COLUMBIA | ENGINEERING
The Fu Foundation School of Engineering and Applied Science

THE 4th ANNUAL

SENIOR DESIGN EXPO

MAY 3RD, 2017
12:00-3:00 PM

ROONE ARLEDGE AUDITORIUM, LERNER HALL
COLUMBIA UNIVERISTY, MORNINGSIDE CAMPUS

Senior Design Expo

WEDNESDAY, MAY 3, 2017
12:00 - 3:00 PM
ROONE ARLEDGE AUDITORIUM
LERNER HALL

COLUMBIA | ENGINEERING
The Fu Foundation School of Engineering and Applied Science


SUSTAINABLE ↔ HEALTHY ↔ SECURE ↔ CONNECTED ↔ CREATIVE ↔
DATA SCIENCE ▪ SENSING ▪ IMAGING ▪ VISUALIZATION ▪ MODELING ▪ SIMULATION ▪ MATERIALS ▪ NANOSCIENCE ▪ DEVICES ▪ ROBOTICS ▪
COLUMBIA ENGINEERING FOR HUMANITY

DEPARTMENTAL GUIDE

Applied Physics and Applied Math……..Champagne
Biomedical Engineering……..…….White
Chemical Engineering……....……...Pink
Civil Engineering…….....…….Burgundy
Computer Science……..…..…….Navy Blue
Earth and Environmental Engineering…….....Teal
Electrical Engineering……..……Royal Blue
Industrial Engineering and Operations Research……...Black
Mechanical Engineering……..Columbia Blue

PROJECTS

Applied Physics and Applied Math Department

1. **Design of an Anomalous Hall Resistivity Measurement System for Characterization of Magnetic Thin Films I**
   Kevin Teng
2. **Development of Quantitative Spectromicroscopy Tool for the Hard X-ray Nanoprobe Beamline at NSLS-II**
   Derek Tropf
3. **Fundamentals of X-Ray Fluorescence**
   Erica Yee
4. **Microstructural Characterization of Thin Metallic Films**
   Michael Berkson
5. **Quantitative Analysis of Excimer Laser-Induced Liftoff of Polyimide Bulk Material from Glass Substrate**
   Sean Mbogo

Biomedical Engineering Department

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3. **DecubiCare**
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9. **OTITAN**
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10. **prosopagKNOWsia**
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11. **Sirena**
    Josh Hughes, Rachit Mohan, Derek Netto, Alexandra Nuzhdin, Zaheen Sarker
12. **Tranquilert**
    Arshia Aalami, Nina Kumar, Maya Patel, Meridith Pollie

Chemical Engineering Department

1. Developing a Methanol Economy
   John Bender, Zoe Zegers, Sophie Jo

Civil Engineering Department

1. AirTrain JFK-LGA Extension
   Kevin Chiu, Colton Doering, Stephen Ho, Anel Redzematovic, Hua Zheng, Rashed Al Qudah
2. Cable Pre-Tensioned Truss Bridge: Replacing the Pleasant Valley Creek Bridge in Clark County, ID
   Marc Dessauvage, Shuyin Hua, Christopher Kim, Oliver Konkel, Daniel Massimino, Mohamad Tuffaha
3. Eldert Terrace
   David Sanchez, Manuel Chafart, Jesse Matza, Lindsay Witt, Anna Mastryukova
4. Nani Hotel
   Courtney Beckwith, Jenna Fontaine, Gayoung Kim, Lizbeth Peña, Anthony Pensiero, Veronica Timpane

Computer Science Department

1. Unraveling the English-Bengali Code-Mixing Phenomenon
   Arunavha Chanda

Earth and Environmental Engineering Department

1. Design of a Vertical Borehole Heat Exchanger to Cool MTA Subway Platforms
   Anna Libey, Chris Ahn, and Fred Enea
2. Efficiency Analysis of Building Retrofits in New York City
   Rebecca Speckenbach, Brendan Stewart, Anna Heath, and Sanura Dewa
3. Feasibility Study of Open-System Geothermal Heat Pump to Cool New York City Subway
   Colette McCullagh, Maria Torres, and Xiaocong Susan Liu

Electrical Engineering Department

1. Fly-on-a-Roomba: A Robotic Platform for Neuroengineering Research
   Zhenrui Liao
2. Electric Flute
   Alexandra Marie Della Santina, Eitan Rami Rothman
3. Hybrid Continuous-Discrete Computer
   Lisa Lei
4. MuddBot
   Ilan Buchwald, Soren Mortvedt, Linhao Zhang

5. **The RoBach Analog Synthesizer**
   Will Cao, Eli Epperson, Cynthia Kallif, Amritha Musipatla, Nick Scarfo, Johanan Sowah
6. **Sleep Enhancement System: Shifting the Metric for Measuring Sleep from Hours to Cycles.**
   Henry Shulevitz, Doug Soto, Alicia Musa, Aiyu Tang
7. **TearsTalk**
   John Kotey, Julian Vigil, Chris Kunkel

Industrial Engineering and Operations Research Department

1. **Cracking Crypto: An Implied Interest Rate Model for Valuing Cryptocurrency Products**
   Dillon Biddiscombe, Aakanxit Khullar, Alec Silverstein, Omer Yatkin

