I was able to validate that this new design concept can be used to build a mobility solution that is feasible and cost effective. Based on the feedback received from potential users, Project Maverick proved its purpose - to improve the quality of life for people with walking disabilities.

Summary Statement
My project is a robotic system that provides a mobility solution for people with walking disabilities, using a 6-axis 3D controller as an input device and a new drive system with 8 motors that allows the user to move in any direction.

Help Received
Excelsior, BP Precision, Serpa Packaging, and Sunrise Medical machined some of the parts I designed. I provided 3D models and engineering drawings.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Sanjeev P. Thurgam

Project Number

S0328

Project Title

Teaching Tennis to Beginners through the Aid of a Hand Device

Abstract

Objectives/Goals

In this project, I am designing a mechanism/device whose purpose is to help tennis players learn how to create/generate topspin in their shots. In tennis, topspin vital to a good player's game, increasing consistency, margin of error, and power, but is extremely hard to master. The design criteria of my device is for it to be comfortable, light, visually appealing, safe, and to ultimately be successful in generating topspin, and to improve the player#s shot.

Methods/Materials

At a glance, the device uses a programmable NXT Mindstorms servo motor, programmed through proprietary NXT software, connected to axles, bound to a simpson tie cinched at 27 degrees, the angle of pronation, that fits into a carpal tunnel wrist stabilizer, with the trigger as a NXT Touch Sensor. When the motor's program activates via contact by the Touch Sensor, the rotation allows for the wrist to spin and curve over the ball, generating topspin in the shot. The device was tested by operating while the subject hit a series of shots. A problem with the project is that topspin exerted on the ball, cannot be quantified as numeric, visual, or any specific or definite data. Instead, I tested for direction of movement on the arm, and degrees rotated on the arm, along with conducting surveys and getting generalized observations of the subject's performances and opinion.

Results

After conducting tests, assuming a western grip, my device averaged 43 degrees back and 40 degrees forward, and was observed that the general push of the device was usually enough to lead the subject into the actual motion, most of the time. Though too weak for the initial level of force envisioned, the degrees generated, along with surveys and observations of the subjects who tested it, proved that the device does perform the motion needed to generate topspin.

Conclusions/Discussion

With the use of the NXT programmable brick, or any other programmable software, the device can be developed to teach the subject all sorts of strokes, including slices, serves, etc. This device mainly focuses on programmable forearm rotation, allowing for this device to be transferable to aid in the teaching of other sports as well, including forearm rotation in football, baseball, etc, based off of the principle and concept demonstrated by this device.

Summary Statement

I created a prototype that helps tennis players learn how to generate topspin in their shots, and can aid in other wrist-related sports.

Help Received

Jim Swansiger- Director of Tennis at Castlewod, gave me access to tennis players who could test my device

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Jerret M. Tingler

Project Number

S0329

Project Title

Building a Smart Blind to Work Off of a Light Sensor

Abstract

Objectives/Goals

People don#t want to be bothered by opening and closing the blinds all the time to conserve energy. To resolve this problem I am going to engineer a computer controlled blind called a Smart Blind. This Smart Blind will increase people's enthusiasm for conserving energy because it will be convenient. This unit will be activated by a light sensor that will control a motor that will open and close the blinds automatically.

Methods/Materials

To build my Smart Blind, I took four 2x4#s and built a frame to which I attached a small blind. For Prototype 1 I added a motor and rubber band which was attached to the housing of blind. For Prototype 2, I controlled the blind from the inside. To do this I attached a gear to the rod on the inside of the blind, I then attached a series of gears to the motor. For Prototype 3 I changed the motor to a stronger motor and changed the sequence of gears. For Prototype 4 I changed a couple of things in the program then added a remote for better accessibility to the program. With Prototype 5, I changed the system entirely using Raspberry Pi #, to reduce expenses.

Results

Prototype 1 did not work because it could not get a grip on the outside rod. In the end it failed half of my design criteria. Prototype 2 worked, but the motor was not able to turn the gears well enough. In the end it failed half of my design criteria. This left me with Prototype 3 which, I succeeded in getting to work, and met four points of the criteria. However, I was unable to use the second light sensor because it's a different type and an older model than my first one so they aren't sending back the same information. It wasn#t as accurate, so I added a second sensor to Prototype 5. For Prototype 4, I used the same unit, but with different programming. This failed one point of the criteria. Prototype 5 worked the best overall. I was able to use an inexpensive computer with good programming, that made it user friendly.

Conclusions/Discussion

I was able to build a computer controlled system that opened and closed blinds using a light sensor. I built six prototypes. Prototypes 1-4 were all using Mindstorms# so they were expensive. Prototype 5 is the Smart Blind of choice, engineered to meet user friendly and cost effective criteria.

Summary Statement

I built a mini-blind that uses a light sensor to open the blinds.

