![NJIT New Jersey Institute of Technology logo]

ABSTRACTS

Seventh International Summer Research Symposium
Thursday, July 31, 2014

Seventh International Summer Research Symposium

Thursday, July 31, 2014
9:20am – 12:00pm

Campus Center Atrium
New Jersey Institute of Technology

<u>Agenda</u>

9:20am   Greeting and Brief Orientation – Dr. Angelo J. Perna

9:30am   Opening Remarks - President, Dr. Joel Bloom

9:45am   Poster Session

11:45am Closing Remarks – Provost and Senior Executive
                 Vice President - Dr. Fadi P. Deek

Symposium Chair: Dr. Angelo J. Perna
Symposium Co-Chair: Ms. Zara Williams

University Heights
Newark, NJ 07102-1982
973-596-3102
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Joel Bloom
President

August, 2014

I am very pleased to welcome you at the Seventh NJIT International Undergraduate Summer Research Symposium. It is a pleasure to see the continuously growing enthusiasm for undergraduate research and innovation that resonates the NJIT strategic plan and vision.

With an overall research enterprise of over $107 million expenditure per year and growing, NJIT has a strong strategic emphasis on Undergraduate Research and Innovation (URI) with several externally and internally funded undergraduate research, design and innovation programs. The URI enterprise includes Provost Summer Research Fellowships, Ronald A McNair Post-Baccalaureate Achievement Program, three National Science Foundation (NSF) funded Research Experience for Undergraduates (REU) programs in Neural Engineering, Nanotechnology and Quantitative Simulations, Faculty NSF REU Supplement Grants as well as privately funded Capital One Bank Innovation Acceleration Challenge and TechQuest Innovation Competition programs. This summer, there are more than 105 undergraduate students working on different research projects funded through different programs from NJIT and partner institutions.

I congratulate summer research students and their faculty advisors for impressive success in research and productivity that is evident from the abstracts and posters presented at the International Summer Research Symposium chaired by Dr. Angelo Perna. It is exciting that the Book of Abstracts of Seventh NJIT International Undergraduate Summer Research Symposium is available through NJIT URI website as an initiative started by Dr Atam Dhawan, Executive Director of Undergraduate Research and Innovation to document the wonderful research work being done at NJIT. I thank Dr. Perna, staff members and program directors for putting together this excellent event.

I am confident that Undergraduate Research and Innovation programs at NJIT will continue to grow significantly providing our undergraduate students an exceptional academic and research experience. It is an integral part of our strategic plan to educate future leaders in the global society. Thank you all for your contributions in supporting the undergraduate research and innovation programs.

Sincerely,

Joel S. Bloom
President

University Heights
Newark, NJ 07102-1982
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Fadi P. Deek
Provost and Senior Executive Vice President

Welcome to the Seventh NJIT International Undergraduate Summer Research Symposium. I would like to congratulate all undergraduate summer research students, their faculty advisors, and program directors for the impressive research work exhibited here. The symposium clearly demonstrates the excellence in interdisciplinary research and innovation by undergraduate students honing their expertise in preparation for taking important leadership roles in science and technology. As it is critically important for all of our students to develop such leadership skills, undergraduate research and innovation has been identified to be an integral part of NJIT's *2020 Vision Strategic Plan*.

I thank Dr. Angelo Perna for his lifelong commitment to student mentoring, and for his continued leadership in organizing and chairing the annual International Undergraduate Summer Research Symposium for the seventh time. I also thank all staff members, faculty advisors, and program directors for organizing this impressive international symposium. Through the Undergraduate Research and Innovation (URI) initiative established by Dr. Atam Dhawan, this year's summer research program has been significantly expanded and has involved more than 105 students from NJIT and partner institutions through different programs.

The online publication of the Book of Abstracts of the Seventh NJIT International Undergraduate Summer Research Symposium is excellent, as it showcases the wonderful research work done by our students and faculty, and will be archived through the URI website.

NJIT is committed to excellence in undergraduate education and research to provide our students exceptional learning experiences enabling them to become leaders in the global society.

Fadi P. Deek, PhD
Provost and Senior Executive Vice President

Ronald E. McNair
Postbaccalaureate Achievement Program

July 31, 2014

Welcome to New Jersey Institute's 2014 International Undergraduate Summer Research Symposium which brings together undergraduate students from colleges and universities in the United States, India and Columbia, South America to undertake research at NJIT under the guidance of its faculty. Over 101 students from ten different programs, will be presenting 91 posters describing their summer research projects under the direction of 49 NJIT faculty. The 2014 Symposium is the largest event of this type held at NJIT and required the effort of numerous faculty and staff as well as the student participants. I consider it an honor to be the Symposium Chair for an event that the seed was planted fifteen years ago by the NJIT Ronald E. McNair program with only ten NJIT students involved. However, I would be remiss not to single out for your attention those individuals that made today possible such as Ms. Talina Knox of URI, Ms. Zara Williams, assistant Director McNair Program and Dr. Atam Dhawan, Executive Director of the Undergraduate Research and Innovation Office and Acting Associate Provost for Research. I also commend to you President Joel Bloom for his long standing commitment to fostering an environment of undergraduate research at NJIT and Provost Fadi Deek for bringing the campus wide undergraduate research initiatives under one office. Together all contributed to the success of our endeavor.

Angelo J. Perna, PhD
Symposium Chair and
McNair Program Director

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UNDERGRADUATE RESEARCH AND INNOVATION

July 31, 2014

I would like to extend warm welcome to all students and faculty advisors participating in the 2014 Seventh International Summer Research Symposium. Congratulations to all NJIT undergraduate students, international students, high school students, faculty advisors and mentors for their impressive research work that spans over core and interdisciplinary areas including science, technology engineering and mathematics (STEM) as well as arts and architecture.

The spectrum of research projects pursued this summer clearly focuses on discovery of new knowledge along with application research addressing the needs and challenges of our global society for high potential impact. Opportunities to work during the summer on research projects bring a special focus as students are not stressed out with heavy course work. Through such opportunities, students get hands experience on working closely with fellow students and faculty advisors to gain valuable research experience that enhances their future career prospects whether they go to graduate or professional school, or join industry. The posters presented in the Symposium emphasize the fact that when our students concentrate on scientific and application research, they produce outstanding results with leading edge of innovation.

I am very pleased to introduce the "Book of Abstracts of Seventh NJIT International Summer Research Symposium" that contains abstracts submitted by symposium participants. We expect that the Book of Abstract will be used as a resource long after the symposium as an online publication. It can be downloaded from http://centers.njit.edu/uri/docs/2014-summer-research-symposium-program.pdf.

Organizing such a symposium requires tremendous efforts and time. I thank, with deepest gratitude, Dr. Angelo Perna, Symposium Chair and Director, Ronald E. McNair Postbaccalaureate Achievement Program for his leadership in organizing and hosting the Symposium. I am also very grateful to President Dr. Joel Bloom, and Provost and Executive Vice President Dr. Fadi Deek for their synergistic vision and kind support to undergraduate research and innovation. Special thanks to Symposium Co-Chair Ms. Zara Williams from the McNair program, Ms. Talina Knox, from the Undergraduate Research and Innovation (URI) program, and staff members from the Office of Communication and Web Services who helped in web publication of the Book of Abstracts.

Again, my heartfelt congratulations to all students, faculty advisors and mentors. I look forward to next year's symposium for more exciting and innovative research.

Sincerely,

With best regards;

Atam P. Dhawan, Ph.D.
Vice Provost for Research and Development (Interim) and Distinguished Professor
Executive Director, Undergraduate Research and Innovation

Seventh International Summer Research Symposium

Thursday, July 31, 2014

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Ronald E. McNair Postbaccelaureate Achievement Program

High-K Dielectric Material (HfALO) - Si Interface Quality Studied by Mos-Capacitance Conductance Techniques

Erole Alexandre, Advisor: Dr. Durgamadhab (Durga) Misra
Department of Electrical and Computer Engineering
New Jersey Institute of Technology, Newark NJ 07102

Abstract: Testing different fabrication methods such as post deposition annealing (PDA) and SPAN, experiments were done on devices made with hafnium dioxide to determine capacitance and conductance by applying an AC voltage to the device with a voltage swing from 1 to -1.5 at ten different frequencies. The defects with each sample revealed issues that are happening due to a poor interfacial layer with the silicon substrate. Silicon dioxide (SiO_2) has been the most stable and reliable dielectric for many years. This compound is used as the gate dielectric in complementary metal oxide semiconductor (CMOS) technology. Silicon dioxide is currently being replaced by higher dielectric constant (high-K) materials to reduce power consumption and increase reliability in microchips. Due to the decrease in size of transistors the thickness of the silicon dioxide gate has also decrease allowing for an increase in capacitance. This drives the current and provides better performance for each device. The issue of leakage currents is high and no longer acceptable for microchip to development at the rate of Moore's Law. Materials such as HfO_2 and Hf_silicate are currently being tested to check for the stability of the new materials. Measurements of the capacitances were taken of these devices as we test the capacitance of the device for characteristics the resemble that of the stable and predominately used SiO_2.

Figure 1: Fabrication Method

| Sample ID	Split Name	Vfb	EOT (nm)	Al/(Al+Hf)%
1333MRPC001-1	40cy HfO	-0.2315	1.012561	0.01204752
1333MRPC001-3	40Cy HfAlOx (0%)	-0.2396	1.006212	0.00034569
1333MRPC001-4	40Cy HfAlOx (0%) + SPAN 680C	-0.3567	0.9020682	0.07448222
1333MRPC001-5	40Cy HfAlOx (0%) + PDA 680C	-0.4407	0.9463223	0.02541354
1333MRPC001-7	20Cy HfO + 20Cy HfAlO (BKM) + SPAN + 680C PDA	-0.3623	0.99720025	4.75043271

Heterogeneous Impact Initiation of Tungsten-based Reactive Materials

Noor Aly, Dr. Mirko Schoenitz, Dr. Edward L. Dreizin
Department of Chemistry and Chemical Engineering
New Jersey Institute of Technology, Newark NJ 07102

Abstract: As a high-density metal, tungsten is of interest for use in penetrators and munitions casings. However, tungsten is not readily ignited, potentially leaving its chemical energy of oxidation unused. In this effort, a set of tungsten-rich composite materials with more than 50 % of tungsten by weight were prepared by mechanical milling. The second component metal was zirconium. Substantial powder particle size reduction was observed with short milling times. The addition of zirconium causes tungsten to amorphize, with average particle sizes around 10 μm. Tests of sensitivity to electric sparks showed that all materials could be reliably ignited with subsequent combustion times of about 100 ms, contrary to unmodified tungsten. Constant-volume aerosol combustion tests showed that as part of the prepared composites, tungsten burns to a substantial degree. Further systematic experiments will be used to establish minimum initiation energies as a function of bulk composition and degree of refinement and amorphization. Net energies that can be recovered by combustion will be determined.
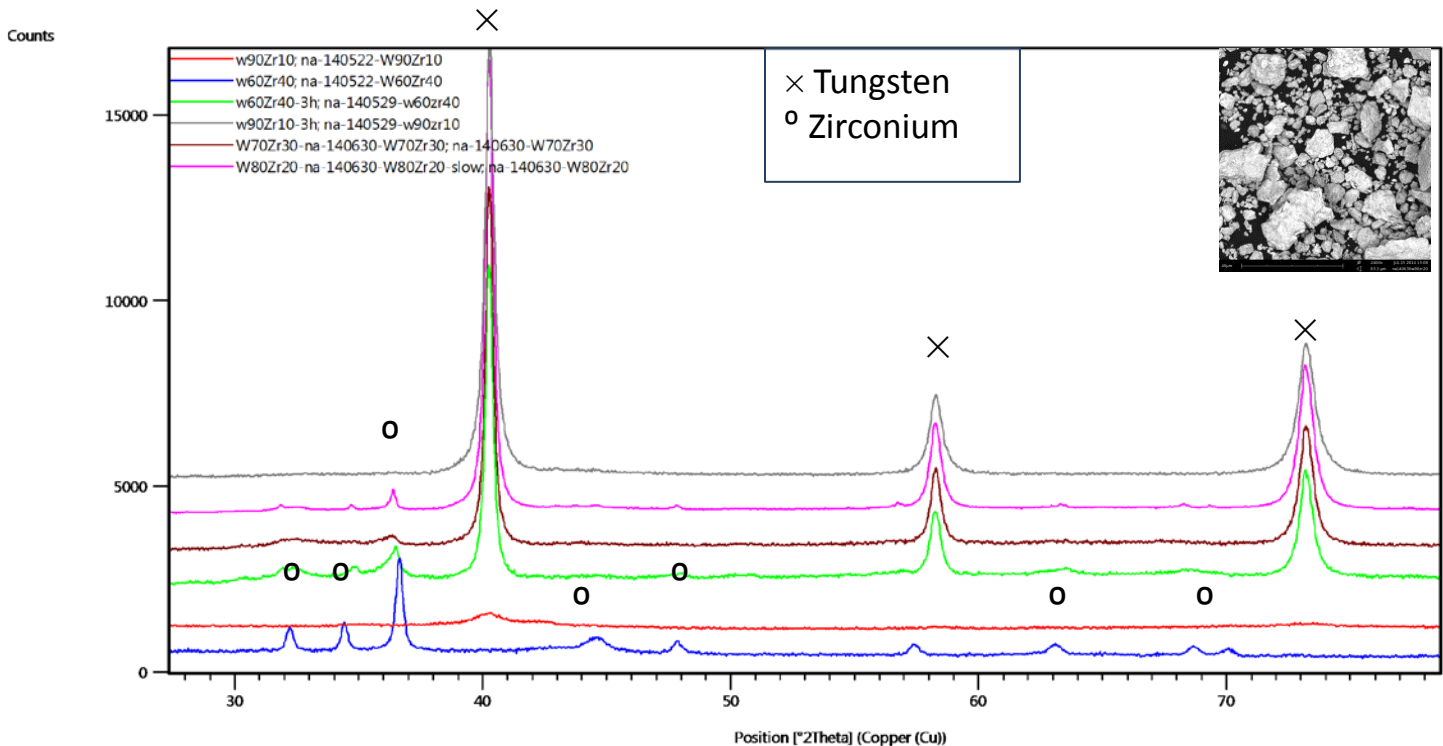
SEM image and X-ray diffraction curve depicting phase compositions of W-Zr powders at varied weight percents

Effect of Turbulence on Burn Rate of Reactive Material Particles

Jose Chacon, Advisor: Dr. Edward L. Dreizin, Mentor: Amy Corcoran
Department of Chemistry and Chemical Engineering
New Jersey Institute of Technology, Newark NJ 07102

Abstract: Metal powders are vastly used as fuel additives due to their high energy densities and their ability to enhance energetic formulations. Although Al is the most widely used metal fuel additive because of its high heat of combustion, it produces long ignition delays and burn times. Preliminary experiments showed Mg as a promising fuel additive producing quicker burn times than that of pure Al with similar size ranges; however, Mg has a significantly lower heat of combustion. Recent work concentrated on characterizing the combustion dynamics of fine, mechanically alloyed Al-Mg powders. The powders were prepared in a planetary mill by combining aluminum and magnesium powder by use of ball-milling.

The experiments were aimed to measure burn times for the alloyed particles igniting in a CO_2 laser. Turbulence will be induced using a wire mesh directly over the laser. Metal powders will be carried by an air flow and fed through a center tube where the particles will escape, ignite, and burn when it passes through the laser. Optical emission of burning particles will be recorded using filtered photomultiplier tubes; emission durations will be represented as burn times and placed into logarithmically spaced bins. Burn times will be correlated with their respective particle size distributions assuming larger particles burn longer. It is expected that these results will serve to develop a mechanistic model for burn rates of Al-Mg alloys in a turbulent environment.
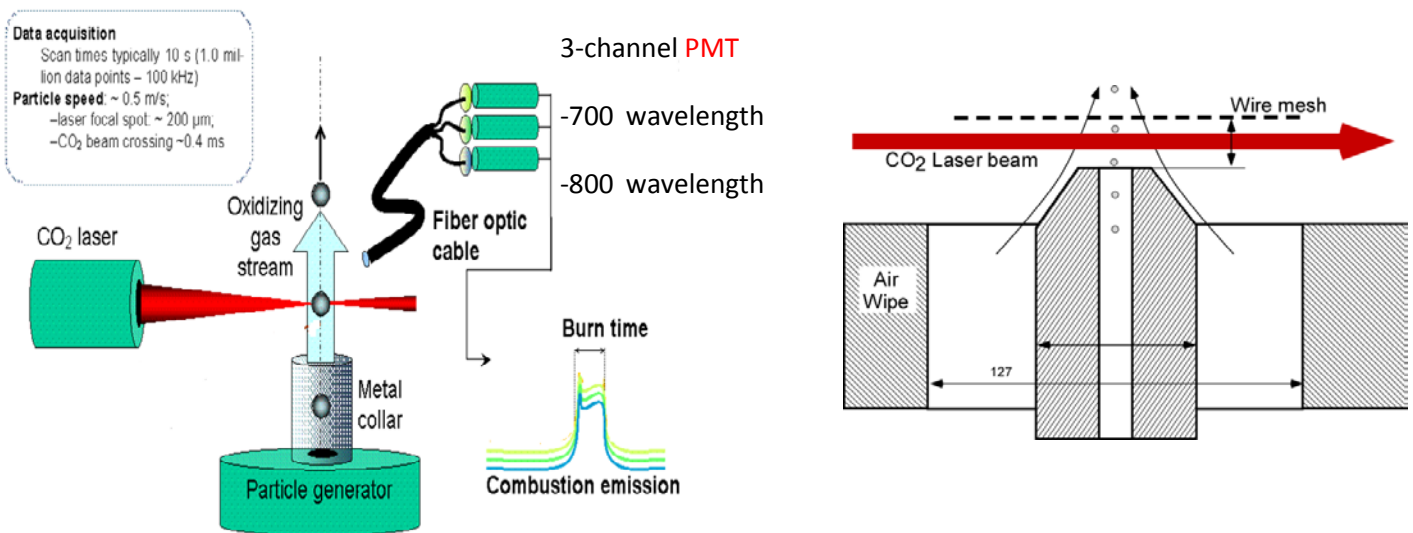
Collaborative Learning through Assessment:
Literature Review on Motivation and Assignment Editor

Michael De La Cruz and Dr. Michael Bieber
Information Systems Department
New Jersey Institute of Technology, Newark, NJ 07102 USA

Abstract: This project is a subset of a larger research effort named Collaborative Learning through Assessment (CLASS), which is a systematic approach and learning tool that promotes deeper learning by engaging students to test each other's knowledge in a course. The goal of this research is to show that the CLASS framework (sets of activities) promotes deeper learning and encourages students to take courses much more seriously. Part of this research, will consist of literature review on how different aspects of the CLASS framework motivate students. The other part of the research entails the migration of the prototype into Moodle and the development of the assignment editor using Hypertext Preprocessor (PHP). We have conducted usability tests on different groups of individual people, such as high school students and NJIT students, but very soon we will test with professors. Our results revealed that people engaged very well with the CLASS system both directly through the website and also through the integrated version from Moodle, and that both are fairly easy to use and navigate, and support the learning process. We anticipate that testing the assignment editor's user interface and functionality with instructors will also provide valuable input to better understanding CLASS and its impact on teaching and learning. Through implementation of the CLASS framework, students should be motivated to learn course subjects much more earnestly, and be more likely to pursue follow-on studies, because they participate heavily and collaboratively learn from their classmates. Further research should experiment with utilizing CLASS in actual courses to determine how well and in what ways it motivates students to become more involved through the active learning experience.