Mechanical Engineering Department

1. **Bar Tender Robot**
   Stanley Brown, Justin Mann, Korey Petgrave, Stanley Sandoval
2. **Cold Brew Coffee Maker**
   Jeffereson Hancock, Jessica Scheff, Allison Spencer, Adelaide Young
3. **Animatronic Face**
   Zanwar Faraj, Maimuna Hossain, Carlos Morales, Mert Selamet, Patricio Torres
4. **Vortex Shooter**
   Seung Bae William McKee, Haroon Mian
5. **Automobile Suspension**
   Clayton Baumgart, Will Clifford, Jay Hyeon Park, Charles Visconti, Joseph Wihbey
6. **Inverted Pendulum**
   Anthony Limani, Yasmin, Mulla-Carrillo, Arya Popescu, Youssef Saafan, Ryan Zimmerman
7. **Beach Roomba**
   Bradley Beeksma, Daniel Gonzalez, Jamie Hall, Alyssa Nicole Posecion
8. **Bolt Sorter**
   Kyle Bauer, Ricardo Fritzke, Oliver Grueterich
9. **Wall Climbing Robot**
   Keenan Albee, Kristina Andreyeva, Howei Chen, Tamas Sarvary, Nathan Werner
10. **Robot Xylophone**
    Sophia Dolan, Stephen Koh, Alexander Kontos, Wilton Rao
11. **Arm Wrestling Robot**
    Benjy Greffin, Sarah Leong, Vidal Nino De Guzman, Urbano San Roman, Jasmine Santaigo
12. **Juggling Robot**
    Jacob Greenburg, Jamar Liburd, Martin Perez Colon, David Verdi
13. **Windproof Umbrella**
    Jake Abitbol, Kevin Baquero, Lane Baze, Benjamin Machtinger
14. **Toulouse: The Robotic Artist**

Evan Hertafeld, Aramael Pena-Alcantara, Amelia Dunn, Yadir Lakehal

15. **Balancing Cube**
    Maciej Biernacki, William Church, Jonathan Cohen, Thomas Rasmussen
16. **Robot that Rolls**
    Qiaoyu (Grace) Liu, Peter Luning Prak, Trevonna Meikle, Yuchuan (Vincent) Zhang

Applied Physics and Applied Math

Design of an Anomalous Hall Resistivity Measurement System for Characterization of Magnetic Thin Films

Kevin Teng
Advisor: William Bailey

The Hall effect produces a transverse voltage when a magnetic field is applied transverse to an electric current in a conductive material. In a normal conductor, this can be explained simply by the Lorentz force. In ferromagnetic materials, the Hall voltage is larger than expected and not simply proportional to the external magnetic field; the voltage also depends on the magnetization. This is known as the Anomalous Hall effect (AHE); the mechanism has eluded theorists and experimentalists for decades. Recently, it has been proposed that the AHE arises from two mechanisms: an intrinsic (spin-orbit coupling effects), and extrinsic (scattering and side jumping mechanisms). By controlling the magnetization of the ferromagnetic material, identification of the Anomalous Hall term is possible at high fields.

Using Python and SCPI commands, we wrote a code which creates an interface to communicate with multiple GPIB instruments to control an external field. The thin film sample is placed upon a wooden base. Using a square Van der Pauw setup, contacts are made at the corners of the film with indium solder. The sample is centered out of plane with respect to the magnet and stabilized with wood supports. The applied magnetic field plane sweeps up to 1.3T; sufficient to saturate film magnetization out of plane. Efforts to measure the AHE and resistivity of thin-film magnetic materials are ongoing.

Development of Quantitative Spectromicroscopy Tool for the Hard X-ray Nanoprobe Beamline at NSLS-II

Derek Tropf
Advisor: Professor I. Cevdet Noyan, Yong Chu, NSLS-II HXN Beamline Group Leader, Photon Division

The Hard X-ray Nanoprobe (HXN) beamline at the National Synchrotron Light Source II (NSLS-II) is an undulator beamline capable of material characterization on the scale of 10 nanometers (nm). One of the important techniques utilized at HXN, x-ray fluorescence microscopy, allows scientists to visualize internal structures and quantify elemental composition. When excited by the incidence x-ray beam, the atoms in a sample emit characteristic fluorescence x-rays providing a unique fingerprint of elemental composition. The analysis of fluorescence data is currently done in a python based package called PyXRF. Although PyXRF offers a GUI design and high level fitting engine, spectromicroscopy data used to investigate reactions at the nanoscale is not currently implemented. To quantify spectromicroscopy data, a python based tool that utilizes PyXRF functionality has been created with the goal of real time analysis by HXN beamline users. The tool is tested by quantifying the oxidation states of Ni via fluorescence data taken of $LiNi_{0.6}Mn_{0.2}Co_{0.2}O_2$ material while subject to an applied voltage. By fitting to a linear combination of X-ray Absorption at Near Edge Structure (XANES) data, results show a fit that lies within the statistical error of experimental data. Further, chemical mapping of oxidation states reveal high intensity areas to be composed primarily of Ni^{2+} followed by Ni^{4+} in quantity. Further tests need to be conducted using data from experiments with more data points for more statistically reliable conclusions. Future improvements will be devoted to improving calculation speed and GUI framework, incorporating analysis of x-ray diffraction data, and integration of tool into HXN beamline structure.

Keywords: X-ray, fluorescence, python, XANES

Fundamentals of X-Ray Fluorescence

Erica Yee
Advisor: Prof. I.C. Noyan

X-ray fluorescence (XRF) is a prevalent technique to quantitatively and qualitatively analyze the elemental composition of materials, used in fields ranging from materials science to archeology to art history. Because XRF is less time- and energy-intensive than x-ray diffraction (XRD), it is a quick and useful tool to confirm and supplement XRD elemental analysis. The objective of this

project was to assemble and implement an XRF detector into the lab's x-ray chamber. Successful detector operation was verified by testing various materials samples and comparing characteristic XRF energies to analytical results derived from Moseley's Law, an empirical formula that relates x-ray frequency to atomic number.

Microstructural Characterization of Thin Metallic Films

Michael Berkson
Advisor: Katayun Barmak

The grain size and grain boundary character distribution (GBCD) of three Al thin film samples were measured using transmission electron microscopy (TEM)-based crystal orientation mapping. The GBCD of the films was compared to that of bulk Al. The GBCD is the relative length fraction (2D) or area fraction (3D) of boundaries as a function of the five crystallographic parameters (three for misorientation of one grain relative to its neighbor and two for the grain boundary plane orientation). Once the films are deposited on thermally oxidized Si wafers, they must be mechanically or chemically thinned so that they are electron transparent. The method of sample preparation I used to prepare several practice samples for TEM involves mechanical grinding and polishing on a lap wheel followed by dimple grinding and Ar ion milling. The crystal orientation data were analyzed to obtain both grain size and the GBCD. My work in this analysis involved using crystal orientation and image analysis software to gather grain size data that could be used to calculate the mean size and the grain size distribution of the sample. The film grain sizes were found to be 109, 152 and 157 nm, for the as-deposited film and films annealed at 400 °C for 30 and 150 minutes, respectively. We also found that the grain size distribution of the thin films was in agreement with the lognormal grain size distributions that have been determined using prior, slower image-based methods. Furthermore, the GBCD of the thin films differed from bulk Al in that the films exhibited a higher frequency of $\Sigma 3$ boundaries, or twin boundaries, which as twist boundaries have a misorientation of 60° about the [111] axis. The length fraction of $\Sigma 3$ boundaries was 0.245 for the as-deposited film compared to 0.016 in the bulk material. Annealing at 400 °C resulted in a decrease of the twin boundary length fraction.