Help Received

I programmed the computer myself after doing some research on the internet and consulting my brother, Ajay Tingler.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Maya A. Valeriano

Project Number

S0330

Project Title

Breaking Point: The Relationship between Strength and Temperature

Abstract

Objectives/Goals

The purpose of this experiment was to determine how lower temperatures would affect the strength of plastics, specifically Acrylic and SAN (Styrene-Acrylonitrile Resin).

Methods/Materials

Both plastics were tested at room temperature (70°F) and, using dry ice as a method of cooling, -109.3 °F. Eight pieces of plastic, each 6 cm x 1 cm x .16 cm, divided into 4 groups of 2 were tested at each temperature using a stress application contraption. Weight was added to the contraption and exerted onto the piece of plastic until it broke. Then the mass of the weight was recorded for each one.

Results

The masses of the weights showed that the average weight required to break Acrylic at low temperature was 310 g higher the weight required at room temperature, and for SAN, there was only a slight 1 g difference between the average weights required to break the plastic at both temperatures, the room temperature weight being slightly higher. The results, however, did not show any significant decrease (at a 99% significance level) in strength as the temperature decreased.

Conclusions/Discussion

Because there was no significant decrease in strength with the decrease in temperature of both plastics, this suggests that in the brittle temperature phase there is no significant change in strength as the temperature is lowered.

Summary Statement

I showed how the strength of plastics changes as the temperature is lowered.

Help Received

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Maya Varma

Project Number

S0331

Project Title

Autonomous Smartphone-Controlled Robotic Wheelchair with Beacon-Assisted Navigation

Abstract

Objectives/Goals

With the aging U.S. population, use of assistive devices by people with mobility impairments has been increasing rapidly. My objective in this project is to design and prototype a highly autonomous wheelchair robot using readily available and low-cost technologies. The wheelchair is controlled by an Android app running on the user's smartphone, which can accept voice commands and navigate autonomously to a specified destination in an indoor environment. The wheelchair makes use of Bluetooth Beacons to identify its location and download navigation data from the cloud, thus avoiding the need to store location data in the smartphone and eliminating the need to train the system in an unfamiliar environment. Such a wheelchair can significantly improve the quality of life for the elderly and the disabled by eliminating injuries from collisions, as well as enabling them to navigate through airports, shopping malls, etc. without assistance.

Methods/Materials

I have designed and built a prototype of the wheelchair robot using off-the-shelf parts. The robot is equipped with an array of sensors, including a LIDAR. An Arduino Due board controls the motors and sensors and performs steering and obstacle detection. Autonomous navigation is performed by an Android app running on a smartphone. I developed both the control software running on the Arduino, as well as the Android app. The app identifies the location of the wheelchair by monitoring Bluetooth Beacons in its vicinity, which is then used to obtain path information to the desired destination from the cloud. My software also supports a semi-autonomous mode in which the user can steer the robot using voice commands.

Results

I have tested the ability of the smartphone app to detect the beacons and navigate the robot by deploying five Bluetooth Beacons along the desired path in my school. The wheelchair controller is also able to steer around obstructions using the LIDAR and other sensors. By incorporating a remote control and monitoring capability where a second smartphone can control and monitor the wheelchair through a WiFi link, I was able to safely deploy the robot and collect real-time data from it.

Conclusions/Discussion

My results show that it is possible to design a wheelchair that can autonomously navigate in an indoor environment without training. My software can be ported to a full-size wheelchair with minimal changes.

Summary Statement

I developed a self-navigating robotic wheelchair controlled by a smartphone app and Bluetooth Beacon technology.

Help Received

None. I designed, built, and tested the robot myself.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
Francisca Vasconcelos

Project Number
S0332

Project Title
Shape-Shifting Origami Robotics

Abstract

Objectives/Goals
This work addresses the design of shape-shifting robots, which can transform into any desired shape.

Methods/Materials
A deformable robot was assembled, consisting of triangular 3D-printed flaps. The flaps are connected by servo joints, so as to create a triangular 2D mesh. This mesh follows the tetraki tiling pattern (deemed the Universal Creasing Pattern), which can fold into any 3D shape if the flaps are small and plentiful enough. For this, each joint is equipped with a pair of micro servos, creating a hinge that can rotate 360°. The servos move in a coordinated manner, under the control of an Arduino Uno. This is connected to a PWM Servo Driver, which distributes current and voltage so as to control 16 servos simultaneously. The coordinated movement of the hinges enables the robot to transform into target 3D shapes. For this, a computer graphics triangulation algorithm is first used to create a 3D triangle-mesh representation of the shape. An origami simulation algorithm then calculates the collision-free folding trajectories that map the 2D triangle mesh of the robot into the 3D shape mesh. These folding trajectories are converted into movement commands for the robot joints, and delivered by the Arduino. Two new Arduino libraries have been developed to easily control each of the hinges and individual servos.

Results
Several demonstrations have been developed to illustrate the countless applications and potential of this technology.

Conclusions/Discussion
While currently an eight-flap robot is implemented, the mathematics and principles can be extended to any number of triangles, enabling robots that can be specialized for countless tasks.