Indoor Hybrid System Cooperating Wi-Fi and Visible Light Communication

Pierre A Mbe Fokam, Advisor: Dr. A Khreishah, and Mentor: S.H. Shao, PhD Student
Department of Electrical and Computer Engineering
New Jersey Institute of Technology, Newark, NJ 07102 USA

Abstract: Nowadays, indoor mobile devices connect to Internet using Wi-Fi, which uses Radio Frequency (RF) band. The growing number of devices and high volume of network usage have drastically increased the use of the Wi-Fi. The overuse of limited resources or spectrum of RF has resulted in wireless traffic bottlenecks. Visible Light Communication (VLC) has several advantages that can be exploited to improve the quality of wireless communication. VLC offers an unlicensed wide bandwidth, high security, low energy consumption, and dual use. This research will propose a system involving the coexistence of VLC and Wi-Fi supported by an asymmetric network scheme. This system will provide a faster connection between the client and server comparing to the traditional Internet connection using Wi-Fi only. Our main focus consists of establishing the connection between the client and the server in a dual networking system involving simultaneously VLC and Wi-Fi. The client uses the uplink channel to make a request to the server. Then utilizes the traditional wireless to receive data from the server that uses the downlink via VLC as shown on the figure bellow. We have successfully tested the throughput from the client prospective. Future research will concentrate on the security aspect of this dual network.
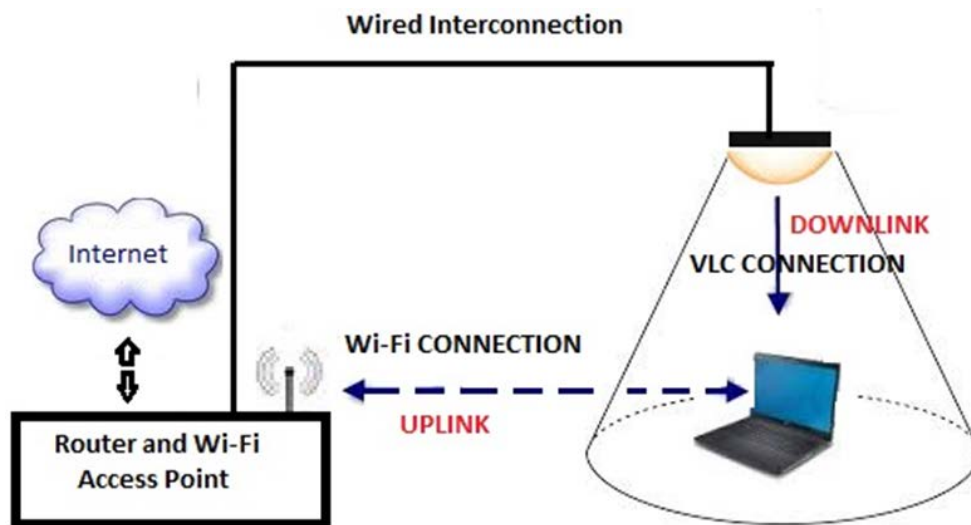
Proposed hybrid Wi-Fi and VLC network model

Spark Ignition of Nanocomposite Thermite Powders

Nazmul Hossain, Advisor: Dr.Edward L. Dreizin, Mentors: Rayon Williams, Xinhang Liu, Ian Monk
Department of Chemical Engineering
New Jersey Institute of Technology, Newark NJ 07102

Using Electro Static Discharge (ESD) the following thermite powders, 2Al-3CuO, 2.35Al-Bi$_2$O$_3$, 2Al-Fe$_2$O$_3$, and 2Al-MoO$_3$, were ignited in the air. In addition, effect of different environments, such as argon and vacuum was observed for ignition of 2Al-Fe$_2$O$_3$, and effect of different milling times on ignition was observed for 2Al-3CuO. Particles placed in a monolayer on a conductive substrate were used. Only individual particles were ignited and ejected from the substrate for the powder monolayer. Time-dependent emission traces filtered at different wavelengths produced by the ignited powders were recorded. Integrated emission spectra were obtained. Emission traces showed both ignition delays, defined as time intervals between spark and powder ignition and averaged particle burn times, determined from the overall duration of the recorded emission pulse. Recorded filtered emission traces were processed to obtain the emission peak position, its width, and height.

Ignition delays changed depending on the ESD voltage in the air. For 2Al-Fe$_2$O$_3$, ignition delays became shorter in argon and much shorter in vacuum. Delays became shorter as voltage increased for different milling time of 2Al-3CuO. Results for different powders, 2Al-Fe$_2$O$_3$ in different conditions, and effect of different milling time for 2Al-3CuO will be presented and discussed in the poster.
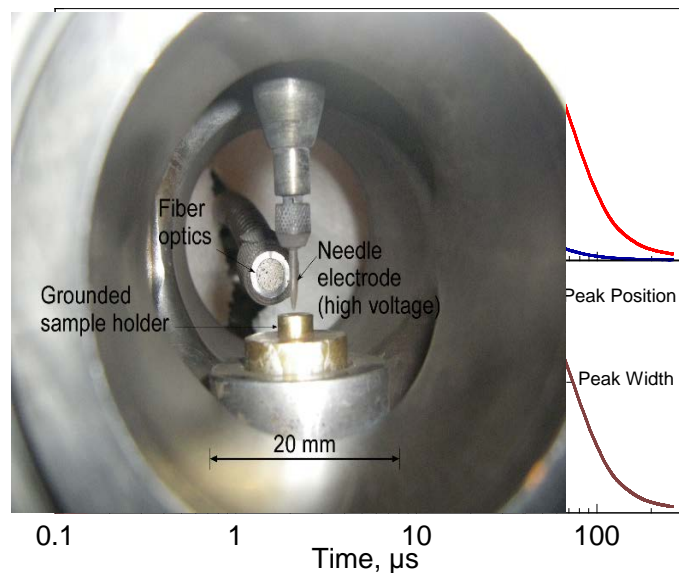
Conversion of Carbon Dioxide to Useful Liquid Chemicals using A Novel Organic Based Catalytic System

Jaelynne King, Advisor: Dr. Xianqin Wang, Mentor: Sherry-Ann TimKee
Otto H. York Department of Chemical, Biological and Pharmaceutical Engineering
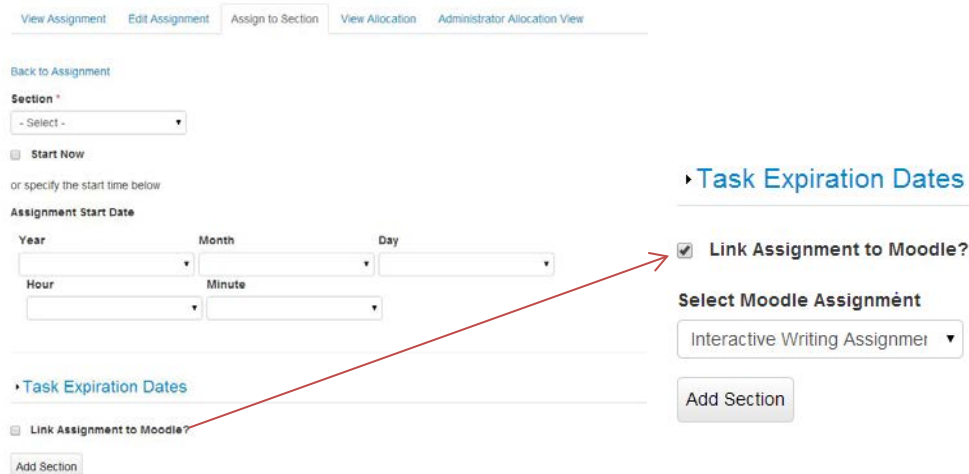New Jersey Institute of Technology, Newark NJ 07102

Abstract: Climate Change is a global phenomenon that is caused by increased levels of carbon dioxide (CO_2) in the atmosphere. The current solution to mitigate the high levels of atmospheric CO_2 is Carbon Capture and Storage (CCS). However, more economical and feasible solutions are being researched. CO_2 conversion to useful chemicals such as formic acid and methanol can help eliminate atmospheric CO_2, which will minimize the effects of global warming and provide a long-term economically feasible solution. CO_2 will serve as a feedstock to fuels that will replace current fossil fuels (gasoline, crude oil and coal) consumption without changing the fossil fuel economy. Conventionally, studies of CO_2 conversion have included many catalysts, such as TiO_2 and copper and zinc based inorganic materials. In this study, we are investigating a novel catalytic system to convert CO_2 to useful liquid chemicals using organic based catalyst. In this talk, some preliminary results using pyridine as a catalyst will be presented and discussed.

Collaborative Learning through Assessment (CLASS): Developing Interpersonal Skills and Establishing Integration of a New Learning Method

Alex Nyamweya, Advisor: Dr. Michael Bieber
Department of Information Systems
New Jersey Institute of Technology, Newark, NJ 07103

Abstract: This research on interpersonal skills is a vital aspect of a greater effort toward a learning system where peers are engaged in deep learning. Collaborative Learning through Assessment, or CLASS for short, is a learning approach implemented within a computer-based system that actively involves students in all aspects of the problem life cycle. The CLASS framework should enable students to build on interpersonal skills, such as leadership, teamwork, and communication. Honing these interpersonal skills will help college graduates be more successful in the workplace and maintain job security in the long run. One of the goals of this project includes developing a literature review on how group assignments through computer-assisted instruction are designed in a way that promotes interpersonal skills among students, in order to design best practices within CLASS. Other project goals include the design of the integration of CLASS with Moodle and the integration of the CLASS-e Assignment Editor with CLASS to make it available for students and instructors. Drupal, a content management system, and PHP, a web server scripting programming language, were both utilized to accomplish these tasks. Expectations for Moodle to CLASS Integration include having synchronized accounts, linked assignments, and grade sharing. Completion of Moodle integration with CLASS will allow further possibilities in using CLASS with other Learning Management Systems, such as Blackboard, that are used by many universities. The literature review will lead to further research implementing and running experiments on how the CLASS framework and system could handle group activities that would best support interpersonal skills.

Screenshots of Moodle and CLASS assignments being linked

Collaborative Learning through Assessment (CLASS)
Facilitation of a Flexible Framework and Literature Review

Joshua Ortega, Advisor: Dr. Michael Bieber
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Abstract: This study is a subset of a larger research project involving a learning system named CLASS (Collaborative Learning through Assessment). CLASS is designed to facilitate problem based and collaborative learning in a virtual environment. To maximize CLASS's effectiveness, previous learning systems were observed and researched. By implementing what was found to be effective into the CLASS system, it is hoped that student learning will increase. Experiments will measure how effective the implemented changes were. Usability studies also are informing CLASS design improvements. It is recommended that CLASS continues development and that further studies are done to properly measure student learning.

Current Task: Grade a Solution

Grade the solution to the specific problem shown above. (There are several different problems so be sure to read the one being solved here.) Each grade has several parts. Give a score and an explanation of that score for each part of the grade. Your explanation should be detailed, and several sentences long.

Evaluate these questions on three criteria:

- Accuracy (40 Points)
- Issue (40 Points)
- Writing (20 Points)

Accuracy

▸ How to Grade

Judge the accuracy of this response. *

| 38 |

Grade Range: 0 - 40

Justify your grade *

| The solution provides all the information required to answer the question, but could use more detail. |

Screenshot of the CLASS system.

Impact of Polymer Molecular Weight on the Physical Stability of Milled Drug Suspensions

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Department of Chemistry and Chemical Engineering
New Jersey Institute of Technology, Newark NJ 07102

Abstract: The goal of this project is to study the impact of molecular weight of a polymeric stabilizer on the breakage rate of drug particles during wet stirred media milling (WSMM) and any particle size change after 7-day storage. Having a large surface area, drug nanoparticles exhibit faster dissolution than typical micron-sized drug particles; in turn allowing for enhanced bioavailability for poorly water-soluble drugs. However, ensuring physical stability of drug nanoparticle suspensions (nanosuspensions) during milling and storage is a big challenge. In this study, griseofulvin, a model poorly water-soluble drug, was wet-milled to prepare nanosuspensions with various stabilizer formulations. Hydroxypropyl cellulose, a non-ionic polymer, with various molecular weights (SSL, SL, and L grades) and sodium dodecyl sulfate, an anionic surfactant, were used as the stabilizers to impart physical stability to the milled suspensions. Particle size distributions during milling and after storage as well as viscosity of the milled suspensions were measured to assess the physical stability of the milled suspensions.

A Beckman Coulter LS 13-320 Laser Diffraction instrument was used to determine the drug particle size distribution using Mie scattering theory. The cumulative volume distribution of the milled suspensions is plotted below. In all cases, drug loading was kept at 10% (w/w), and HPC concentrations varied from 0.25% to 7.5% (w/w) at an SDS loading of 0.05% (w/w). For formulations with HPC SSL (HPC with ~40 kDa), the milled suspensions had small drug particles (d90 < 250 nm), and the polymer concentration did not seem to affect the particle size distribution significantly (Left Panel). On the other hand, coarser drug particles formed when HPC SL (~100 kDa, Middle Panel) or HPC L (~140 kDa, Right Panel) was used at a concentration less than 5% (w/w), which could be too high for some pharmaceutical applications. An increase in HPC concentration led to finer particles and narrower size distributions. These observations can be explained by steric stabilization action of the HPC and its impact on the prevention of nanoparticle aggregation. HPC with the lowest molecular weight (SSL) is the most effective at low concentrations for stabilizing the drug nanoparticles.
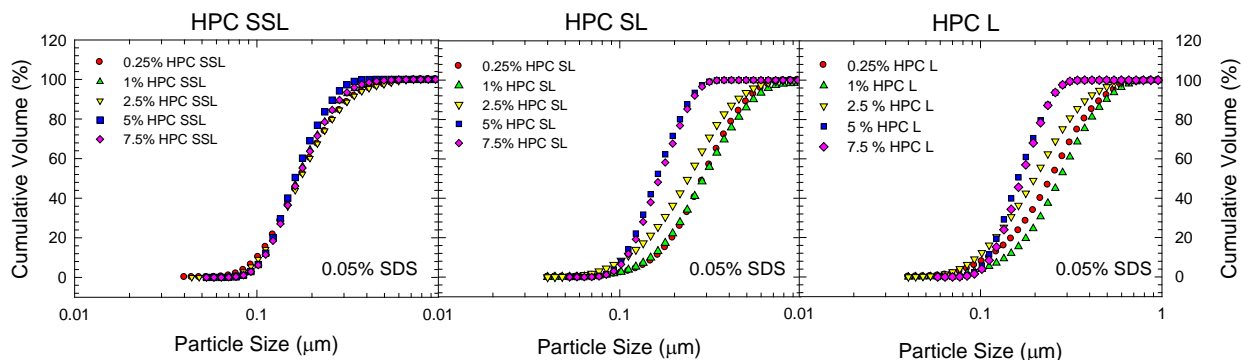
Figure: Cumulative particle size distributions of griseofulvin particles in milled suspensions with 0.05% SDS (surfactant) and various grades of HPC (polymer). SSL, SL, and L grades have average molecular weights of ~40 kDa, 100 kDa, and 140 kDa, respectively.