Keywords: transmission electron microscopy; precession electron diffraction; crystal orientation mapping; thin film; twin boundary; grain boundary; grain size distribution

Quantitative Analysis of Excimer Laser-Induced Liftoff of Polyimide Bulk Material from Glass Substrate

Sean Mbogo
Advisor: James S. Im

An investigation of the lowest possible energy required to induce complete liftoff of polyimide (PI) bulk material from a glass substrate utilizing a 308 nm XeF laser was conducted. Polyimide can be used as a plastic substrate for flexible organic electroluminescent devices which are desired in high quality display materials commonly found, but not limited to, portable devices. PI bulk samples deposited on a SiO_2 substrate were provided by a reputable company, and testing was performed by incrementally adjusting the energy deposited on the polyimide material until the lowest energy deposition required for complete separation of the polyimide film from the glass substrate was determined. A lower required deposited energy is ideal for large-scale processing of PI films by reducing overall cost. The minimum energy required for complete laser lift-off of this particular polyimide sample set utilizing the XeF 308nm Coherent laser was determined to be $219\frac{mJ}{cm^2}$ for an array of 30 PI squares.

Keywords:
Process Optimization, Display Materials, OELD, Polymer Melting and Solidification Characterization

Biomedical Engineering

AdneXXa

Tess Cersonsky, Erika McManus, Nina Moiseiwitsch, Lara Warner
Advisor: Prof. Katherine Reuther

Millions of women worldwide have an unmet need for contraception. Most existing, female-controlled contraceptive options do not provide both pregnancy prevention while protecting against HIV and other sexually transmitted infections (STIs). In places like Uganda where HIV/AIDS is prevalent, lack of adequate STI protection could be life-threatening, especially in rural areas. Our solution is a female condom that is controlled by women users, protects women from STIs and prevents unwanted pregnancy. It is inserted with an applicator, and then removed and may be sterilized for reuse, reducing the cost of contraception in low-resource settings. The major components of the design include a cervical barrier, a vaginal wall barrier, and an applicator. These components together will provide a significant advantage over existing

contraceptives, and will therefore respond to the problem of unwanted pregnancy as well as STI transmission and the concomitant health burden for women in low resource countries.

Amnitect

Olivya Caballero, Rosa Kim, Namji Park, Shaw Yang
Advisor: Prof. Henry Hess

Premature rupture of the amniotic membrane (PROM) occurs in over 10% of pregnancies in the United States. Such rupture heightens the risk of infection, is the leading cause of premature birth, and accounts for 20% of perinatal mortality. The most prominent symptom of premature rupture is the leakage of amniotic fluid. However, leakage can occur slowly or in small quantities: 45% of PROM sufferers do not notice these symptoms. Outcomes are improved by early detection of PROM; however, this usually occurs via prenatal examinations. Leakage that occurs between doctor visits may go undetected. Amnitect has developed a device that can detect amniotic fluid leakage in the home setting, thus facilitating consistent, frequent monitoring. The device utilizes inherent differences in fluid conductivity to detect the presence of amniotic fluid. Amnitect is designed to be safe and suitable approach to amniotic fluid leakage detection.

DecubiCare

Svetlana Bagdasarov, Kathleen Fan, Sahir Jaggi, Alexander Wang
Advisor: Prof. X. Edward Guo

Decubitus ulcers, also known as pressure sores or bedsores, are open wounds that result from prolonged pressure to the skin. These wounds typically arise in individuals with mobility issues who are either bedridden or confined to a wheelchair. Bedsores afflict over 2.5 million people in the U.S. annually, causing severe pain, infection, and even death in 60,000 cases each year. The current gold standard for prevention is manual repositioning of patients by nurses, an inconsistent and inefficient method due to its lack of informed re-positioning and quantifiable results. DecubiCare seeks to provide medical professionals with a more informed method of sore prevention by identifying high-risk areas and notifying personnel of the exact locations that require relief. As a unique, pressure-sensing adhesive patch, DecubiCare is compatible and adjustable for all patient sizes, providing a user-friendly interface for medical staff to continually monitor patients.

Haiku Prosthetics

Amanda Jiménez, Chiang Liu, Roberta Lock, Georgiana Yang, William Yu
Advisor: Prof. Clark T. Hung

Approximately 95,000 children in the U.S. suffer from limb loss and use a prosthetic device as a replacement. As children age, their substantial physical growth typically demands annual replacement of their prostheses. The frequency of replacement is inefficient, and carries significant costs: a lengthy period of therapy and a price upwards of $5000 per device. To reduce this burden, the replacement frequency of pediatric prosthetic devices must be minimized. Haiku Prosthetics' solution is an adaptable, universal prosthetic socket for transtibial amputees that accommodates residual limbs of varying sizes and is capable of adjusting with the user as they grow. User friendly and manually adjustable, the design consists of a rigid open exterior, which bears load, as well as a soft, conforming, flexible interior, which secures the limb in place, resulting in a design that can accommodate the average residual limb sizes of children from early childhood to adolescence.