Summary Statement
I built a shape-shifting origami robot, consisting of 3D printed flaps, servos, and an Arudino Uno, that can fold into a variety of shapes and structures.

Help Received
None. I designed, built, and tested the robot entirely by myself (in my bedroom). My parents provided all the used materials and work space.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
Justin C. Weiner

Project Number
S0333

Project Title
The Effect of Football Helmet Inflation on Energy Absorbance

Abstract

Objectives/Goals
The objective of this experiment was to determine the effect of football helmet inflation on the amount of energy that the helmet absorbed.

Methods/Materials
In order to test the hypothesis, an anatomically accurate human analog head was constructed using a mannequin head which was hollowed out and the cranium was replaced with a coconut shell while the remaining space inside the head was filled with simulated cerebrospinal fluid. An accelerometer was placed inside the head and secured to a modeled brain stem. It was used to determine the forces exerted on the human brain and the head was placed inside of a Shutt DNA football helmet. The helmet was then struck in the same place by an air powered pneumatic cylinder pressurized to the same 550 kPa each time to ensure maximum consistency.

Results
It was found that at lower helmet pressures the energy absorbance was slightly higher (approx. 0.3% difference). At 100% inflation, 99.25% of the energy was absorbed whereas at 80% inflation, 99.34% was absorbed; at 60% inflation, 99.46% was absorbed; at 40% inflation, 99.47% was absorbed; at 20% inflation, 99.48% was absorbed; and at 0% inflation, 99.51% was absorbed. The average deviation was found to be extremely low at 0.026%.

Conclusions/Discussion
Under normal circumstances the 0.3% difference would have likely been deemed inconclusive, however the human brain is so delicate that this seemingly small energy difference could have a profound clinical impact; especially when considering that for professional players, 0.3% of the impact is still a difference of nearly 7 newtons.

Summary Statement
I demonstrated that by lowering the inflation pressure within a football helmet, the risk of a player getting a concussion could be lowered.

Help Received
I did the majority of the work myself, however I received help with the research from Kalli Ickes, A.T.C and Dr. Jonathan Minor, M.D. I also received aid on my experimental design from my stepfather, Ryan Jonson, who is a mechanical engineer.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Alexander Woodside

Project Number

S0334

Project Title

Finding a Strong Affordable Material to Construct a Simple Quadcopter Frame

Abstract

Objectives/Goals

The goal of my project was to find what affordable material would be best to build a simple quadcopter frame.

Methods/Materials

In my project I tested the strength of materials available in common hardware stores. To test the strength of these materials, I dropped 5, 10, 20 pound exercise weights from a height of 46 inches from the material. This gave me corresponding energy levels of 26.5, 52.2, 104.5 joules. All tests were recorded with a camera to ensure the weights impacted the materials at the desired angle and location. The materials I have chosen to test are Polyvinyl Chloride (PVC) foam, High Denstiy Polyethylene (HDPE), Plywood, Medium Denstiy Fiber (MDF) board, 3/4" wood, Birch, Poplar, Craft Pine and Red Oak. The dimensions of the materials were kept at store bought dimensions for two reasons; a hobbyist new to quadcopters will most likely keep them at these dimensions and the goal of the project was to keep engineering of the frame as simple as possible.

Results

My mount in trial 1 was not as secure as I would have liked. As a result the mount absorbed a portion of the energy of the impact. In trials 2 and 3 a new satisfactory mount was used. Plywood, MDF board, and Craft Pine never survived the 5 lbs. tests with any of the mounting techniques in all the trials. Poplar was damaged once and broke twice at 5 lbs. In trial 1, Red Oak, HDPE, PVC foam and Birch all survived the 10 lbs. tests. In contrast, only Birch survived the 10 lbs. tests in trial 2 and only Red Oak and Birch survived in trial 3 at 10 lbs. PVC foam broke at 5 lbs. once and twice at 10 lbs. The two "finalists" were Red Oak and Birch. Birch broke twice at 20 lbs and Red Oak broke only once.

Conclusions/Discussion

Red Oak is the best material to construct a simple quadcopter frame of the materials I have tested. Red Oak is an open grain wood and has a density of 0.733 g/cm^3. In comparison, Birch is a closed grain wood and fast growing. These factors lead to it not surviving as well as Red Oak. HDPE had the highest denstiy but it is heat sensitive. As a result all the KE made it bend. PVC foam is a bendable foamed plastic. I believed this would help create a shock absorbing frame. It turns out the weight easily pushed the PVC foam past its maximum bending point. Poplar also had a similar density as Birch but its brittle nature caused it to fracture. I must conclude Red Oak is the best material to build a simple quadcopter frame.

Summary Statement

This project will allow first time quadcopter builders to learn how to fly without needing to worry about rebuilding their frame after many inevitable crashes.

Help Received

I received help in conducting this experiment from many people. Mom and Dad funded this project. My Mom and Jim Bock gave me Physics advice. My Dad gave his help and advice during the fabrication of my material mounts.