Heritage Institute of Technology – NJIT Summer Research Program

Fabrication of gelatin/glycosaminoglycans (GAGs) scaffolds for spinal cord repair

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New Jersey Institute of Technology, Newark, NJ 07102 USA

Abstract: Spinal cord injury (SCI) occurs due to trauma and results in the loss of functional nervous tissue. Using tissue engineering scaffolds may be an approach for spinal cord repair because they may provide a favorable environment for axonal growth. The electrospinning technique has been used to produce such scaffolds of high porosity and surface area to support cell attachment and growth. Aligned fibers produced by the electrospinning technique have been used in order to provide directionality to the neurites growing on the scaffolds. In this study, scaffolds composed of gelatin with glycosaminoglycans mimics-I (mGAG-I) or GAG mimics-II (mGAG-II) were fabricated. Gelatin being a natural polymer provides cell adherence and proliferation properties to the scaffolds. The mGAGs mimic chondroitin sulfate (CS), which is produced in spinal cord injury, may play a role in promoting axonal growth. Scaffolds with fiber diameters of approximately 700nm were produced (Figures 1 and 2). This material has great potential for therapeutic repair of the spinal cord due to its physical features and biochemical composition and will be investigated for in vitro testing of neurite outgrowth.
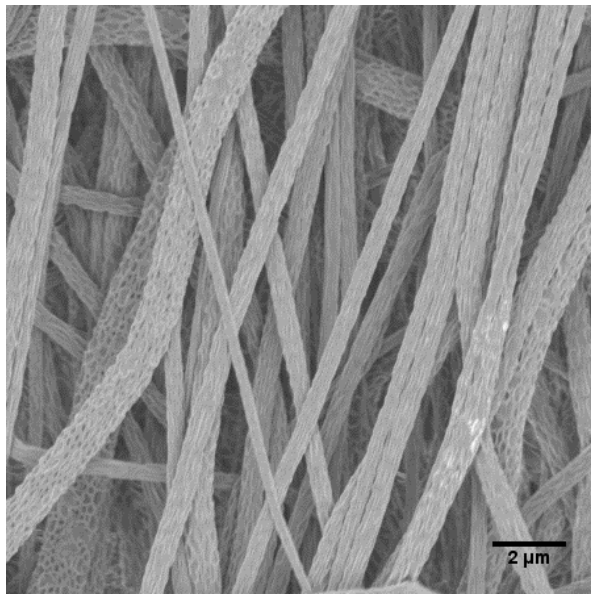
Figure 1. SEM image of mGAG-and Gelatin fibrous scaffolds (Magnification 10,000 X, scale bar 2 µm). Fiber diameter is 672.2 ±45.16 nm
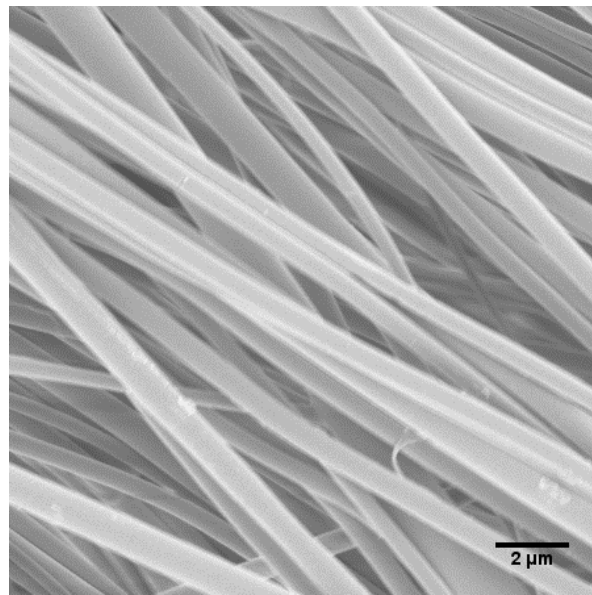

Figure 2. SEM image of Gelatin fibrous scaffolds. (Magnification 10,000X, scale bar 2 µm). Fiber diameter is 835.16 ± 263.25 nm

A Hybrid System: Co-existence of Visible Light Communication (VLC) and Wi-Fi.

Indrasis Banerjee, Sihua Shao and Dr. Abdallah Khreishah
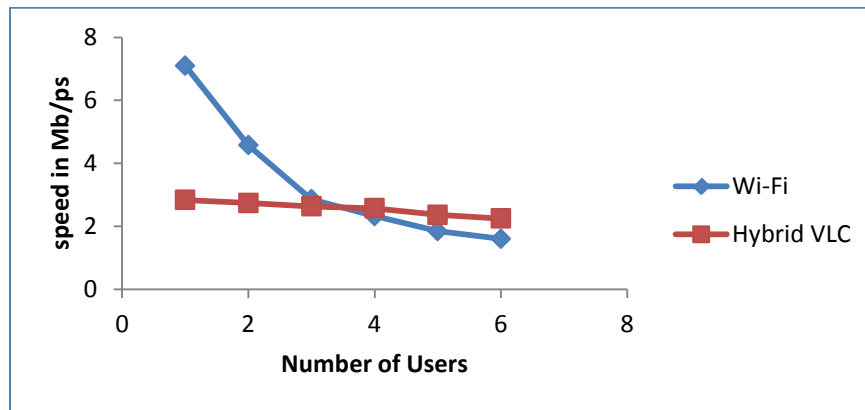*Department of Electrical and Computer Engineering.*
New Jersey's Institute of Science and Technology

Abstract: This project aims to integrate Wi-Fi and Visible Light Communication (VLC) as the uplink and downlink channels, respectively. Visible light communication refers to indoor optical wireless communication that uses the visible light spectrum from 380 to 780nm, data in VLC is transferred by intensity modulating optical sources, such as LED's that are being used, faster than the persistence of the human eye, the data is received by a photo-detector which demodulates the light signal into electronic form. VLC is used here for the downlink. Wi-Fi is used for the uplink. The reasons behind choosing Wi-Fi for the uplink are the following:

- The Wi-Fi consumes less power than the VLC; therefore the total energy consumption is lower.
- The relative position of the receiver with respect to the transmitter changes which changes the amount of light received by the transmitter which results in the variation of the uplink signal strength.
- The presence of Unpleasant irradiance affects the VLC.

As Radio frequency Communication below 6GHz is quickly running out of bandwidth for high data-rate communication, VLC with ~ 600THz of available bandwidth, multi-gigabit-per-second data rates could be provided over short distances at low power and cost, using simple LED's. The integration of lighting and communication will provides significant advances in this technology, and with growing integration of LED's in indoor light sources and the advances in the design of the low cost LED's with fast sub-nanosecond switching response time, this technology will receive further boost.

The figure below shows the plot showing the average download data rate of Wi-Fi only and hybrid VLC system:

STATISTICAL MODELING OF THE RECEIVED POWER IN WIRELESS NETWORKS

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New Jersey Institute of Technology, Newark NJ 07102

Abstract: It is important to realize that the knowledge of the received signal level is not sufficient to evaluate correctly the performance of a system. Random small-scale fading creates changes in the received signal amplitude that can have a profound impact on the quality of the reception, as well as on the performance of the wireless network. Fading is caused due to interference of the multipath waves.

Statistical distribution of received power is measured in indoor environment using software defined radio units. Random positions of the receiver were used in order to see the effect of multipath propagation due to some barrier in the path of propagation of the signal. The mean square error measures the difference between the values predicted by a model and the values actually observed. Thus the model for which the area between the predicted and the actual curve is least the i.e. MSE is minimum, is the most suitable distribution.
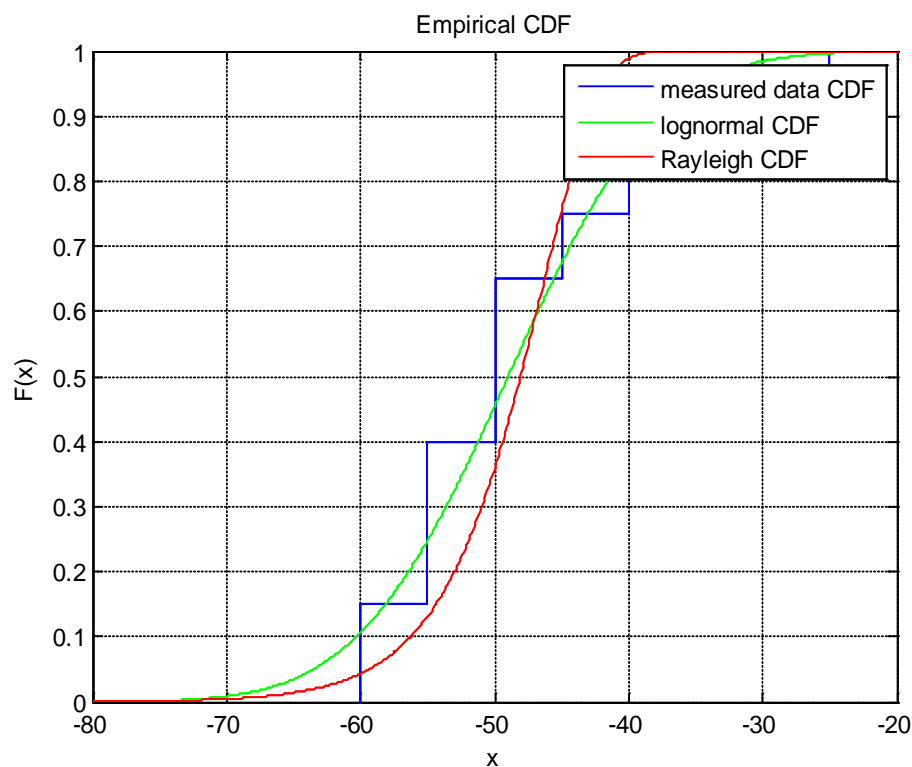
Now, we are working on Rice fading model and estimation of the rice factor 'k'.

# Image Statistical Analysis and Its Application to Information Forensics

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New Jersey Institute of Technology, Newark, NJ 07102 USA

Abstract: 'Image statistical analysis' actually means to analyze the statistical nature of a given image. The is often done by applying Fourier spectrum analysis. The histogram of the image pixels is often another way for analysis in spatial domain. In this study, we apply both of these two kinds of technologies to certain images. In other words, image, features can thus be obtained. Applying these two types of features to the advanced classifier known as SVM (support vector machine), the image tampering detection can be conducted by using the Columbia Data Set. That is, 80% of images in the dataset are used for training the machine, and the remaining 20% images are used for testing. The classification rate can reach above 90%. This indicates that the machine learning is an effective way for information forensics.

From the Fourier Spectrum it can be seen that the image power tends to get high concentration towards the center of the image (shown in the left) as shown in the middle graph. From there, one can observe that the DC and low-frequency portion occupy majority of the signal power. The histogram derived from the pixels (shown in the right) is another way to describe the distribution of pixel gray-levels in spatial domain.

The real image having low frequency
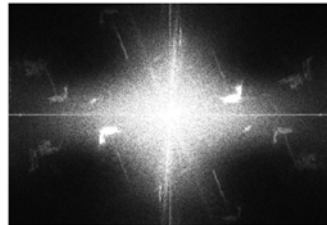
Fourier Spectrum of the image
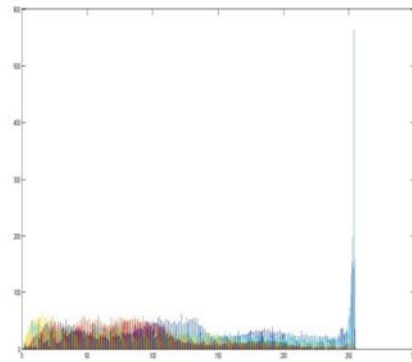
Pixel Histogram of the image

# Engineering CotA Laccase for Acidic pH Stability using *Bacillus subtilis* Spore Display

Sunandan Dhar, Silu Sheng, Edgardo T. Farinas
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New Jersey Institute of Technology, Newark NJ 07102

Directed evolution is an effective strategy to engineer and optimize protein properties and microbial cell-surface display is a successful method to screen protein libraries. Protein display on spore coat of *Bacillus subtilis* is a useful tool for directed evolution. By virtue of the natural sporulation process, protein-folding issues are avoided. Furthermore, spores remain viable in harsh chemical and physical environments. As a result, proteins can be evolved with extreme properties. Next, surface displayed proteins are preimmobilized in the inherently inert outer spore coat and immobilized proteins have economic and technological advantages in industrial processes. For example, spores are easily removed from the reaction solution by filtration. The laccase CotA, which is a *Bacillus subtilis* spore coat protein, was evolved for enhanced stability at pH 4. Laccases have biotechnological applications, which include bioremediation, biosensors, green chemical synthesis and biofuels.

The CotA shows maximum catalytic activity at pH 4, but the half-life ($t_{1/2}$) is only 18.3 minutes. Hence, wild-type CotA was evolved for enhanced $t_{1/2}$ at pH 4. A E498G mutant was identified after screening approximately 3000 clones. This variant had a $t_{1/2}$ of 918 minutes, which is 50 fold better than the wild-type.

Graph: Acid Inactivation of Wild-type and Mutant CotA Enzyme over Time
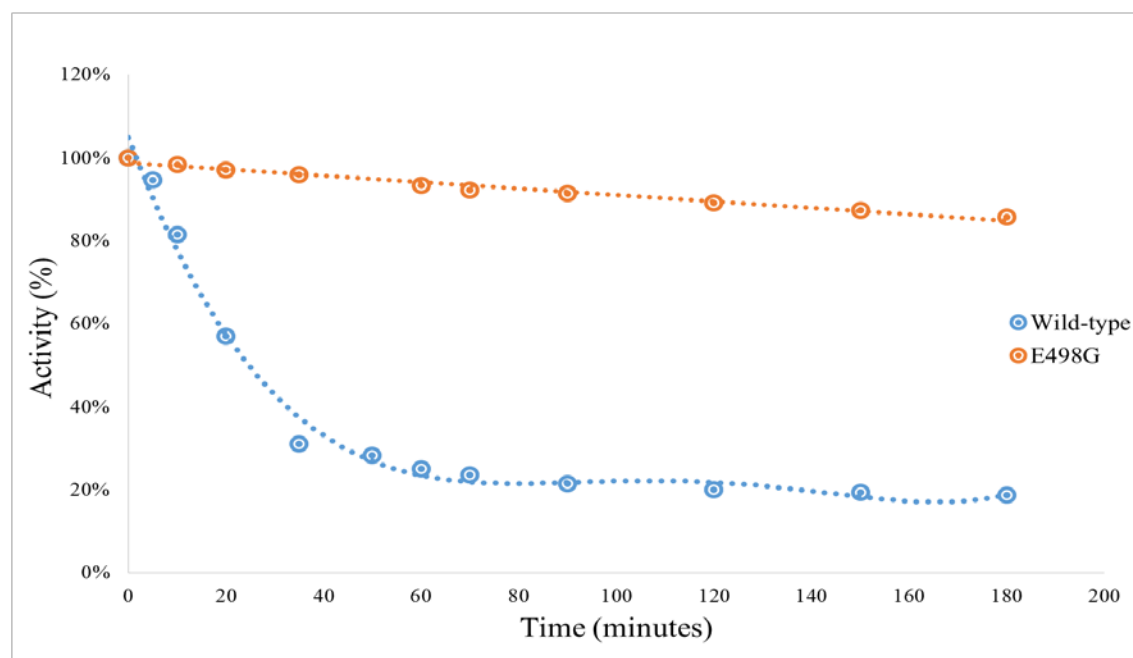
Characterization of Deep Level Defects in a Thin Film Solar Cell

Sourav Dutta, Yiming Ding and Durga Misra
Department of Electrical and Computer Engineering,
New Jersey Institute of Technology, Newark, NJ 07102 USA

Abstract: Production of Thin Film Solar Cells is still limited by the low efficiency as compared to silicon-based solar cells. One of the main reasons for the poor performance is the presence of deep level defects or traps in the absorber layers. These defects can capture charge carriers generated by the photovoltaic process, resulting in decrease in output current and overall efficiency of the cell.

In an effort to characterize traps present in a semiconductor, a new technique, Deep Level Transient Spectroscopy (DLTS) is used. In DLTS a capacitance transient is thermally scanned to detect a wide variety of traps close to the mid-ap. There are two kinds of traps, the majority carrier traps and minority carrier traps. Increasing capacitance indicates majority carrier traps, while a decreasing capacitance indicates minority carrier traps (Fig. 1).