Lumenda

Lizzette Delgadillo, Bryan Louie, Priya Medberry, Sid Perkins
Advisor: Prof. Katherine Reuther

Neonates have a significantly elevated risk of bacterial meningitis particularly in low-resource settings, where 126,000 cases of neonatal bacterial meningitis occur per year and 40-58% of infected neonates die. The current standard for diagnosing bacterial meningitis is a cerebrospinal fluid (CSF) culture, which can take between 24 - 48 hours to yield conclusive results. This diagnostic timeline is often far too long, resulting in serious medical consequences or death in untreated infected neonates. Additionally, because nonspecific antibiotic treatment is often administered without a proper diagnosis, 20-30% of antibiotics are wasted, contributing to the healthcare deficit in low-resource settings. Lumenda is a point-of-care diagnostic device for bacterial meningitis in neonates that analyzes how the optical properties of the cerebrospinal fluid change with the onset and progression of infection. Our device is able to assess CSF in under 10 minutes, providing an efficient, portable, and low-cost solution for diagnosing neonatal bacterial meningitis in low-resource settings.

LUNA

Shujian Deng, Kristopher Harris, Nicholas Primiano, Payal Rana, Zane Zemborain
Advisor: Prof. Joshua Jacobs

Each year in the U.S., roughly 420,000 ultrasound-guided needle biopsies are performed to obtain a tissue sample from an abnormal mass. Even with the aid of real-time ultrasound imaging, this procedure is often a complicated mental and visual task. Specifically, it is difficult to ascertain and maintain an appropriate angle of needle insertion. Inaccurate needle insertion may result in greater perceived soreness and higher rates of infection, bleeding, and tissue damage. Our solution, Laser Ultrasound-Guided Biopsy Needle Aid (LUNA), facilitates easier and more accurate insertion of the needle compared to the free-hand method. Our device projects an image onto the screen of a smart-phone secured to the ultrasound probe. The smart-phone, in turn, displays a guide, which, when matched with the laser-projection, results in proper needle orientation for insertion. Preliminary testing demonstrates that the LUNA system, given only the ultrasound-determined mass depth, can accurately guide the insertion of the needle without repeated attempts.

NjaKnow

Nina Sabharwal, Cosmas Sibindi, Cameron Statton, Samuel Weinreb
Advisor: Prof. Paul Sadja

Neonatal jaundice occurs when a baby has a sustained high level of bilirubin in the blood, resulting in yellowing of the skin and eyes. In severe cases, consequences can include cerebral palsy, deafness, brain damage (kernicterus), and death. In low resource settings, jaundice poses a major threat due to the lack of sustainable technology and reliance on subjective visual assessment of skin yellowing. There is a need to accurately and quickly diagnose the severity of jaundiced neonates to allow for proper administration of care. NjaKnow's solution includes glasses, worn by the doctor, with specialized lenses to selectively filter blue light, making it easier for the doctor to see the contrast in the yellowing of the baby's sclera. The filtered view of the sclera is compared to a color test strip with indications for jaundice severity for rapid, objective assessment of jaundice severity. This solution provides a quantitative method for doctors to compare neonates' jaundice conditions for proper triage.

NoMor

Caroline Chiu, Hae Seong Kim, John Mavroudes, Walid Rahman, Chiara Vallini
Advisor: Prof. Barclay Morrison III

Over 10 million Americans suffer from Essential Tremor (ET), a neurological disorder characterized by a kinetic tremor of the upper extremities. ET patients struggle to perform many daily activities that require use of their arms and hands. Although medications and brain surgery can be effective treatments, 40% of ET patients do not respond to either and are forced to rely on assistive devices. Current assistive devices either lack multifunctionality or are bulky and uncomfortable. As a result, there is a need for a subtle and comfortable assistive device that helps ET patients perform normal daily tasks. The NoMor Sleeve uses mechanical suppression to comfortably and subtly reduce tremors at the wrist and hand, allowing the user to carry out regular tasks that would otherwise be highly difficult to perform. Preliminary testing shows tremor reduction at the hand and wrist by more than 60% in abduction, adduction, flexion, and extension.

OTITAN

Nick Lamb, Wanying Li, Crystal Mejia, Tiffany Tuedor, Adil Tyeb
Advisor: Prof. Tal Danino

Acute otitis media (AOM), or ear infection, is the most common childhood infection. It accounts for 60% of antibiotic prescriptions in children. The proper use of antibiotics shortens the duration of symptoms and reduces the likelihood of persistent ear infections, especially in children younger than two years. However, according to the CDC, 50% of antibiotic prescriptions for ear infections are administered prophylactically in part due to misdiagnosis. The otoscope is commonly used for AOM diagnosis. But with accuracy only as high as 77% for experienced doctors, it is still susceptible to erroneous detection, prolonging treatment and causing children to experience ongoing pain while increasing the likelihood of hearing damage. Our device, Auri, is designed to aid physicians in the diagnosis of AOM. It performs an automated image analysis of the eardrum to provide a physician with an objective, non-invasive assessment of whether infection may be present, facilitating more targeted therapeutic intervention.

prosopagKNOWsia

Abhinav Goyal, Mary Kate Montgomery, Andrew Tsao, Katie Yang
Advisor: Prof. Elizabeth M.C. Hillman

Prosopagnosia is a disorder in which a person is unable to recognize others due to the brain's inability to either differentiate or recall faces. People with the disorder are forced to utilize secondary characteristics to identify others. However, these coping mechanisms often fail. Difficulty with social interactions may lead to a lifetime of personal and professional distress. Our device addresses the need for those suffering from prosopagnosia to be able to discreetly and reliably identify people. The primary user interface is a smartphone Android application. A camera mounted within an earpiece acquires an image of the person the user is facing. The microprocessor of the device utilizes existing facial recognition algorithms to identify the faces within the image. These are relayed to the phone and displayed to the user. Initial prototype testing shows that our device is both accurate and works in real time, all while being discreet, comfortable, and inexpensive.