The DLTS measurement for the CNBM center solar cell sample was carried out. The sample was cooled to 130 K and then slowly heated up to 330 K. Temperature was increased by 1 K and was held at a constant temperature for 10 seconds. During the 10 seconds of holding, the DLTS spectrum (Fig. 2) was measured 10 times per each time window and then the average was calculated. Four possible defects were identified where one of them is an electron trap and three others are hole traps (Table I).
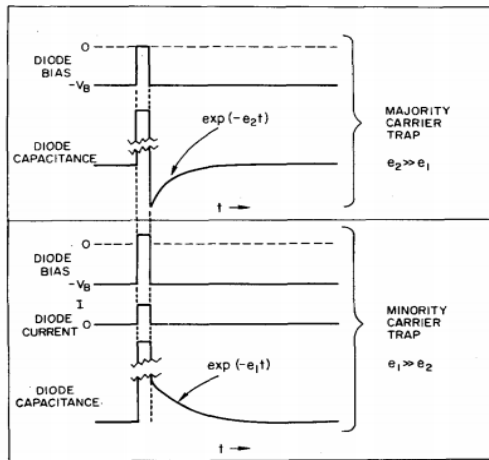
Fig. 1
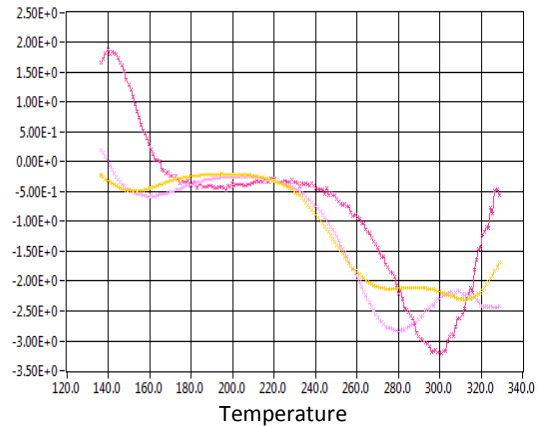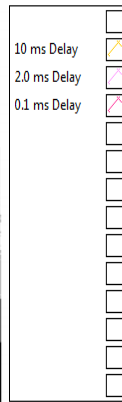
Fig. 2

Table I		Experiment 1	Experiment 2	Experiment 3
HL1	E_L	0.35 eV	0.371 eV	0.351 eV
	N_L	4.79×10^{12} cm^{-3}	4.72×10^{12}	4.66×10^{12}
	σ_p	3.84×10^{-14} cm^2	1.32×10^{-13}	1.6×10^{-14}

Functional Magnetic Resonance Imaging (fMRI), A Tool For Quantifying Psychiatric Disorders

Saptadwipa Ganguly, Suril Gohel and Prof (Dr) Bharat Biswal
Department of Biomedical Engineering,
New Jersey Institute of Technology, Newark, NJ 07102 USA

Abstract: Functional Magnetic Resonance Imaging (fMRI) due to its high spatial and temporal resolution in addition to its noninvasiveness has become the method of choice for studying whole brain imaging in human and animal models. fMRI uses the paramagnetic properties of oxygenated and deoxygenated haemoglobin to see images of changing blood flow in the brain. Due to the differences in the Blood Oxygen Level Dependent (BOLD) signal amplitude across subjects resting state fMRI is a specific type of fMRI that collects BOLD signal when the subjects is not performing any specific cognitive tasks. Mapping brain function using resting state fMRI has emerged as an alternative to task activation and has been found to be robust and reliable across subjects. A number of features of resting state fMRI have been used to characterize the resting state fMRI signal- amplitude of low frequency fluctuation.It is one of the most common index for measuring spontaneous brain activity, is computed by calculating the power spectrum within the low frequency range(.01-0.1Hz). In the current study we use mALFF and fALFF data obtained from 1103 healthy subjects from resting state fMRI as it is the data obtained from each of the voxels in the brain. Each of the subjects mALFF images were divided in to a set of 200 different and distinct brain regions and mean ALFF values were extracted for each of the subjects. We have observed that certain brain regions () have displayed consistently lower signal power across subjects compared to brain regions () that were found to be higher across subjects. We aim to use the ratio of ALFF of these brain regions in characterizing subject variation in age, sex and use it as a tool for quantifying psychiatric disorders such as Schizophrenia.

MEAN ACROSS ALL THE ROIs IN ALL THE SUBJECTS
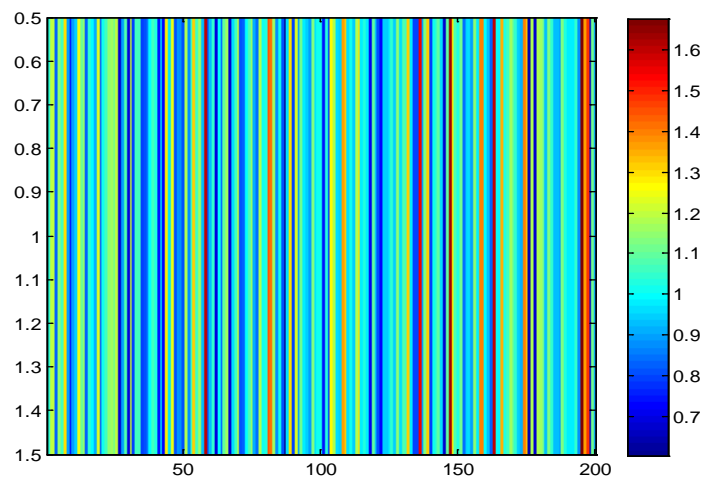
Finding and Analyzing Solar Burst Events Using IDL.

Sunil Kumar, Gelu M. Nita and Dale E. Gary
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New Jersey Institute of Technology, Newark, NJ 07102 USA

Abstract: Solar flare is a sudden flash of brightness observed over the solar limb. Typical energy released in a large flare is approximately 10^{32} erg and the solar luminosity is 4 x 10^{33} erg s^{-1}. Magnetic recombination is the reason for producing solar flares.

The solar interferometer arrays situated at Owens valley solar array, gave the data in primary form. Then that data is converted into archive files. The archive files for 2005 and 2006 were analyzed by using IDL (Interactive Data Language). Solar flares were recognized by doing background subtraction (fig.1) then set the fit intervals for the files which contained the flare events. If a file contained more than one solar flare then set the peak frequency intervals. Peak flux (unit is in SFU; 1 SFU = 10^4 jansky = 10^{-2} W m^{-2} Hz^{-1}), peak frequency (1.2 kHz to 18 kHz), low and high frequency power index were carried out (fig.2).
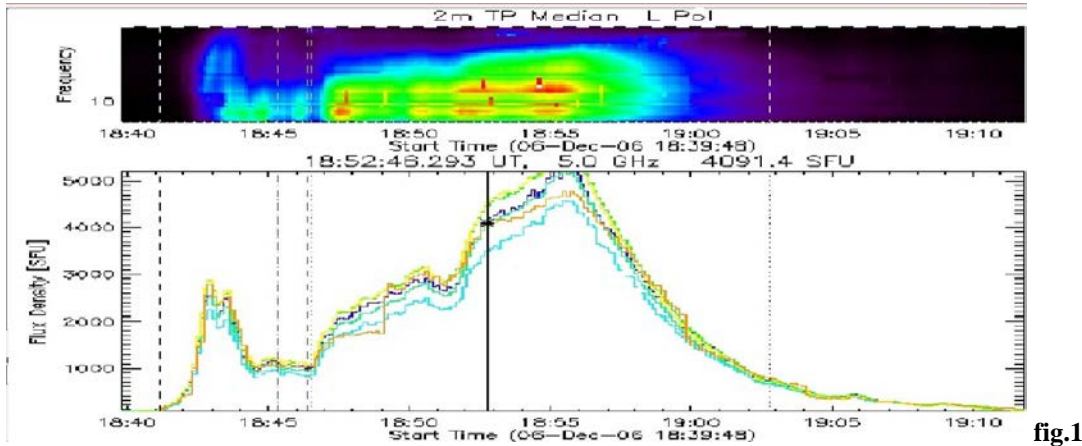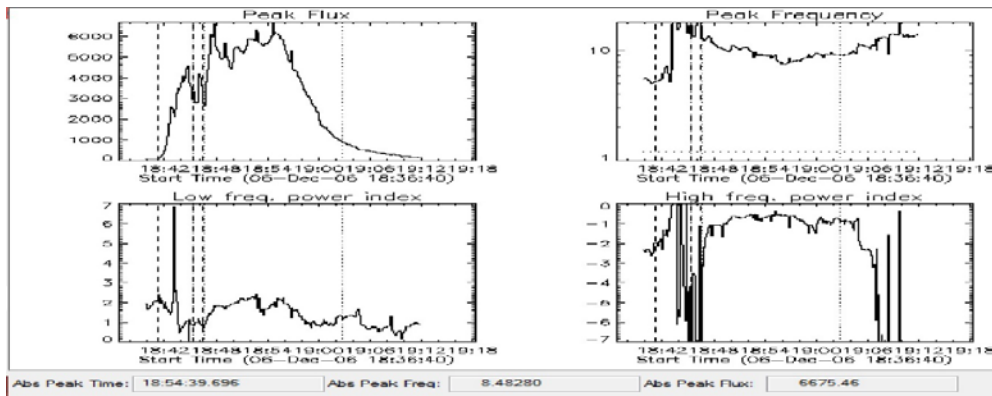
SOLAR FLARE Analyzed FILE:

fig.1

FIT RESULTS:

fig.2

Analysis of Repeatability of an Industrial Robotic Arm

Gaurab Kar, Mitul Khanchandani, Babak Hoseini and Sanchoy K. Das
Department of Mechanical and Industrial Engineering,
New Jersey Institute of Technology, Newark, NJ 07102 USA

Abstract: The Positional Repeatability of a Robotic Arm is a measure of its ability to move back to the same position and orientation, and place its end point on the same target point within the work envelope while doing a repetitive task.

One of the main obstacles of robotic applications in Industry is to minimise positional errors under different working conditions. The objective of this research is experimental analysis of how the repeatability performance of a LabVolt 5200 Industrial Robotic Arm is affected by varying the three factors: i) Density of points, ii) Path sequence and iii) Speed of movement. Six experiments are designed in increasing order of complexity with variations of the aforementioned factors. The Robot is programmed to trace some predetermined points in a grid repetitively. After conducting the experiment it is observed that the displacements of the traced points from the target points are slightly different in almost each case. Statistical analysis is done on the data by performing ANOVA(Analysis of Variances) and drawing Box Charts to analyze which of the factors affect positional repeatability.

Figure 1 shows the six experimental setups with the red points indicating the points to be traced, and the blue arrows indicating the path sequence, and Figure 2 shows the Box Charts drawn with data collected for variation of error for different point densities at three constant speeds.
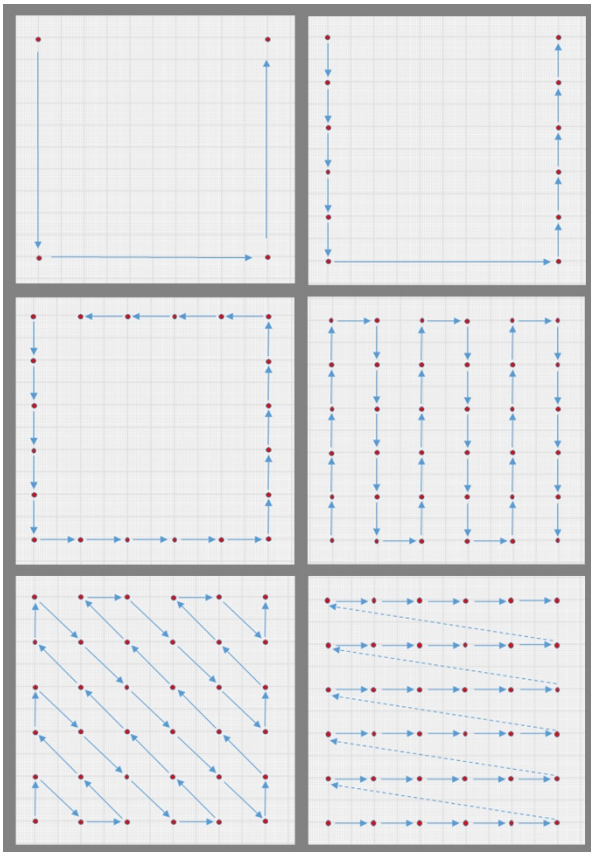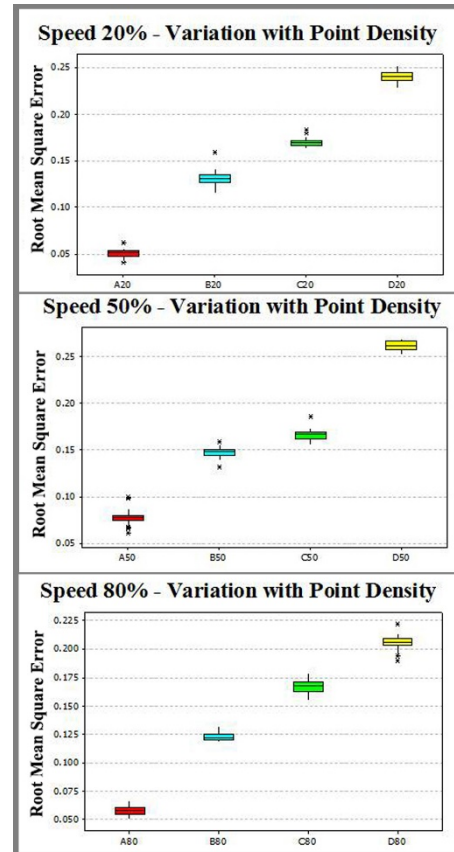

Figure 1

Figure 2

Design and Fabrication of Constant-Fluid-Flow Regulating Micro Fluidic Valve

Vikas Mittal, Rajendra K Jarwal and Dentcho Ivanov
Department of Electrical and Computer Engineering
Microelectronics Fabrication Center
New Jersey Institute of Technology, Newark NJ 07102

Abstract: A constant-fluid-flow-regulating variable-pressure-sensing micro-valve is presented. The valve provides a stable constant fluid flow and can operate in combination with on-off micro-fluidic valves used in drug delivery implantable devices or catheters where a constant flow of the fluid is required. If the pressure in the fluid storage container changes because of temperature variations or any other reason the flow will vary accordingly. The valve has a form of a cantilever embedded in a micro-fluidic channel through which the fluid is running. If the pressure at the input of the channel changes, the cantilever will bend accordingly up or down. A pair of metal electrodes - one on top of the cantilever and another one on the bottom of the micro-channel - form a capacitor. When the cantilever moves, the distance between the plates of the capacitor will change and the capacitance will also change. An electronic circuit detects the capacitance change and signals to a transistor inverter to reverse accordingly the polarity of the capacitor. The electrostatic force created between the electrodes will bring the cantilever back to equilibrium thus ensuring a constant fluid flow.

The electrostatic force as a function of the distance between the capacitor's plates (d) is plotted. The curve shows a non-linear relationship between both parameters.

The fabrication is done by using three different silicon wafers. The process flow includes photolithography, metallization, etching and bonding of all the wafers. The Schematic Diagram of the valve is shown in fig.1
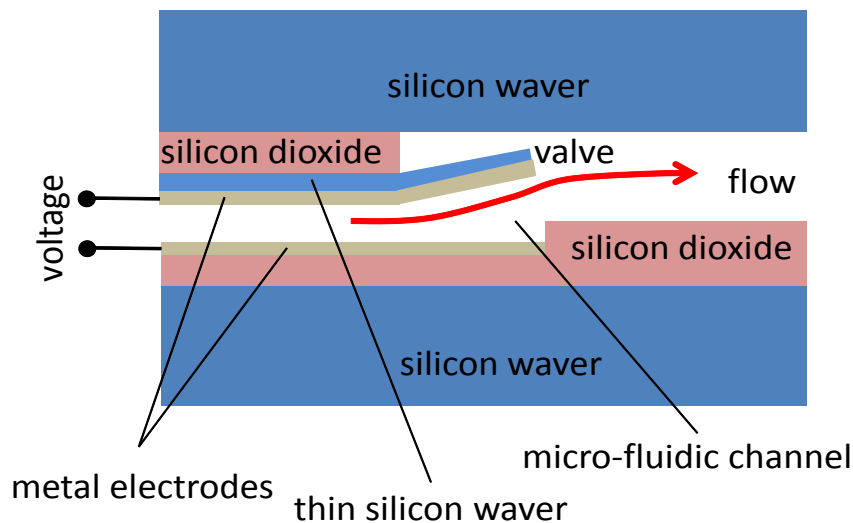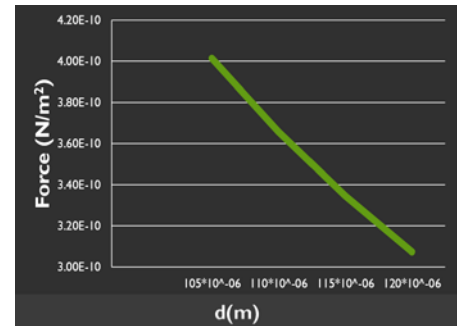
Understanding Defects in TiN/HfZrO/SiON/Si Gate Stacks

Swapnadeep Poddar, M.N. Bhuyian and D. Misra
Department of Electrical and Computer Engineering
New Jersey Institute of Technology, Newark NJ 07102

Abstract: In this study the effect of constant voltage stress on defects in TiN/HfZrO/SiON/Si Gate Stacks was observed from their Current-Voltage characteristics measured at different temperatures. The dielectrics were fabricated by using various methods and composition as listed: i) cyclic SPA Ar plasma treated (DSDS) HfO_2, ii) DSDS $Hf_{0.2}Zr_{0.8}O_2$, iii) As-Dep (without any treatment during dielectric deposition process) HfO_2, and iv) As-Dep $Hf_{0.2}Zr_{0.8}O_2$. Both DSDS and As-Dep processed dielectrics were subjected to constant voltage stress in the gate injection mode at -1V and -2V at room temperature. The stress-induced trap energy levels were observed for different dielectrics. The energy levels calculated from the slopes of the Arrhenius plots in both high field and low field regions showed that most defect levels are within 1eV near the conduction band edge. It was further observed that Zr addition slightly decreases the trap energy level for both DSDS and As-Dep processing, while DSDS process showed an increase in trap energy level. When the devices were stressed at -2V, DSDS $Hf_{0.2}Zr_{0.8}O_2$ showed 23.3% reduction in trap energy level as compared to 44.3% for As-Dep $Hf_{0.2}Zr_{0.8}O_2$ which indicates that cyclic SPA Ar plasma exposure suppressed stress induced trap generation for these devices. DSDS HfO_2 on the other hand showed more stress induced trap generation as compared to As-Dep HfO_2.
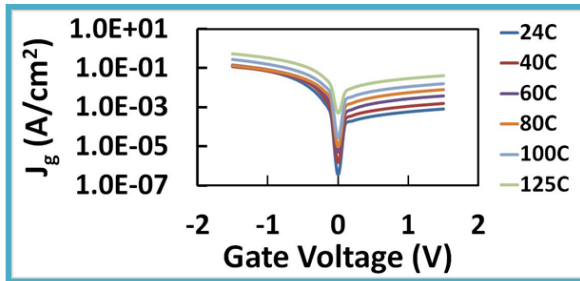
Fig. 1: IV plots at different temperatures for DSDS $Hf_{0.2}Zr_{0.8}O_2$
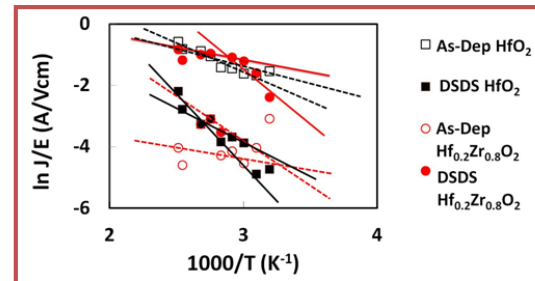
Fig. 2: Arrhenius plots for different dielectrics (Stressed at -2V for 500s)

Table I: Comparison of the trap energy levels for different dielectrics obtained from the Arrhenius plots

Stress Voltage (Volt)	E_T for As-Deposited HfO_2 (eV)	E_T for DSDS HfO_2 (eV)	E_T for As-Deposited $Hf_{0.2}Zr_{0.8}O_2$ (eV)	E_T for DSDS $Hf_{0.2}Zr_{0.8}O_2$ (eV)
0 Volt	0.407, 0.1856	0.930, 0.509	0.357, 0.147	0.532, 0.222
-1 Volt	0.328, 0.1	0.350, 0.141	0.285, 0.103	0.447, 0.145
-2 Volt	0.3105, 0.110	0.284, 0.138	0.1988, 0.069	0.408, 0.072

Fabrication and evaluation of PVDF-TrFE/PEO scaffolds for growth factor delivery

Aruja Rustagi, Siliang Wu, Treena Livingston Arinzeh
Department of Biomedical Engineering,
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Abstract: Electrospun scaffolds are widely investigated for their application in tissue engineering. Electrospun scaffolds mimic the structure of natural extracellular matrix and the scaffolds can provide a three dimensional environment for cell growth. Electrospinning technique can produce fibers with diameters in the nanometer to micrometer range, and electrospun fibers have high surface to volume ratio which will benefit cellular adhesion. The highly porous structure of scaffolds will also promote exchange of nutrients, and metabolites during cell growth. Growth factors can be incorporated directly into the scaffolds during or after the fabrication. These scaffolds have the ability to control the release of bioactive proteins over a period of time. Moreover by incorporating these proteins into polymeric scaffolds, protein structure and biological activity can be stabilized, prolonging the length of time over which the protein is released. The objective of this study was to fabricate and evaluate the protein release from aligned fibers of polyvinylidene fluoride trifluoroethylene (PVDF-TrFE). PVDF-TrFE is a piezoelectric material which can generate electrical stimuli by mechanical deformation, and electrical stimuli have been demonstrated to promote axon regrowth which makes PVDF-TrFE a promising material for promoting axon regeneration. Polyethylene oxide (PEO) was used to facilitate protein incorporation into the fibers by acting as a carrier for the protein. The morphology of the scaffolds was characterized using scanning electron microscopy (SEM), and the controlled release of lysozyme, a model protein, from the scaffolds was studied for three weeks. Protein containing fibers had uniform morphology (Figure 1) and an average fiber diameter of 813±236 nm. Experiments determining the lysozyme release are ongoing.
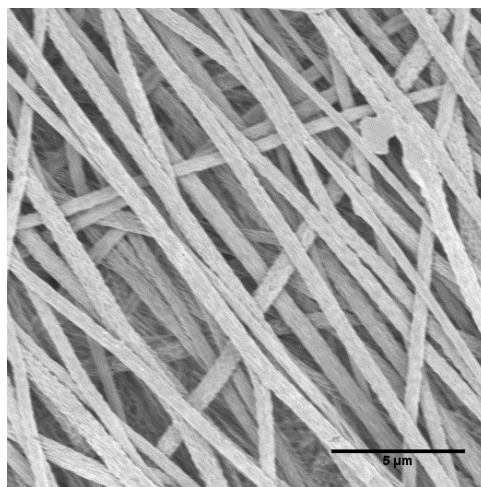
# A Hybrid System: Co-existence of Visible Light Communication & Wi-Fi

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Abstract: Today, the most commonly used wireless communication technology is Radio Frequency (RF) communication. However, since the number of wireless devices keeps increasing each year, the wireless traffic congestion problem has become significant and wireless network data consumption is experiencing drastic increase. Wireless indoor networks using RF communication are characterized by limited ability to scale with increasing demands.

In order to mitigate wireless traffic congestion, Visible Light Communication (VLC) is a promising RF communication alternative which is emerging as a viable means to overcome the crowded radio spectrum for highly localized communication systems. VLC can provide excellent scalability through spatial reuse of the medium which is limited in RF communication.

Visible Light Communication, as the name itself suggests, is a short range wireless communication technology that transmits / receives signals using the visible light spectrum (380 - 780 nm). This technology serves as a dual purpose system providing both lighting as well as wireless communication. VLC transmits data by Intensity Modulation (IM) - a modulation scheme where the intensity of an optical source (array of smart white LEDs) is modulated by the RF wave signal. Demodulation is achieved through Direct Detection (DD) of the optical carrier and conversion using a photo-detector. The "Software Defined" concept is applied to VLC where the components of the system are implemented in software instead of typically implementing them in hardware. The front ends (antennas) of Software Defined Radio (SDR) are replaced with optical front ends (LEDs / photo-detectors) which makes the system Software Defined Visible Light Communication (SDVLC).

However, as far as the present condition of technological development is concerned, "UPLINK" through VLC has many disadvantages e.g. energy consumption for RF communication is low and for VLC, it is more. In this project we study an indoor hybrid system that integrates SDVLC (for DOWNLINK) and Wi-Fi (for UPLINK) so that we can use the advantages of VLC along with those of Wi-Fi system, eliminating their disadvantages.
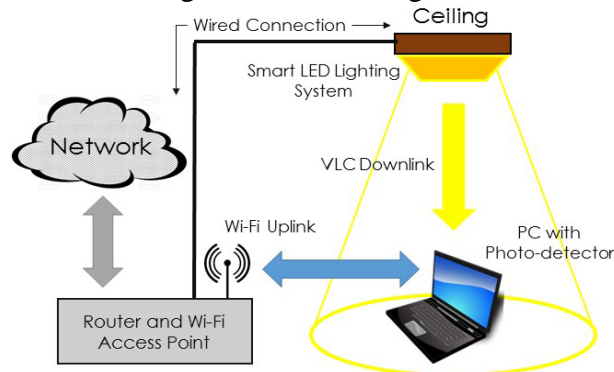
Proposed Hybrid System: Broadcast SDVLC – WiFi

Provost's Undergraduate Summer Research Program

COMFYMAT for diabetic foot ulcers

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Diabetic Foot Ulcers result from a peripheral nervous system dysfunction known as diabetic neuropathy. This condition affects the patient's ability to feel sensation on the feet, as a result of the damage of certain nerves that transmit stimuli such as pain, cold, etc. This could lead to abnormal loading on some areas of the feet due to the patient's inclination to exert more pressure on certain areas of the foot. The result is the development of callus on such areas of the foot, and consequently occurrence of foot ulceration.

COMFYMAT is a device that would be designed to detect abnormal loading, even before ulceration occurs. This diagnostic system is based on plantar pressure measurement. Currently, I am working on a Forefoot-to-rearfoot plantar pressure (F/R) ratio system of measurement. Research studies have shown that an F/R ratio > 2 could predict the occurrence of foot ulcers. The F/R ratio has the advantage of being a relative value, and different units of measurement, calibration methods, and sensor resolutions do not affect it.[1]
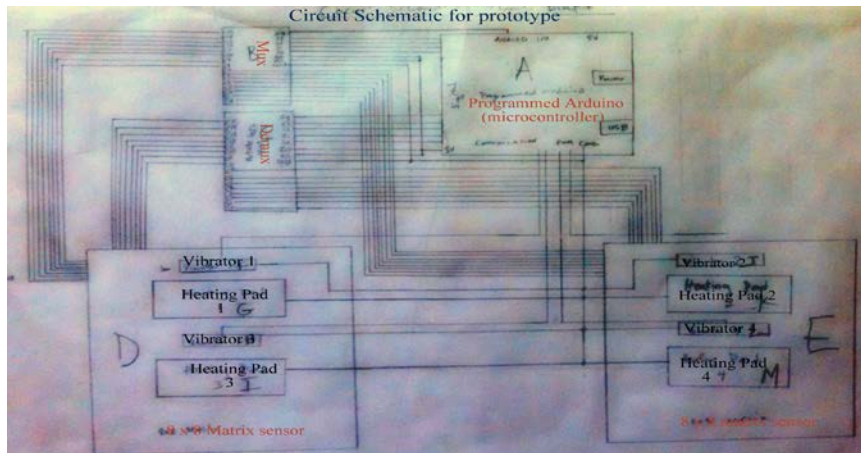
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Infrared Imaging of Objects in Contact with Water

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Abstract: Thermal imaging operates on different frequency bands of the electromagnetic spectrum. Recent technological developments have made microbolometers the most efficient technology and they operate on wavelengths from 7.5 to 14 μm, also known as long wavelength infrared (LWIR). Water has a window in the visible light with a lower absorption coefficient in the blue band. The absorption coefficient increases towards the infrared. It is not so high in the near-infrared but it becomes larger in the LWIR. The absorption coefficient of water exhibits several peaks in the infrared but it remains high throughout the entire infrared spectrum.

The infrared camera, Flir® E6, operating with microbolometers[1], is used for the experiments. Imaging different objects, in contact with water, is investigated by comparing visible light images and infrared images. The behavior of different materials (plastic, Styrofoam, glass, steel, ceramic), in contact with water, at different temperatures is imaged in the infrared, and the temperature output of the camera is compared to measurements using a standard mercury thermometer. The optical transmittance of these materials in the infrared is also investigated. The imaging of the phase transition, ice-water, was imaged and analyzed. Hot water was placed inside the cups. The temperature of the material of the cup measured using the camera and the temperature of the water measured with a thermometer is recorded. The graphs show both temperature - measured by the thermometer and camera, and the difference between those two quantities, for four different materials. Plastic cups show a good agreement between camera and thermometer measurements. Steel and Styrofoam have a significant difference which decreases as the temperature approaches the room temperature
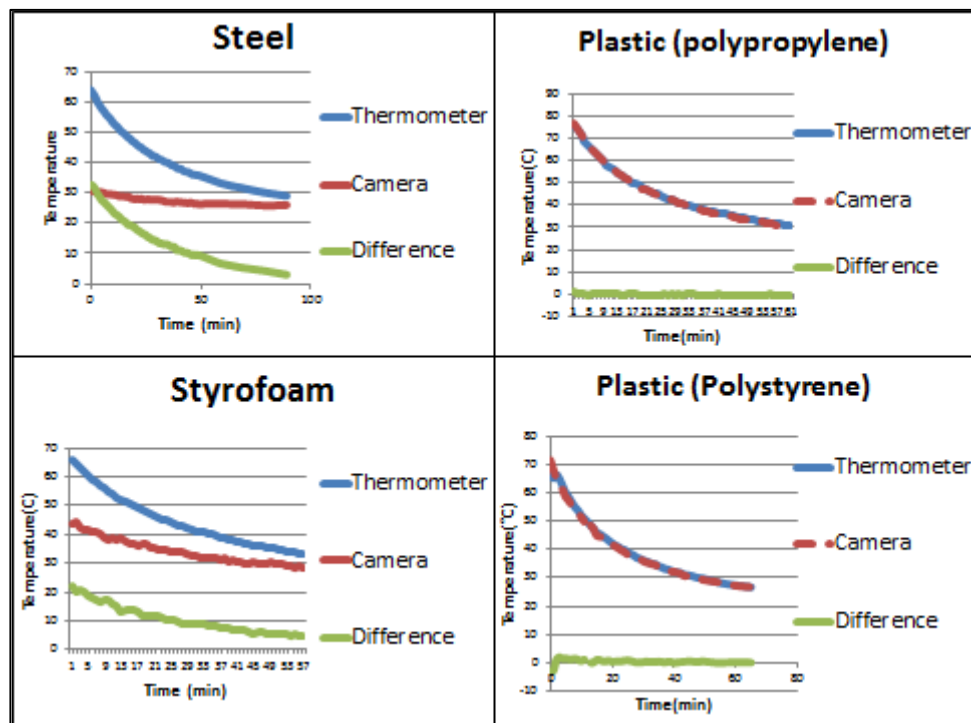
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Magnetic Nanoparticles for Algal Harvesting

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Abstract: Algal biomass is emerging as one of the important renewable feedstocks for biofuels and bioproducts. However, in order to make a large-scale industrial production economically viable, there is a pressing need to develop efficient and cost-effective separation technologies for harvesting biofuel-producing algal biomass. The aim of this work is to demonstrate the application of magnetic Fe_3O_4 nanoparticles (MNPs) coated with a cationic polymer, polyethylenimine (PEI), toward the separation of algae (*Scenedesmus dimorphus*) from the medium broth. The influences of surface coating, UV irradiation and magnetic field on the magnetic separation were systematically examined. After the PEI coating, zeta potential of MNPs shifted from -7.9 ± 2.0 mV to + 39.0 ± 3.1 mV at a pH of 7.0, which significantly improved the surface interactions between MNPs and the algal separation. For instance, the harvesting efficiency was increased from 80.3 ± 1.4 % to 84.3 ± 0.9 % (*p*<0.05) when MNPs were coated with PEI. Furthermore, the algal harvesting efficiency was also improved under the UV irradiation, which potentially serves as a non-invasive measure to boost algal coagulation. Overall, magnetic separation for algae harvesting holds much promise for cost effective algal biomass harvesting but yet many process parameters (e.g., the sizes and doses of MNPs) are still needed to optimize.
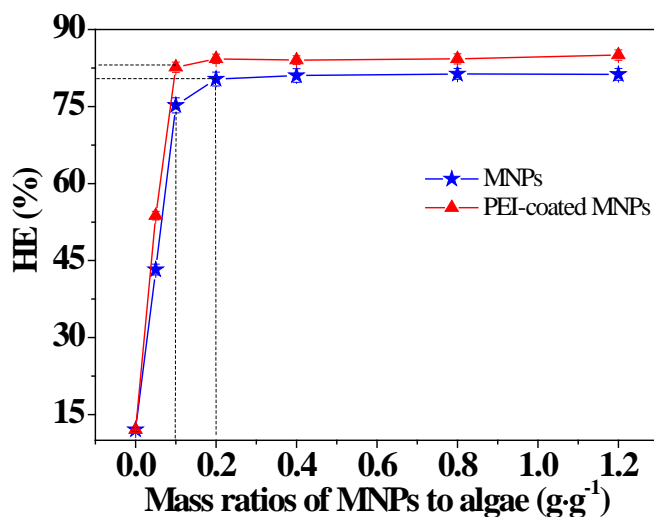
Figure 1. Harvesting efficiencies (HE) of *S. dimorphus* as a function of the mass ratio of MNPs to algae under room light. The initial algal concentration was 1.0 $g \cdot L^{-1}$. The magnetic field strength is 100 mT.

Development of Economical and Robust Homogeneous Liquid Phase Catalysts via Computational Chemistry: Reactive Hydrogen's on Resonantly Stabilized Hydroxyl Amines

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Amines are currently used as catalysts in reactions that convert commercially available hydrocarbons such as alkanes and substituted benzene, which are high volume products of petroleum refineries as well as reactants in various spark ignition, diesel and aviation fuels, into higher value chemicals for which there is a much larger profit. The chemical process involves removal of a target, weakly bound hydrogen atom from the hydrocarbon molecule and converting it to a hydroperoxide. There have been a number of well-established reaction processes which add valued derivatives to the peroxide to react into higher value products.

The study proposes to identify a catalyst to generate reactive peroxide intermediates from non-reactive resonantly stabilized hydrocarbon systems. The catalyst is to serve to: (i) remove a hydrogen atom from the hydrocarbon, forming a hydrocarbon radical, (ii) in the presence of molecular oxygen, the oxygen will add to the radical site forming a peroxyradical, (iii) the catalysis returns the hydrogen to the peroxyradical site in order to (iv) cap the peroxide radical to the initial hydrogen atom and form a stable hydroperoxide. The overall result is that the hydrocarbon is converted into an intermediate – a moderately stable hydroperoxide. This stable intermediate is the objective of conversion through facile reactions to a wide range of higher value intermediates and product chemicals via the reactivity of the peroxide.

			-25		42.67		-30		
	CH3NjCH3	+	CCC	→	CH3NjH	+	CCCC	**CH3NjCH3**	Standard Enthalpy of Formation
m062x	-134.355973		-118.966139		-95.089163		-158.232194	Average Total	**37.6**
cbs-apno	-134.412397		-119.026273		-95.130225		-158.309137		

			-20		45.5		-25		
	CH3NjH	+	CC	→	NjH2	+	CCC	**CH3NjH**	Standard Enthalpy of Formation
m062x	-95.089163		-79.700684		-55.825512		-118.966139	Average Total	**42.7**
cbs-apno	-95.130225		-79.743562		-55.852625		-119.026273		

			-20		42.67		-25		
	CH3CH2NjH	+	CC	→	CH3NjH	+	CCC	**CH3CH2NjH**	Standard Enthalpy of Formation
m062x	-134.356079		-79.700684		-95.089163		-118.966139	Average Total	**36.3**
cbs-apno	-134.415911		-79.743562		-95.130225		-119.026273		

Bond Dissociation Reaction
Heat of Reaction = 101 kcal/mol

CH3NH2	→	CH3NjH	+	H		**CH3NH2**	Standard Enthalpy of Formation
???		42.7		52.1		Average Total	**6.2**

Relationship Between Brain Connectivity and Cerebral Blood Flow in Stroke Patients

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Abstract: Stroke is a neurological disorder defined as intracranial neuronal cell death secondary to insufficient blood flow to the brain. Depending on the region affected, stroke may induce deficits in sensation, speech, memory, and motor activity. Improvements in clinical treatments for patients suffering from stroke have been made due to our improved ability to image the brain. This study compares two different functional imaging signals, blood oxygen-level-dependent (BOLD) signal and arterial-spin labeling (ASL) signal. The BOLD signal shows the brain's neuronal activity as a result of its metabolic demands, while the ASL signal shows shows cerebral blood flow (CBF). By correlating specific measurements derived from the BOLD and ASL signals of 70 homogenous subjects, this study attempts to discover the relationship of a stroke's size and location and it's impact on CBF and intracranial neuronal connections based on various signal derived correlations. Currently, we have found intersubject correlation variability in the whole brain and three different networks (Default Mode Network, Primary Visual Network, Bilateral Dorsal Attention Network). Further analysis must be completed to draw more specific conclusions.