Sirena

Josh Hughes, Rachit Mohan, Derek Netto, Alexandra Nuzhdin, Zaheen Sarker
Advisor: Prof. Samuel Sia

Emergency medical technicians administer a variety of medications and interventions while stabilizing patients during transport. Interventional procedures are often inaccurately documented or not transmitted leading to lowered quality of care, malpractice suits, and extraneous treatments. Sirena aims to eliminate these documentation errors and their consequences. We propose a trimodal assistive system for EMTs to use at the time of an emergency that will facilitate optimal documentation and lossless transfer of information to healthcare practitioners. Sirena is composed of three modules: an input modality, a feedback mechanism, and an information transfer system. The input modality collects binary inputs from users through a touch sensor mounted onto a mouthpiece. These inputs answer questions fed through the second module: a heads-up display traversing a binary decision tree. Initial validation has been met with approval from test users and validated by EMTs for use in the field.

Tranquilert

Arshia Aalami, Nina Kumar, Maya Patel, Meridith Pollie
Advisor: Prof. Elizabeth Olson

Children with Autism Spectrum Disorder (ASD) are often impaired with emotion dysregulation and are prone to high levels of stress that may lead to meltdowns. Children with ASD, especially those on the low-functioning end of the spectrum, have trouble communicating that they are experiencing stress; the only indication that the child is stressed may be the consequent emotional meltdown, at which point it is too late to intervene. Tranquilert aims to address the need to detect increased stress in these children and facilitate the calm-down process for their caretakers. Tranquilert detects stress in autistic children by monitoring: auditory stimuli that can agitate a child, exaggerated motor stereotypies, or repetitive motions, and increased electrodermal activity, or stress-induced sweating. The system sends alerts with calm-down instructions to a mobile device, allowing a caregiver to intervene before the onset of a meltdown. Initial testing shows that Tranquilert can accurately detect and alert for different scenarios that mimic the triggers and responses of stress events in autistic children.

Chemical Engineering

Developing a Methanol Economy

John Bender, Zoe Zegers, Sophie Jo
Advisor: Dr. Joseph Porcelli

The production of Methanol has been considered as an alternative towards fossil fuels. Dubbed as the "Methanol Economy", this economy can be easily transported using the current gasoline infrastructure, and the product from this economy, liquid methanol, can be easily stored as well. Methanol demand has been steadily increasing over the past decade, which has lead to the increase in opportunities for increased Methanol production. Global Energy Solutions has designed a Methanol production plant with a 20 year lifetime, coupled with an electricity generation unit, in order to meet the increasing energy demands. This plant, operating for 354 days per year, will produce 400,000 metric tonnes of Methanol per year at a 99.7% product purity. The total capital investment of this plant will be near $280 million, and will have an annual production cost of approximately $153.7 million. The total revenue generated per year will equate to near $406.5 million, greatly outpacing the annual expenses.

When analyzing the expenses and revenue streams, it was determined that after a typical 20 year contract, the net income figures to be a massive $3.6 billion. The IRR comes out to be at 63.08%, and the projected payback period is within a year and a half. The total retained profit versus the original investment comes out to be 12.90, and the NPV and ratio of the NPV to initial investment is $780 million, and 278%, respectively. All monetary figures prove that there is a large incentive to invest in this bid.

The production design has also taken measures towards preserving the environmental integrity of the surrounding area. The flammable by-products are combusted, electricity is generated in-house, heating and cooling is efficiently utilized, and much of the material streams are recycled within the plant. In addition, after analyzing the Heuristics, this production design satisfies 28 of the 30 categories, with the other 2 inapplicable towards Methanol production.

Keywords: Methanol, production diagram, heuristics, profitability

Civil Engineering

AirTrain JFK-LGA Extension

Kevin Chiu, Colton Doering, Stephen Ho, Anel Redzematovic, Hua Zheng, Rashed Al Qudah

In New York City, prior to the start of construction of the AirTrain JFK project, there was a demand for an easy and accessible public mode of transportation that could take you from Manhattan to one of the major airports in Queens, NY (John F. Kennedy Airport and LaGuardia Airport). The current AirTrain fails to meet this demand since it spans from John F. Kennedy Airport (JFK) to Jamaica, Queens. With the current condition of NYC's public transportation system, it takes up to 40 minutes alone going from Midtown Manhattan to Jamaica. Our proposal is to extend the existing AirTrain from Jamaica, Queens to Astoria, Queens. LaGuardia Airport (LGA) would be the one stop between Jamaica and Astoria. The AirTrain would specifically end in Astoria Blvd where the N and W subway lines are located. The N and W subway lines will provide access to the city. With this proposal, a commuter starting in Midtown Manhattan could reach JFK in less than 45 minutes, compared to the current optimistic travel time of 62 minutes. Just as in the original AirTrain design, the path of the AirTrain would sit on the medians of the major highways. For this proposal, the extended AirTrain path would follow the Van Wyck Expressway (VWE) and the Grand Central Parkway (GCP). This extended 9.1-mile path would allow commuters to access these major

airports without having to use the existing congested forms of public transportation.

Cable Pre-Tensioned Truss Bridge: Replacing the Pleasant Valley Creek Bridge in Clark County, ID

Marc Dessauvage, Shuyin Hua, Christopher Kim, Oliver Konkel, Daniel Massimino, Mohamad Tuffaha

Our project focuses on the construction of a novel type of bridge structure, using a pre-stressed cable to support tension loads in the bottom chord of the truss. This allows the truss to be significantly lighter and shallower than standard truss bridge construction. Our intent is to validate the feasibility of this design concept. We have selected a site in Clark County, Idaho, for our bridge, where it is designed to serve as a replacement for the Pleasant Valley Creek Bridge. This existing bridge was constructed in 1934 and closed to traffic in 2016 due to deterioration and the inability to carry typical service loads. Our replacement bridge structure is 480 feet long with anchorages at either end and a deck width of 45 feet, providing one traffic lane in each direction with a sidewalk on either side. The truss is 24 feet deep, with a depth to length ratio of 1:20 significantly lower than the typical truss bridge design ratio of 1:10.

Eldert Terrace

David Sanchez, Manuel Chafart, Jesse Matza, Lindsay Witt, Anna Mastryukova

New York City and other dense metropolitan areas are increasingly in need of affordable housing options for a growing urban population. Our senior design project sought to create a solution to this problem with the construction of Eldert Terrace. Eldert Terrace is a modularly constructed 10-story apartment complex located at 419 Eldert Street in the Bushwick neighborhood of Brooklyn.