A Markovian Dependability Model with Cascading Failures

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Abstract: Cascading failure is a property of large interconnected systems whereby one component's failure can cause other components to fail, which in turn can cause further component failures. Cascading failures arise in a large variety of systems, such as the national power grid, communication networks, and cloud computing networks. We model a cascading failure as a tree, with the failing component that triggers the cascade as the tree's root, its children as the component that are immediately caused to fail by the root, and so on. Since these systems are interconnected, there are an exponential number of ways in which cascades may arise. For example, if we consider a system with three unique components A, B, and C, there are nine possible trees by which all components might fail. More generally, if there are N unique components in a system, then there are N^{N-1} possible trees. Solving for the dependability measures (e.g., the mean time to failure and steady-state unavailability) of the resulting Markov-chain mathematical model requires generating all possible cascading trees. The exponential nature of tree permutations severely restricts the size of the models that can be fully solved.

Because of the exponential behavior, we want to reduce the computational requirements by generating only a subset of the possible cascading-failure trees. Each tree has a rate of occurrence, and since omitting trees introduces error in the models, we want to ensure that we generate those trees that contribute most to the dependability of the system, while omitting those trees that have little effect. To do this, we determine a rate threshold using shortest-path algorithms to approximate the most likely way to system failure, and we only generate trees having rates larger than the computed threshold. We have implemented the appropriate algorithms in our software package, DECaF (Dependability Evaluator of Cascading Failures). We ran numerical experiments on a dependability-system model with 972 states, and the rate-threshold algorithm reduced the computation time by 97% with only a 2% error in the computed dependability measures.

|	Time Spent (seconds)	Trees Generated	Mean Time to Failure (hours)	Steady-State Unavailability
Exact Model	1918.56	7,388,914	395.376	1.48512×10^{-6}
Approximate Model	56.45	3,306	398.882	1.45614×10^{-6}

Engineering *Bacillus subtilis* spores to evolve G protein-coupled Receptors for Directed Evolution

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Abstract: All cells in the human body are encased in a plasma membrane. It is composed of a phospholipid bilayer, which functions in regulating the passage of materials in and out of the cell. Embedded in the plasma membrane are proteins. G Protein-Coupled Receptors (GPCR) are a class of membrane proteins responsible for the transmission of signals across the plasma membrane. These proteins are involved in nearly every human physiological process. GPCR malfunction results in serious illness. As a result, they are major drug targets in a multi- billion dollar pharmaceutical industry. The crystal structure of these proteins would reveal many secrets behind their activation and deactivation. Unfortunately, due to stability issues, this becomes a major challenge. The goal of this project is to create a high-throughput screening system to assay for GPCR stability. Human parathyroid hormone receptor (HuPTH1R) is used as a model. HuPTH1R regulates calcium and phosphate levels in the blood. If this GPCR were to malfunction it could lead to dwarfism, failure of tooth eruption and bone tumors.

Molecular biology techniques created a plasmid that contains the HuPTH1R gene, which is fused to a spore coat protein. HuPTH1R will be displayed on the spore surface. This system can be used as a general method to engineer and optimize membrane proteins by directed evolution.
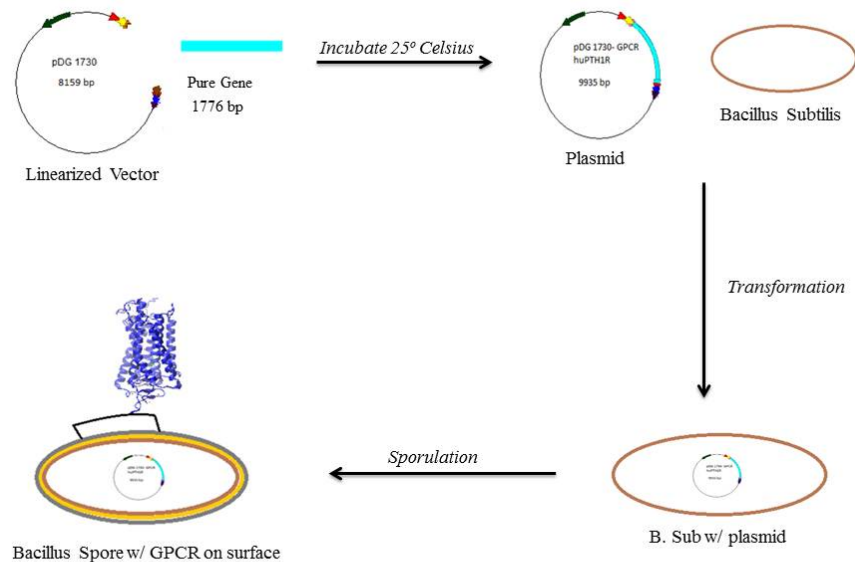
Manufacturing and Characterizing an Air-Breathing Fuel Cell

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Abstract: The ever-changing domain of electrochemistry is vast and flourishing. A tank of hydrogen and some fresh air will change electrical nature forever. The electrochemical device known as the proton exchange membrane fuel cell is the future of science and engineering. Thermodynamically, it has less irreversibilities than a traditional combustion engine making it superior and more efficient. Unlike batteries, fuel cells never die as long as fuel is supplied. They offer the tremendous benefits of fossil fuels in addition to renewable resources in respect to lower emissions. The bare minimum in volume and mass, the air-breathing planar fuel cells are ideal for portable and smaller stationary applications. Conveniently, they use the natural convection of ambient air instead of forced oxygen as well as the most abundant element in the universe, hydrogen, to harvest electrical current generated by the chemical reaction.

An eight layer fuel cell will be manufactured using aluminum machined end plates with a double serpentine flow field incorporated into the anode side. The cathode side has open channels to the air while both have self-sustaining current collectors. A membrane lies directly in the middle of the cell with catalysts and gas diffusion layers surrounding it on both sides. A neoprene gasket is used on one side of the cell to prevent the membrane electrode assembly from being crushed. Nylon nuts and bolts are used in order to prevent the current from traveling from one plate directly to the other. Several appliances are used to characterize a fuel cell including electrochemical impedance spectroscopy (EIS) and cyclic voltammetry (CV). Both methods will be used to test the cell using a potentiostat as well as a custom test station. In the experimental stage, fuel cells are designed with stability, conductivity, temperature uniformity, and durability in mind. I am committed to manufacturing and characterizing the most efficient, cost effective, and maximum performance air-breathing planar fuel cell ever witnessed.
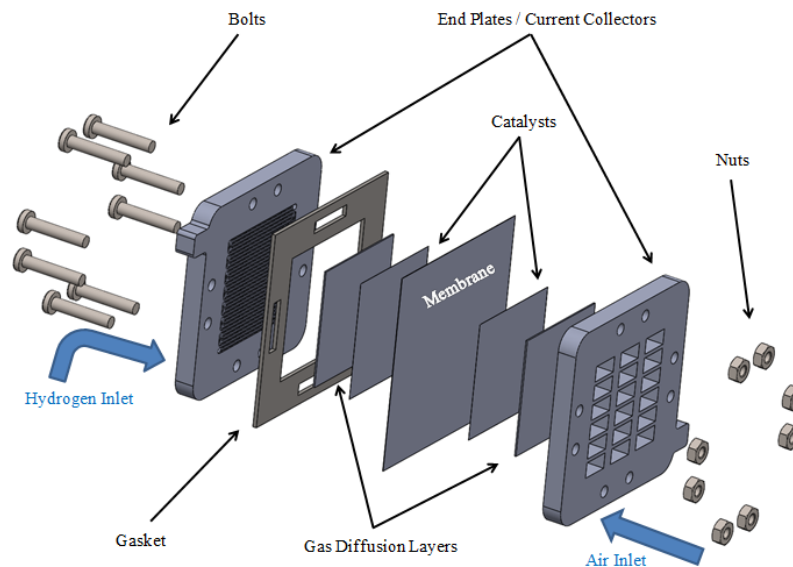
# Complete Genome Pipeline for Mapping and Viewing Short Reads

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Abstract: The biological and medical communities are using the human genome to understand how the body functions and how genetics plays a role in patient care. Tools in the field of Bioinformatics (the crossroad between biology and computer science) are key to this understanding. Yet most lack graphical user interfaces and are not easily ported to Microsoft Windows, the dominant operating system found in the world.

We have developed a Microsoft Windows program with a graphical user interface that implements a basic popular genome analysis pipeline used in many medical and biological labs. Our program creates alignments between short read DNA sequences and a reference genome by calling the popular Bowtie software and then detects variants using the SAMtools gold standard package. Our program also shows the actual alignments with an option to zoom into a selected part of the genome. The novelty of our work is that the program is fully based on a graphical user interface and runs on Microsoft Windows, which makes our program readily available to the medical and biological communities.
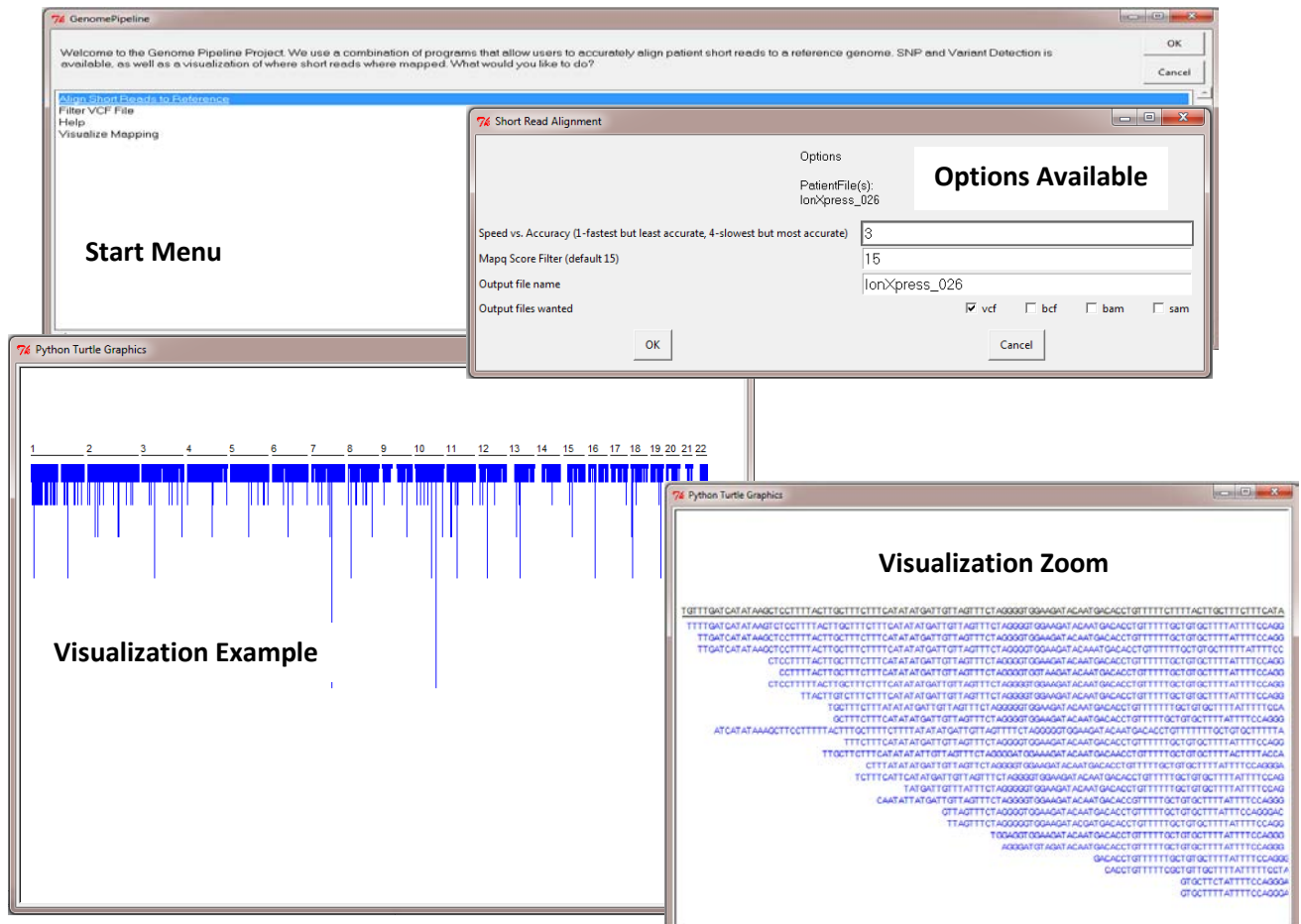
SenVis: The Vision You Can Feel
A Smart Cane with Proximity Sensors that Warns Users via Vibration

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Advisor: Atam Dhawan, Ph.D.
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Abstract: There are 285 million people who are blind or visually impaired globally. Millions of people every year struggle to navigate freely through optic issues they face. Some of these individuals have optic nerve damage or retinal detachment, permanent issues that cannot be corrected using modern Lasik procedures. The current marketed solutions for the visually impaired are the walking stick/cane and seeing-eye dogs, both of which are limited and can only provide minimal guidance. Our mission is to help the visually impaired "see" through various vibration frequencies indicating the 3D location of their current environment. By integrating proximity sensors in a cane, with vibration frequencies in wristbands that relay the processed information, the user will be able to better interact with the area around them.

The current prototype features a fully functioning smart cane with two different sensor sets, a rechargeable battery, secure components, and Bluetooth connectivity to the wristbands. The wristbands are completed with two vibration motors, another rechargeable battery, and Bluetooth connectivity to the smart cane. Through information from various field test data, recordings, and analysis of the efficiency of the model in real world environments, the new smart cane has been designed. Research during the summer has led to the new design of the device using the Bluetooth 4.0 (Low Energy) technology over the traditional Bluetooth 2.1 protocol. This creates faster connecting of components and shorter startup time for the devices, as well as faster communication speeds. Better ultrasonic sensors with pre-defined ranges and shape of sensing areas were implemented, resulting in improved conflict resolution. Programming of the microcontrollers managing the separate devices has been revised, leading to faster communication speeds, reliable data transfers, significantly reduced errors, and proper interrupt-driven loops. The multiple sensors also combine their data to produce a single pulsing signal. This version of the smart cane is now ready for the first phase of exhaustive field testing and troubleshooting with real subjects.

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Distribution of GABA and Glutamate in Weakly Electric Fish

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Abstract: The fundamental goal of neuroscience is to understand how the brain controls the behavior of organisms. Neurons communicate through junctions known as synapses, typically via the release of neurotransmitters from one neuron which selectively activate receptors on another neuron. Receptor molecules in synapses largely determine how information flows between neurons and contribute to the computational properties of neural circuits. The most common excitatory transmitter in the brains of vertebrates is glutamate and the most common inhibitory transmitter is GABA (gamma-aminobutyric acid). Glutamate produces a depolarizing effect on the post-synaptic cell whereas GABA produces a hyperpolarizing effect on the post-synaptic cell, impeding the cell's ability to fire action potentials.

A critical component in understanding the neural mechanisms for behavior is the arrangement of the distribution of receptor types in these neural circuits. However, studying the distribution of receptors in vertebrate brains is challenging, as receptors are structures embedded within neural tissue. By using an immunohistochemical approach we can map receptors, such as GABA and glutamate receptors, used in the control of social behavior in a well-studied animal – weakly electric fish. For this study we focused on three species of weakly electric fish: *Eigenmannia, Sternopygus,* and *Gymnotus.*
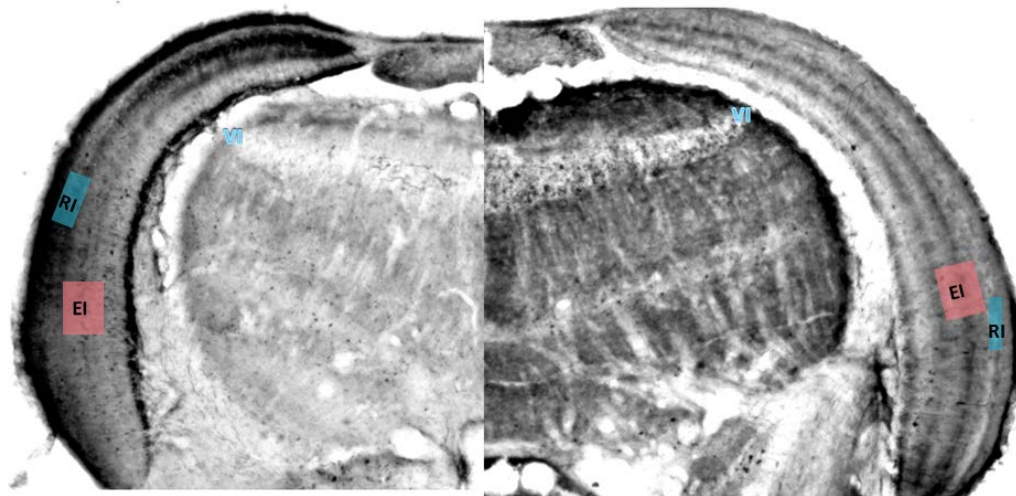
Figure 1 *Eigenmannia* brain slice stained for GABA (on the left) and glutamate (on the right). Brain segments labeled are lamina VI (VI), EI (area of the optic tectum receiving electrosensory input), and RI (area of the optimal tectum receiving retinal input). The darker areas on the left and right show a greater concentration of GABA and glutamate receptors respectively.