This site was chosen for a number of reasons: it sits in its own cul-de-sac, minimizing the interruption of local traffic flow; it is nearby to warehouses, increasing the use of local business for offsite construction; and it is mere steps away from the L train, offering easy access to Manhattan. We chose modular construction as opposed to traditional construction because it cuts costs, shortens the project timeline, offers a higher degree of control over the environmental impacts of construction and is overall a much safer process.

To elaborate on this fairly new construction technique: the first floor of the building will be built using traditional construction on a mat foundation, and the

remaining nine floors will be created by stacking individual modules. The modules themselves will be constructed offsite and then assembled and connected on-site. Modules will be combined to create floor plans offering studio, one-bedroom, and two-bedroom units. We have laid out the design specifications and construction process for Eldert Terrace in detail in our report. Once construction is complete, the remaining lot area and assembly space will be converted into a public park for residents and the greater community of Bushwick to enjoy.

Nani Hotel

Courtney Beckwith, Jenna Fontaine, Gayoung Kim, Lizbeth Peña, Anthony Pensiero, Veronica Timpane

Nani Hotel is a 10-story hotel designed to serve as the main building of a resort in Ko Olina, Hawaii. Ko Olina is an unfinished 11.5-acre resort complex on the island of O'ahu in Hawaii, and Nani Hotel is intended to fill one of its two empty lots. This lot is between two smaller resorts, and thus Nani Hotel can be marketed as a quieter and more exclusive alternative to the hustle and bustle of the two larger resorts, while still having access to all the amenities of the full resort complex.

The design of the hotel has been approached from structural, geotechnical, environmental and construction management perspectives in order to address the full spectrum of Civil Engineering design. All structural and geotechnical work has been done according to 2006 International Building Code and Revised Ordinances of Honolulu, the local jurisdiction. After analysis of the structural loads on the building and the soil conditions in Hawaii, the structural and geotechnical teams have selected a concentric steel braced frame structure with a mat-slab connecting piles for the foundation. Meanwhile, the construction management team has analyzed the financial viability of Nani Hotel and scheduled the building's construction. To do this, they have estimated a daily expected income using income per room and the vacancy rate and performed other cost analysis.

Finally, the environmental team has ensured that the building is designed to achieve LEED certification, as both Ko Olina and the state of Hawaii are making great strides in green infrastructure. This included a consideration of which of all credits possible in the categories of sustainable site credits, energy and atmosphere credits, materials and resources credits, and indoor environmental quality credits could be accommodated by the restrictions of the structural, geotechnical, and construction management teams. Ultimately, this led to many green design aspects in Nani Hotel, most notably the green roof, which

will also harvest rainwater to irrigate the greenery on the roof and surrounding landscape through a drip irrigation system, and the solar panels on other roofs to supplement the building's energy use.

Computer Science

Unraveling the English-Bengali Code-Mixing Phenomenon

Arunavha Chanda

Code-Mixing is a prevalent phenomenon in modern-day communication: verbal and textual. One of the major goals of Natural Language Processing is to be able to take in a piece of text and interpret it as a human would and further process it or act accordingly. The first step in this is identifying the language of the text. Though several systems enjoy success in identifying the language in monolingual texts, identifying languages of words in code-mixed texts is a herculean task. This task is further complicated in a social media context. Our research explores the English-Bengali code-mixing phenomenon and presents algorithms capable of identifying the language of every word to a reasonable accuracy in specific cases (defined type of corpora) and the general case (undefined corpus). The type of corpus (chats, search terms etc) influences the success of certain algorithms, while there are some algorithms, which perform in a relatively similar way for all corpora.

We develop several resources for Romanized Bengali text, such as dictionaries, training corpora and suffix lists. We create and test a predictor-corrector algorithm that boosts accuracy of language identification based on word context. We also develop a new annotated code-mixed corpus from Facebook chats and make it publicly available to reduce the dearth of publicly available annotated corpora. We also test several Machine Learning algorithms on our corpora, such as J48, IBk and Random Forest and also compare the performances of rule-based algorithms to Machine Learning ones. We also seek to remove ambiguities in the language identification process to aid systems looking to perform sentiment analysis or build predictive models on this language pair.

Earth and Environmental Engineering

Design of a Vertical Borehole Heat Exchanger to Cool MTA Subway Platforms

Anna Libey, Chris Ahn, and Fred Enea

New York City subway platforms can reach dangerous temperatures with highs of 107°F during the summer. Traditional HVAC systems would be costly because the cooling load for R62A trains entering the station was calculated to be 900,000 BTU/hr - as much as cooling 28 average American homes.

A closed-loop geothermal system with a ground coupled heat pump (GCHP) was designed to make use of the year-round cooler bedrock temperatures underneath Manhattan while minimizing maintenance costs and the impact on the surrounding city, the environment, and the local aquifers. For the two cooling cases proposed, the GCHP employs water piped inside u-shaped tubes inserted into either 12 or 25 sealed boreholes drilled into the ground underneath the station to a depth of 300 ft where the water rejects heat when it comes into contact with the year-round ground temperature of 62°F, cooling the subway platform by 7-17°F.

Efficiency Analysis of Building Retrofits in New York City

Rebecca Speckenbach, Brendan Stewart, Anna Heath, and Sanura Dewa

This project examines the efficacy of various green building design strategies for New York City retrofits using two building energy modelling softwares: Tas Thermal Analysis Simulation Software by EDSL and Sefaira Architecture by Trimble. These programs were used to model and analyze the energy flow of two buildings, one residential and the other commercial, in New York City. The building information was provided by Skidmore, Owings & Merill LLP (SOM) and Allen, Killcoyne Associates (AKA), two architecture firms based in Manhattan. A rendered model of SOM's commercial building was uploaded to the online Sefaira application to create iterative energy models and analyze the efficacy of their recent retrofit project. Simultaneously, an analysis of building energy, air flow, and heat transfer through a newly constructed cavity-wall facade was performed for AKA's residential property using Tas. The software was used to generate visuals and produce a comparison between the old and new facades. Hand calculations were also used to define the properties of wall constructions within the modeling software and to recommend operable conditions. Through these analyses, this project examines thermal bridging, heating and cooling, electricity and energy

savings, ventilation, passive design features, and building envelope materials to produce cost benefit analyses of sustainable building retrofits in New York City.

Feasibility Study of Open-System Geothermal Heat Pump to Cool New York City Subway

Colette McCullagh, Maria Torres, and Xiaocong Susan Liu
Advisor: Tamara Pearl, Environmental Engineering
Division of the New York Metropolitan Transportation Authority

The present paper seeks to evaluate the feasibility and effectiveness of open loop low-enthalpy geothermal systems when applied to the cooling of New York City subway stations. A quantitative analysis, including heat output and cooling potential calculations, is conducted based on a hypothetical model station. Air handling units are sized to the system according to estimated aquifer output characteristics, and conservative parameters yielded a cooling of 0.7˚F. More generous parameters representing a scenario with greater groundwater resources resulted in cooling up to 2.1˚F. It is therefore recommended that the Metropolitan Transportation Authority (MTA) not continue exploring the possibility of open-system geothermal due to physical restraints and a highly prohibitive upfront cost. Finally, other potential solutions regarding the problem of hot subway platforms are explored briefly, including the utilization of surface water sources.

Key words: subway cooling, geothermal, open loop systems, New York City

Electrical Engineering

Electric Flute

Alexandra Marie Della Santina, Eitan Rami Rothman
Advisor: Prof. David Vallancourt

Our Electric Flute is an actual acoustic flute filled with sensors and connected to an Arduino-powered sound generator. The mechanics of playing the instrument are preserved, but new possibilities open up for practice and performance. For example, this low cost alternative to more expensive electric wind instruments will allow students to practice the flute essentially silently with headphones. It also enables sound processing effects normally associated with other instruments such as the electric guitar.

Fly-on-a-Roomba: A Robotic Platform for Neuroengineering Research

Zhenrui Liao
Advisor: Prof. Aurel Lazar

Abstract

Much progress has been made towards understanding the connectome (neural wiring) of the housefly. Biologically- grounded models now exist for most of the fly brain, and their computations have been simulated extensively *in silico*. However, integrating these models into an autonomous whole-brain simulation, capable of internally representing its environment and performing behavioral tasks in a biologically faithful manner, remains an open problem. In this research project we build such a system using an open-source wireless robotic platform together with an extensible software training regimen, with the goal of recreating the fly "mating chase" behavior.

Hybrid Continuous-Discrete Computer

Lisa Lei
Advisor: Prof. Yannis Tsividis

The Hybrid Continous-Discrete Computer is clockless, continuous-time computation and signal processing IC, capable of solving nonlinear differential equations up to 32nd order. By eliminating the clock signal during computation, convergence problems are avoided in solving differential equations and no sampling-induced aliasing occurs. The HCDC chip shows potential for accelerating digital iterative algorithms due to its time-efficient analog integration and multiplication operations, which are sometimes expensive in digital discrete-time computation. The HCDC also is extremely energy-efficient, making it a good choice for the computation engine in such devices as autonomous microrobots, which must perform tasks in real time.

MuddBot

Ilan Buchwald, Soren Mortvedt, Linhao Zhang
Advisor: Prof. David Vallancourt David Gidony

Muddbot is a self-navigating delivery robot that is designed to be utilized throughout the Mudd building. A user enters the room number of the destination and places the package into the payload bay. The Muddbot then retrieves the nodes of the path which have been stored in the memory and maneuvers to the destination autonomously, with the aid of sonar, cameras, and

some hints (in the form of ceiling markers). On the way it has been known to troll passersby.

RoBach Analog Synthesizer

Will Cao, Eli Epperson, Cynthia Kallif, Amritha Musipatla, Nick Scarfo, Johanan Sowah

Advisor: Prof. David Vallancourt, David Gidony

We have created an analog synthesizer from the ground (EE pun) up, and an AI from the top (Mozart-trained) down to play it. In between, music students can play the synthesizer using a modified MIDI keyboard that optionally suggests notes for improvisation. The RoBach is your personal composer/trainer!

Sleep Enhancement System: Shifting the metric for measuring sleep from hours to cycles.

Henry Shulevitz, Doug Soto, Alicia Musa, Aiyu Tang
Advisor: Prof. David Vallancourt, David Gidony, Alexander Gazman

Many people, especially students, face a familiar problem with the recommended eight hours of sleep per night: we are restless when we set our alarm and tired when it goes off. Our Smart Sleep mask and expanded sleepsuit systems aim to correct this by shifting the focus of sleep from *time* to *completed sleep cycles*. Common alarms wake the user after a preset amount of time with no concern for the body's sleep cycle. Our system instead utilizes a piezoelectric sensor array integrate into an eye mask in order to detect REM sleep and make informed decisions about waking based a user's personal sleep cycle and circadian rhythm. Further, recorded REM sleep information can be used to induce lucid dreaming. Finally a perfect night's sleep!

Keywords: Sleep Mask, REM sleep, Lucid Dreaming, Sleep Cycles

TearsTalk

John Kotey, Julian Vigil, Chris Kunkel
Advisor: Prof. David Vallancourt

TearsTalk is an IOT solution that combines a sensing device, machine learning, and a mobile app to decipher why a baby is crying. It then alerts parents, guardians and/or hospitals via the app and/or text message. Further, it attempts

detection of certain health problems such as cleft palate, exposure to drugs, autism and physiological changes, and can be altered to diagnose other conditions associated with a sound signature, such as car engine problems.