Boron-based reactive materials with biocidal combustion products

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Abstract: Current research is focused on halogen-bearing reactive materials capable of generating biocidal combustion products destroying spores and bacteria that might be released when biological weapon stockpiles are attacked. Recently, a ternary composite of Al-B-I$_2$ was prepared and its combustion products were found to be effective when tested against aerosolized microorganisms. In this work, new iodine-containing, boron-based materials were synthesized. A binary B-I$_2$ powder was initially prepared by mechanical milling and chilled to prevent iodine sublimation. Iodine-stabilizing metals (Al or Mg) were added in a second milling step to improve the stability and achieve enhanced combustion performance of the final ternary material. Specific compositions for each ternary material were varied. Different milling times were explored to maximize stability of the prepared powders.

Stability of the samples was assessed by their heating in argon using Thermo Gravimetric Analysis (TGA) and observing weight loss. Al-B-I$_2$ composites prepared by both single and two-staged milling displayed nearly identical properties, while two-staged milling for Mg-B-I$_2$ composites yielded a more stable material compared to the single stage milling. Ternary Mg-B-I$_2$ composite powder prepared by two-stage milling was more stable than any of the previously prepared iodine-bearing materials with the same concentration of iodine (20 wt %).

The study further focused on Mg-B-I$_2$ (33% Mg-47% B-20% I$_2$), which was characterized using electron microscopy; particle size distributions were measured using low-angle laser light scattering. Powders were ignited using Electrostatic Discharge (ESD) and fed into an air-acetylene flame. Burn times and ignition delays were measured optically and compared to previously studied materials. The powder was found to have longer burn times than pure magnesium. Work is currently in progress to optimize the magnesium-to-boron ratio in these powders.

Figure 1. TGA results displaying Mg-B-I$_2$ (33% Mg, 47% B, 20%I$_2$) one-stage vs. two-stage milling. Two-stage milling shows much less weight loss, thus making it the more stable powder.
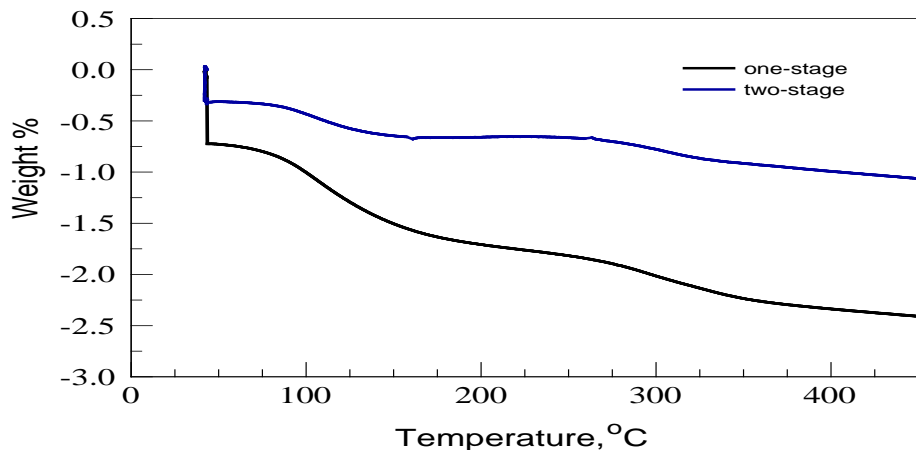
Malcolm Wells:
[New Jersey's] Father of Modern Earth-Sheltered Architecture

Kevin McIlmail; Advisor: Gabrielle Esperdy
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Abstract: In 1965, New Jersey architect Malcolm Wells wrote an article entitled, "Nowhere to Go but Down," a youthful manifesto that advocated for architects to design subterranean structures for aesthetic and environmental reasons while simultaneously admonishing the American building industry for its wastefulness and lack of ecologically sensitive professionals. Wells referred to the article as his "polemic against everything that had ever been built on the surface of the earth," which seems odd coming from a successful architect and favored draftsman of Camden-based electronics company, RCA. By 1977, Wells had become disenchanted with suburban life, and following his own advice, relocated his one-man practice from the suburbs of Philadelphia to Cape Cod, Massachusetts. There, he established the Underground Studio and Art Gallery in an earth-sheltered concrete structure covered by a dirt mound and growing plants. In the latter part of his career, Wells wrote over 15 books, contributed a regular column for the Cape Cod Times and lectured at universities all over the world.

As the self-proclaimed "Father of Modern Earth-Sheltered Architecture," Wells was a pioneer of eco-friendly, sustainable architecture, a legacy that has overshadowed his early, more conventional work. As a result, an important connection to New Jersey has also been overlooked: Wells maintained a thriving practice in Cherry Hill for over 20 years, successfully completing numerous churches, libraries, factories and homes in and around The Garden State. Critics of Wells' work cite deferred maintenance, flawed building systems and the struggle to integrate new technology as recurring problems in his designs for civic buildings. Owners of his houses praise their unconventional use of conventional materials, informal landscaping and distinctiveness amid endless tracts of suburban sprawl. After only half of a century, the voracious developer culture of New Jersey has rendered many of Wells' designs functionally obsolete and too costly to retrofit for modern needs. As these buildings are destroyed, replaced and remodeled, it is critical that a compendium of his work be assembled documenting this period of progressive architecture in historically conservative South Jersey towns. More broadly, documenting the little known early work of Malcolm Wells makes an important contribution to expanding awareness of the traditionally overlooked and understudied built form of New Jersey. This research, told through the narrative of Malcolm Wells' career, unpacks a critical transect in 20th century American history spanning the proliferation of East Coast suburban tract housing to the nascency of the sustainability movement.
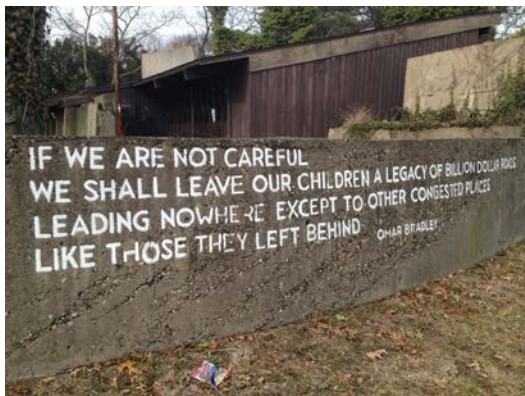
Wells Office I (1955)

Wells Office II (1971)

Elementary, Fundamentals Based Reaction Mechanism to Model Oxidation of C1 to C4 Sulfide Hydrocarbons under Combustion and Atmospheric Environments

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Abstract: The molecular structure, standard enthalpies of formation (Hf), transition state structures (for kinetic parameters) and thermochemical properties (entropy and heat capacity as a function of temperature) are determined using computational chemistry calculations. Entropy and heat capacity (S^{o} and Cp(T)) as function of temperature are determined from calculated structures, moments of inertia and frequencies and from group additivity methods. Kinetics parameters are determined from the computational chemistry data via transition state theory.

We have a developed number or reaction to describe the initial reactions of Ethyl – Methyl sulfide and also a number of reactions to more completely describe sulfur oxidation mechanism of C1 to C4 sulfur species relevant to combustion and atmospheric chemistry. Thermochemistry and rate constants for initial abstraction reactions on methyl – ethyl sulfide (CH3CH2SCH3) by the radical pool species (hydrogen and oxygen atoms, OH, HO2, CH3, radical and oxygen molecule to yield the initial radicals CjCSC, CCjSC and CCSCj where j is the radical site, were calculated. Unimolecular decomposition of these radicals and their reaction with molecular oxygen were implemented into a mechanism and products of the oxidation reactions were accounted for. Thermochemical properties and kinetic rate constants as a function of temperature were developed for new species in the mechanism as below.

Reactions	A	T^n	Ea(kcal)	k	Reactions	A	T^n	Ea(kcal)	k
CSCC + H = CJSCC + H2	2.40E+08	1.5	1.97E+00	4.21E+10	CSCC + O2 = CJCSC + HO2	1.00E+13	0	5.20E+01	7.12E-26
CSCC + O = CJSCC + OH	1.70E+08	1.5	1.50E-01	6.79E+11	CSCJC + O2 = CSCQJC	1.00E+13	0	0	1.00E+13
CSCC + OH = CJSCC + H2O	1.20E+06	2	1.50E-01	8.27E+10	CSCCJ + O2 = CSCCQJ	1.00E+13	0	0	1.00E+13
CSCC + CH3 = CJSCC + CH4	8.10E+05	1.87	5.02E+00	7.37E+06	CJSCC + O2 = CQJSCC	1.00E+13	0	0	1.00E+13
CSCC + H = CSCJC + H2	2.40E+08	1.5	1.77E+00	5.90E+10	CSCJC = CH3CH*S + CH3	4.52E+26	-2.8	2.62E+01	3.18E+00
CSCC + O = CSCJC + OH	1.70E+08	1.5	1.50E-01	6.79E+11	CCSCJ = C2H5 + CH2*S	9.35E+13	0	3.56E+01	7.40E-13
CSCC + OH = CSCJC + H2O	1.20E+06	2	1.50E-01	8.27E+10	CCJSC = CH3CH*S +CH3	9.35E+13	0	3.40E+01	1.03E-11
CSCC + CH3 = CSCJC + CH4	8.10E+05	1.87	4.83E+00	1.03E+07	CCJSC = C*CSC + H	1.00E+13	0	4.14E+01	4.40E-18
CSCC + H = CSCCJ + H2	2.40E+08	1.5	6.52E+00	2.10E+07	CJCSC = C2H4 + CH3SJ	9.35E+13	0	1.69E+01	3.87E+01
CSCC + O = CSCCJ + OH	1.70E+08	1.5	4.33E+00	6.13E+08	C*CSC+ H = C*CSCJ + H2	2.40E+08	1.5	1.50E-01	9.58E+11
CSCC + OH = CSCCJ + H2O	1.20E+06	2	5.29E-01	4.58E+10	C*CSC + O = C*CSCJ + OH	1.70E+08	1.5	3.62E+01	2.55E-15
CSCC + CH3 = CSCCJ + CH4	8.10E+05	1.87	9.57E+00	3.60E+17	C*CSC+OH = C*CSCJ + H2O	1.20E+06	2	1.73E+01	2.10E-02
CSCC + HO2 = CSCCJ + H2O2	1.40E+04	2.69	1.84E+01	2.15E-03	C*CSC+ HO2 = C*CSCJ + HO2	1.40E+04	2.69	2.96E+01	1.24E-11

Units: kcal/mole "J"= radical site "*"=double bond R=1.987 kcal/K-mol

Do motoneurons supply cross-inhibition in *C. elegans* locomotion circuit?

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Abstract: *Caenorhabditis elegans* are arguably the most comprehensively described animal. We know the complete genome, cell lineage, neuronal connectivity and much about the behavior, and physiology of this 1 mm long round worm that shares molecular, cellular and physiological characteristics with all other animals. However, there is much to be found out about how the parts of its nervous systems produce behavior. The locomotion circuit is composed of 75 motoneurons located along the animal's body and innervating muscle cells. The 19 inhibitory motoneurons in *C. elegans* use GABA as a neurotransmitter to hyperpolarize the muscle cells. They receive input only from other inhibitory and excitatory motoneurons. Anatomically, each excitatory motoneuron innervates muscle cells as well as an inhibitory motoneuron that innervates opposing muscle cells. We hypothesize that this network motif is used for inhibitory motoneurons to supply cross inhibition for the motor pattern. This idea is widely accepted but was never demonstrated. The hypothesis leads us to three predictions: 1) When *C. elegans* body is going through a bend, the inhibitory motoneuron that innervate muscle on the outside of the bend will be active. 2) If a muscle cell is excited during a certain locomotion phase then the dorsoventrally opposing muscle will be inhibited during that phase. 3) In a mutant that lacks GABA activity, D-motoneurons will be active as in wildtype but muscle cells on both sides of the body will be active simultaneously.

To test these predictions, we are recording neuronal and muscular activity by fluorescence imaging of calcium indicators *in vivo*, while the animal is in locomotion inside a microfluidic device made of silicone. We tested the device with wildtype animals and they can freely move inside it in their normal range of motion. Second, we are producing a transgenic strain of *C. elegans* in which a genetically encoded calcium indicator is expressed in the inhibitory motoneurons. We designed an expressing plasmid and used a transposase-mediated method to insert the transgene into the genome. We injected the plasmid into several animals and are waiting for progeny. Third, we are carrying our imaging experiments in animals that express a genetically encoded calcium indicator in their body wall muscles. In those animals, when the body is going through a bend, the muscle cells on the inside of the bend are active while those outside are not. We are now crossing these transgenic animals with mutants that are deficient for a GABA synthesizing enzyme.

This project sets the grounds for either proving or disproving a widely accepted fact in the worm community. Cross-inhibition has been demonstrated or postulated in many sensory and motor neuronal networks and in vertebrate locomotion. Understanding locomotion in a model biological organism will enable further insight to be gained on the locomotion in other animals.
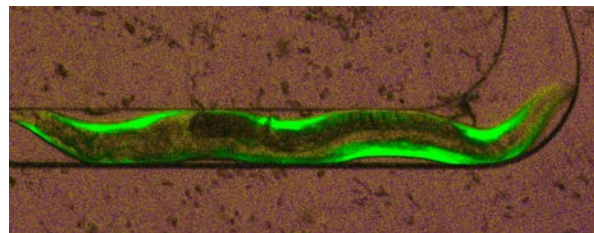

Figure 1: Body wall muscle (green) expressing GCaMP in *C. elegans* in PDMS device.

Tracking Superparamagnetic Nanoparticles in Blood Flow

Josef Mohrenweiser[1], Iris Rukshin[2], Farris Ahmed[3], and Shahriar Afkhami[1]
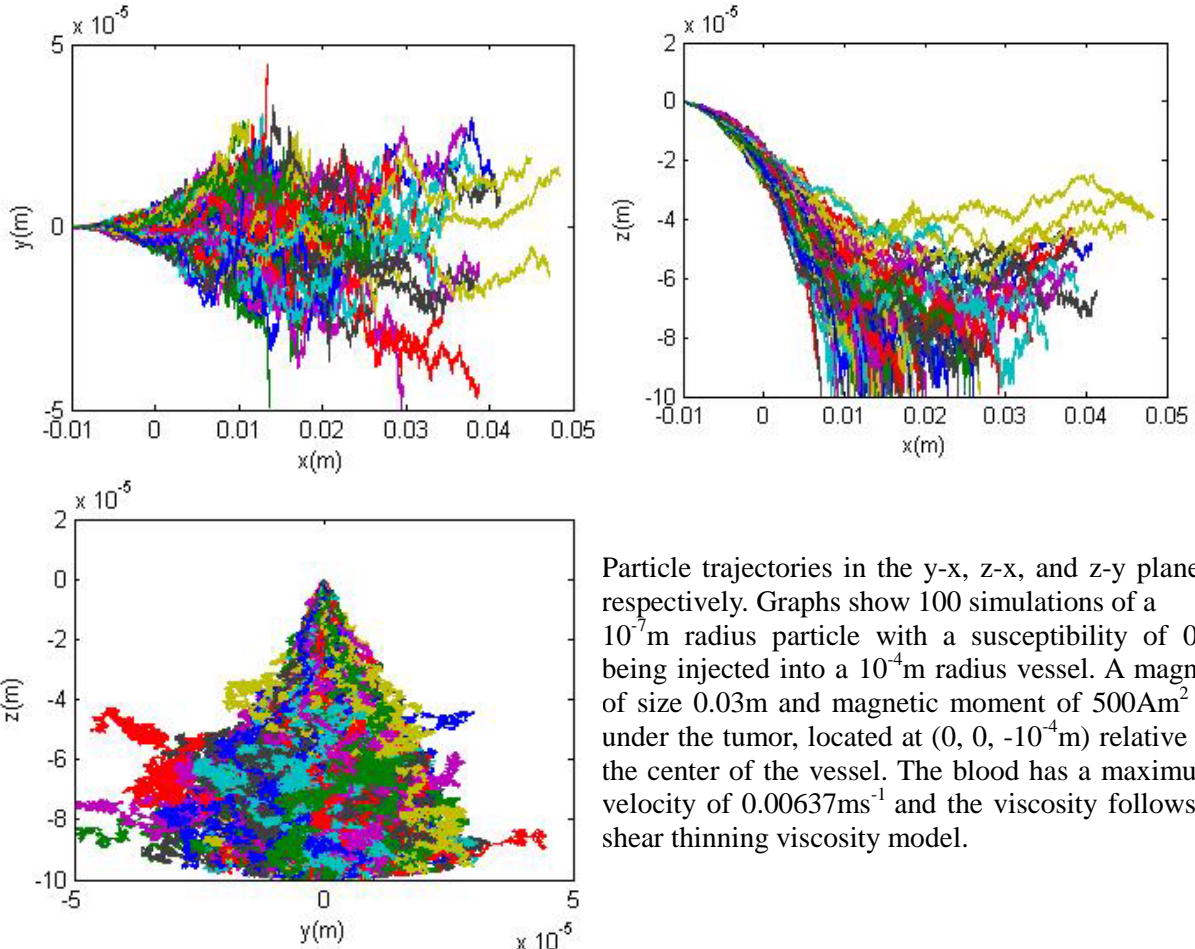[1]Department of Mathematical Sciences
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Abstract: A mathematical model is developed for tracking individual superparamagnetic nanoparticles in a blood flow when under the influence of an externally applied magnetic field. The model considers the magnetic attraction between the particles and the external magnet, the influence of the Hagen-Poiseuille flow, the diffusive interaction between the particles and the blood, and the random collisions with red blood cells. A stochastic system of differential equations is presented and solved numerically to simulate the paths taken by particles in a blood vessel. This model can be applied to magnetic drug targeting, which has recently come to light as a method of drug delivery that reduces the disadvantages of conventional treatments. This study focuses on localized cancer treatment, in which a surface tumor is accessed through smaller blood vessels, which are more conducive to this delivery method due to their slower velocities and smaller diameters. The probability of the particles reaching the tumor location is found to be directly dependent on ambient factors; thus, different magnetic field and force models, blood viscosities, particle sizes, and release points are considered to determine optimal parameters.