Keywords: signal processing, health issues for infants, early detection, IOT solution

Industrial Engineering and Operations Research

Cracking Crypto: An Implied Interest Rate Model for Valuing Cryptocurrency Products

Dillon Biddiscombe, Aakanxit Khullar, Alec Silverstein, Omer Yatkin

With the rise of global interest in a decentralized ledger, BlockChain Technology and its more commonly recognized application, cryptocurrency Bitcoin, have become widely integrated within the financial ecosystem since their introductions in 2008. Although cryptocurrencies and related financial products have been known for speculative purposes and gray market transactions, the need for derivative products to hedge volatility in these instruments is ultimately growing. An inherent challenge in valuing cash flows denominated in Bitcoin and other decentralized protocol is the lack of a credit market to provide an exogenous interest rate to determine the present value of future or past cash flows. Upon further examination of the Bitcoin monetary system, an implied interest rate, comprised of a deterministic inflation factor and stochastic "residual premium," is proposed when valuing decentralized cryptocurrency products. Applications of such implied rates include pricing derivatives and valuing future Bitcoin denominated cash flows. This study examines pricing contingent claims such as Non-Deliverable Forwards and Futures (NDFs) of Bitcoin currency pairs, as well as a project valuation and risk analysis of Bitcoin transactions for fintech startup, The Sun Exchange.

Mechanical Engineering

Bar Tender Robot

Stanley Brown, Justin Mann, Korey Petgrave, Stanley Sandoval

A.B.L.E. (Automatic Bartending Luxury Experience) was developed with the goal of providing a bartender right at home. As a bartender may entertain with glass

flairs, we seek to awe through a seamless automatic interface that shakes, stirs, and serves your favorite drink.

Cold Brew Coffee Maker

Jeffereson Hancock, Jessica Scheff, Allison Spencer, Adelaide Young

The intent of this project is to design and build a cold brew coffee machine employing vacuum extraction that reduces the time and requires no heat in the brewing process. The major specifications are that it produces a cup of coffee in less than fifteen minutesanf fits within a 2' by 2' by 2' space.

Animatronic Face

Zanwar Faraj, Maimuna Hossain, Carlos Morales, Mert Selamet, Patricio Torres

The aim of this project is to develop a robotic face that is capable of replicating human facial expressions and
movements. This robotic face will serve as a platform for research into artificial and emotional intelligence by the Creative Machines Lab at Columbia University.

Vortex Shooter

Seung Bae William McKee, Haroon Mian

The Vortex Shooter was designed to combine the power of a pneumatic air cannon with thetracking ability of an Xbox Kinect Sensor. The control lies entirely with the user, as the cannon will mimic the movement of the user's hand, and with a simple gesture, fire a volley of air rings at a series of targets.

Automobile Suspension

Clayton Baumgart, Will Clifford, Jay Hyeon Park, Charles Visconti, Joseph Wihbey

The goal of this project is to improve the handling and cornering characteristics of a four-wheel vehicle by
implementing an active camber suspension system. A steering and speed-proportional model is used to change wheel camber based upon driving conditions to increase the available lateral force at the tires. The system is tested on a 1/10-scale vehicle.

Inverted Pendulum

Anthony Limani, Yasmin, Mulla-Carrillo, Arya Popescu, Youssef Saafan, Ryan Zimmerman

The inverted pendulum is a classic physics problem, in which a pendulum must balance upright in unstable equilibrium. This project is a mechanically powered inverted pendulum with a two-variable controls system that will serve as an educational tool for future controls students.

Beach Roomba

Bradley Beeksma, Daniel Gonzalez, Jamie Hall, Alyssa Nicole Posecion

The goal of this project is to build a beach cleaning robot, capable of autonomous movement, obstacle avoidance, and trash disposal. This is a cost effective means of cleaning beaches that moves away from traditional methods such as manual cleanups and specialist-operated shore-sweepers.

Bolt Sorter

Kyle Bauer, Ricardo Fritzke, Oliver Grueterich

The user loads assorted bolts into the rotary feeder, which feeds bolts to camera. The bolt sorter uses optical recognition to determine the maximum diameter and thread count of a bolt and the gantry system sorts the bolts into labeled bins.

Wall Climbing Robot

Keenan Albee, Kristina Andreyeva, Howei Chen, Tamas Sarvary, Nathan Werner

WALLY is an autonomous 4-limbed wall-climbing robot. Using computer vision and path planning, WALLY can navigate a vertical surface and serves as a proof of concept for uses including planetary exploration and mountain rescue.

Robot Xylophone

Sophia Dolan, Stephen Koh, Alexander Kontos, Wilton Rao

A 16-key mechatronic xylophone that plays notes by dropping steel balls on machined aluminum keys.

Arm Wrestling Robot

Benjy Greffin, Sarah Leong, Vidal Nino De Guzman, Urbano San Roman, Jasmine Santaigo

A multibody dynamic approach to arm wrestling. The robotic arm will replicate a fun and safe arm wrestling match based on the player's strength

Juggling Robot

Jacob Greenburg, Jamar Liburd, Martin Perez Colon, David Verdi

Ju-Ju, The Last Ball Bender, is a one-of-a-kind dual vertical gantry robot capable of manipulating multiple projectiles simultaneously. In other words, it juggles. Ju-Ju has an machined aluminum frame, a calibrated motor control system, and a computer vision system to deliver precise and accurate
throwing and catching.

Windproof Umbrella

Jake Abitbol, Kevin Baquero, Lane Baze, Benjamin Machtinger

The aim of our project is to design and build a truly windproof umbrella. We'd like to introduce much needed innovations to the design of an everyday item, thereby improving the lives of millions of people.

Painting Robot

Amelia Dunn, Evan Hertafeld, Yadir Lakehal, Aramel Pena-Alcantara

I'm Toulouse! I am an aspiring artist who also happens to be a robot. I'm more than the sum of my parts, and my dream is to someday be taken seriously as a creative artist in my own right.

Balancing Cube

Maciej Biernacki, William Church, Jonathan Cohen, Thomas Rasmussen

Design of a cube that uses three reaction wheels to balance itself.

Robot that Rolls

Qiaoyu (Grace) Liu, Peter Luning Prak, Trevonna Meikle, Yuchuan (Vincent) Zhang

The objective of this project is to create a spherical robot capable of navigating by means of range-finding sensors without human input. Its on board algorithms enable obstacle avoidance and the finding and following of paths

Stage Demonstrations

Beach Roomba, Robot that Rolls, Automobile Suspension

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