Particle trajectories in the y-x, z-x, and z-y planes, respectively. Graphs show 100 simulations of a 10^{-7}m radius particle with a susceptibility of 0.2 being injected into a 10^{-4}m radius vessel. A magnet of size 0.03m and magnetic moment of 500Am^2 is under the tumor, located at $(0, 0, -10^{-4}$m$)$ relative to the center of the vessel. The blood has a maximum velocity of 0.00637ms^{-1} and the viscosity follows a shear thinning viscosity model.

An approach to mimic fibrous protein in the extracellular matrix of articular cartilage via electrospinning

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Abstract: Electrospinning is a process by which nanofibers can be easily fabricated. In Electrospinning, a charged polymer solution is drawn out of a capillary by the action of an applied electrostatic field. The randomly arranged nanofiber constructs produced by this technique allow them to be utilized as mimics of the fibrous proteins in the extracellular matrix in the form of tissue engineering scaffolds. A particularly challenging problem is the regeneration of articular cartilage tissue which is aneural, alymphatic and avascular. The regeneration is approachable by mimicking the components of the extracellular matrix of cartilage using components that are similar in chemical composition and molecular architecture. The fibrous protein in articular cartilage is composed of Type II collagen decorated with Type IX collagen which is chemically bound to chondroitin sulfate which provides structural stability. In this work, the fibrous protein of the extracellular matrix of cartilage tissue was mimicked using two different approaches: Gelatin and k-carrageenan; zein and k-carrageenan. Gelatin, a denatured and structurally degraded collagen, is mimicked as a replacement of Type II collagen. Gelatin is a product of the structural and chemical degradation of collagen. Zein, a corn derived protein, also being used as a replacement for Type II collagen. Zein has been identified as biodegradable, biocompatible, microbial resistance and to have good mechanical properties. A linear sulfated polysaccharide extracted from seaweed, k-carrageenan as a replacement for chondroitin sulfate. In the molecular structure, k-carrageenan has been identified as a mimic for chondroitin-4-sulfate. Both are pyranose polydisaccharides with one unit in the disaccharide structure sulfated and the other unit not sulfated. While there are some differences in structural detail, it is assumed that the pattern of sulfation is important, both chondroitin-4-sulfate and k-carrageenan contain a 1-3 beta linked galatopyranose sulfated at the 4-position. Zein and k-carrageenan as well as gelatin and k-carrageenan were electrospun together in a solvent of ethanol and water which resulted in non-woven nanofiber scaffolds. Both kinds of scaffolds become biomacromolecular tools that can be implemented to simulate the fetal environment using mesenchymal stem cells and examine the impact of that environment on the ability of the chondrocytes differentiation to adopt a phenotype that is capable of producing ECM in a manner necessary to affect cartilage repair.
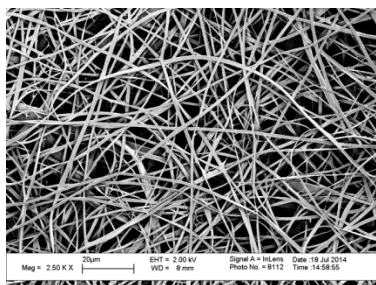
Electrospun zein and k-carrageenan
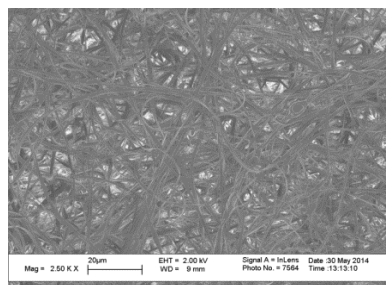
Electrospun gelatin and k-carrageenan

Modeling and Animation of Mechanisms used in Mechanical Design

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Abstract: Mechanisms are integral components in engineering found in almost every assembly that requires a predetermined motion. They are so universal that their applications range from tiny devices such as nail cutters which use the basic concept of a fulcrum and lever, to massive machines like cranes and industrial robots which have much more complex motions associated with them. As vital as mechanisms are, there are still a number of them that have not been explored – and are confined to the pages of textbooks without any idea of their practicality or functionality. However, 3-D representations of these mechanisms and their corresponding animations enhance their understanding and the reader would be able to assess the feasibility of using such mechanism(s) in any desired product. Our research is aimed at making this a reality by modeling, animating and studying possible applications of these mechanisms in our world today. Upon completion of the analysis, the animated mechanisms would be converted to movie files and archived in a database of mechanical simulations (*www.designwell.me*) to serve as a quick reference guide to any product design engineer.

Design well^{TM} is a search enabled relational database of mechanism animations and offers a variety of search options for idea-seeking entrepreneurs and other individuals alike. *Design well*^{TM} not only serves as a resource to experienced engineers who already have passion for their work but also stimulates interest and instills the same passion in young students in K-12 encouraging them to pursue a career in mechanical engineering.

Figure 1 shows an example of one of the mechanisms studied. This represents a 3-arm delta head robot used in various industrial applications such as pick and place operations that require speed and accuracy. This has recently found applications in 3-D printing where resolution is important. The mechanism was achieved by using pin and ball connections with servo motors attached to the *pin* connections to generate constant motion. This research is limited to exploring the modeling and animation of the delta head and such mechanisms using Creo Parametric 2.0 solid modeling software.
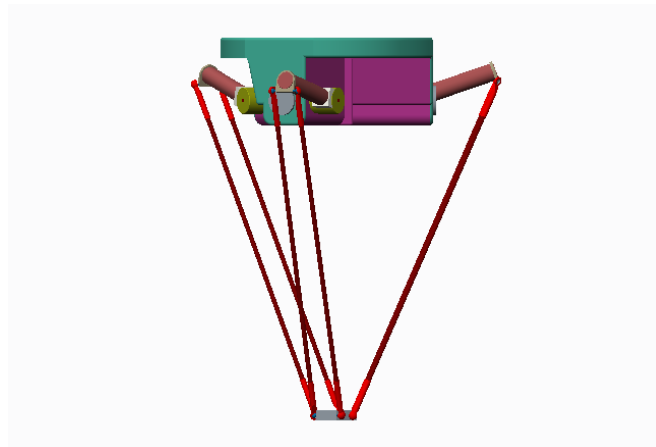

Fig. 1: 3-ARM DELTA HEAD ROBOT

Applications to Cancer Treatment: The Determination of Young's Modulus for Microtubules Stabilized with Paclitaxel and Analysis of Vibrational Modes

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Abstract: This research project will analyze the effects of Taxol, a cancer drug scientifically known as Paclitaxel, on the intracellular mechanisms associated with dynamic instability of microtubules. The ultimate goal of the research is to acquire more knowledge about the function of Taxol in order to discover a more effective cancer treatment method with fewer side effects and also with applicability to neurodegenerative diseases. Since Taxol affects the stability of microtubules, the general process of microtubule polymerization and depolymerization will be studied closely throughout this research project. By analyzing the dynamic instability in microtubules, the effects of Taxol on the microtubules can be used to elucidate the complex functioning of Taxol within the cell. The observations and discoveries of the research can have revolutionary effects in the fields of life science and medicine.

The short-term goal of this project will involve analysis of the thermal fluctuations of Taxol-stabilized microtubules grown and diluted in an aqueous buffer. By analyzing the movement of the microtubules and changes in their end-to-end distances, the Young's Modulus values of microtubules stabilized with Taxol will be determined. From our understanding of the modulus of elasticity for Taxol-stabilized microtubules, analysis of the vibrational modes of the microtubules will be conducted. We propose that the vibrational modes of microtubules will vary based on the Taxol concentration at which they are grown and diluted. Then, by comparing the vibrational modes to the resonant frequency of the Taxol-stabilized microtubules, we will relate the dynamic instability of the microtubules to the change in vibrational mode. These findings will elucidate the confounding enigma that plagues humanity (cancer) and will lead to further advancements in cancer therapy research.

According to the following figure, the microtubules stabilized with Taxol at a concentration of 20 µM had an average Young's Modulus of 9.94 MPa. Also, from this graph a positive relationship can be seen between the length and Young's Modulus of a microtubule stabilized with Taxol. The length is a general polynomial fit of second degree with the equation $y = 0.043x^2 + 0.11x$ and an R-value of 0.89. This fit shows that the rigidity of the microtubule will increase as the length of the microtubule increases.
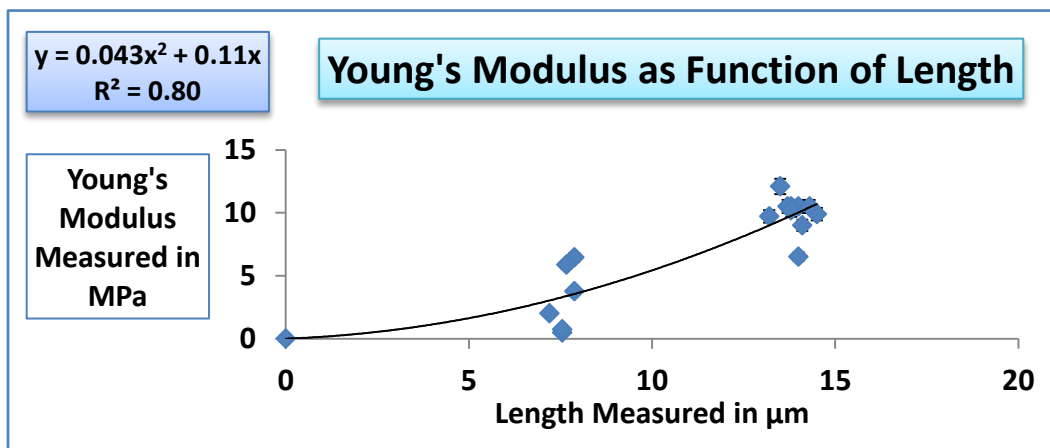
Developing a New Eco-Village Implementation Plan

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Abstract: Zhangdu Lake Farm is a sustainable rural residential community in a suburban interface of the Wuhan metropolitan area in Hubei, China. A South site of 237,200 square meters and a North site of 113,700 square meters are created to house 10,500 new residential units and a total planned population of 3,180 households. The planning of the Zhangdu Lake Eco-Community involved the registration of three distinct scales at which the integration of architectural, ecological, and landscape systems come together to form a new model for a dense countryside living on both the North and South site of the project. These communities will have fully supported and ecologically sustainable infrastructure, including bioswales and constructed and natural wetlands. This practice of consolidating residential areas in agricultural regions is becoming prevalent in rural areas of China as domestic food production becomes an increasing concern for the country's expanding population.

The sites were organized through a parametric "packing" equation. 17 groups of cells or "neighborhoods" are created to form residential clusters. Proposed streets, as well as parking and open areas for public and civic events separate these neighborhoods. Residential units are proposed in a series of tower types- three types on the North site and two on the South. There are connecting "bridge" buildings that are planned on the perimeter of each neighborhood cell, creating open space at the interior of these cells for residential use. Each cell functions as a community and has its own community identity making individual neighborhoods. Clustering these cells and utilizing open space between them allows for larger public and civic functions. Natural and constructed wetlands surround these communities and form a soft transition between the built environment and the agricultural fields that surround it. Each cell has a unique green interior that contains walking paths, managed lawns, rain gardens, and natural areas that support and reinforce the ground floor design of the neighborhood buildings and facilitate the interaction between residents and nature. The surrounding constructed and natural wetlands provide ecological functions including natural storm water management and wastewater treatment.

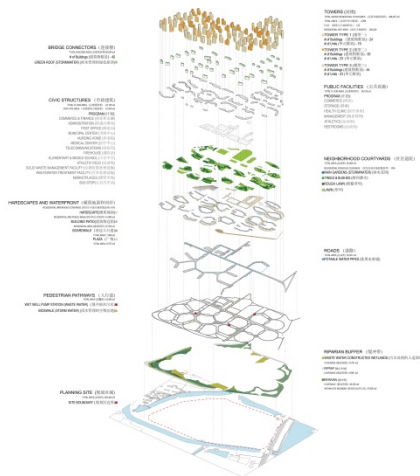**Figure 1: Exploded Axonometric Drawing of South Site Elements**

Figure 2: View of South Neighborhood


Figure 3: North Site Neighborhood Section

Decoding brain mechanisms for sexual signaling

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Abstract: Understanding how nervous systems work is a daunting task, in part because the brain controls almost everything that animals do. When scientists study the brain, they must necessarily focus their experiments on only a small subset of brain functions, often examining a single behavior or neural mechanism. Behaviors related to sexual selection— those communication signals that animals use to find and attract mates— have proven to be a particularly useful category for the study of brain mechanisms because 1) sexual signals are commonly overt and easily characterized, like the songs of songbirds, and 2) because many species have specific, enlarged brain areas that are dedicated to the generation and perception of these signals. We propose to describe and quantify the sexual signals produced by *Eigenmannia virescens*, a species of weakly electric fish. These fish are ideally suited for these studies because their sexual signals are modulations of a self-generated pseudosinusoidal electrical signal that is continuously produced by each individual. Because the signal is pseudosinusoidal, precise mathematical descriptions of these complex behaviors are possible. These mathematical descriptions will be used, in turn, to decode the neurophysiological mechanisms used in the neural circuits to control reproductive behaviors.
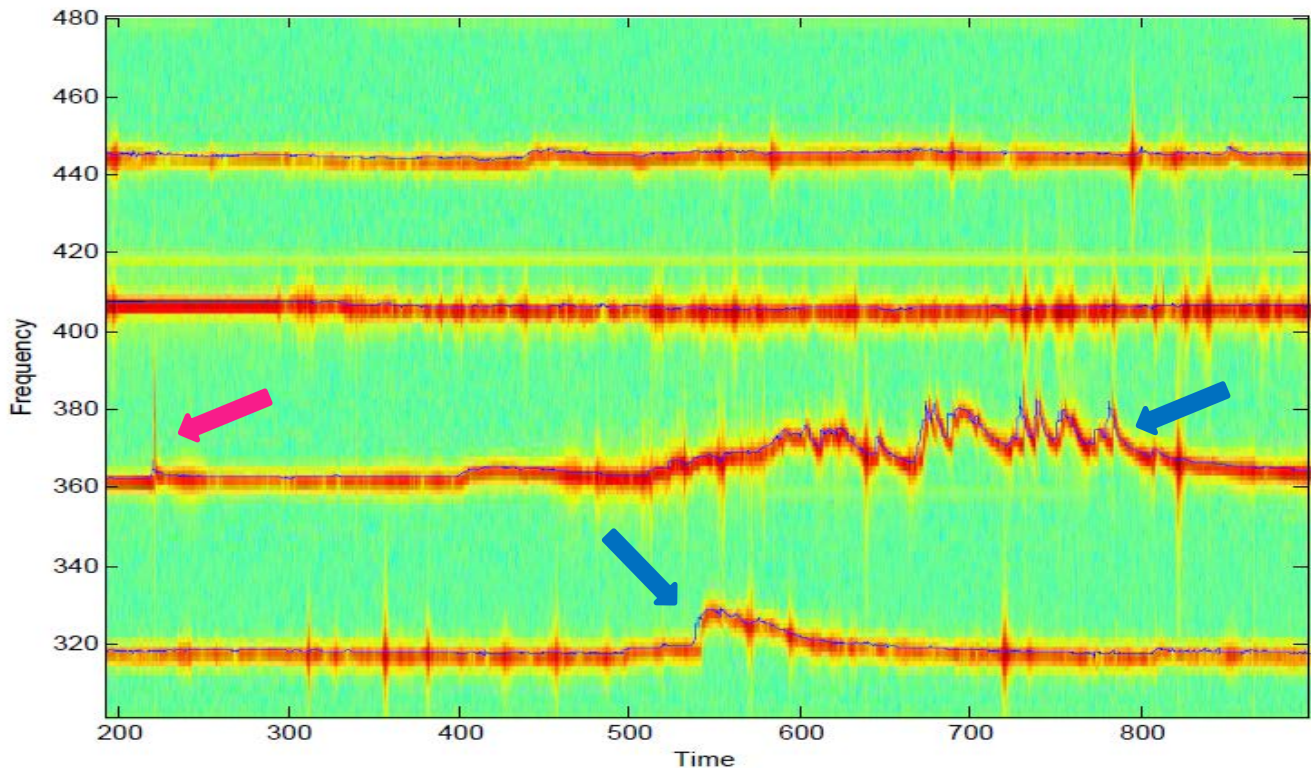
This spectrogram illustrates the unique electric field frequencies emitted by four individuals over roughly 700 seconds. Each fish generates a constant frequency; however, individuals can also vary their frequency allowing them to communicate with other fish within the range of their field. Two forms of communication are illustrated above, chirping (pink arrow) and 'singing' (blue arrow).

Precipitation Reaction Experiment for the ChE Student Laboratory

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The project is focused on the development of a student experiment for the chemical engineering (ChE) laboratory that mimics a pharmaceutical crystallization. The precipitation reaction is: $Na_2CO_{3(aq)} + CaCl_{2(aq)} \rightarrow 2\ NaCl_{(aq)} + CaCO_{3(s)}$. Several developmental steps are involved.

The first is investigation of crystal formation using optical extinction. The intensity of a visible laser beam, passing through a transparent agitated batch vessel (Figure 1), reduces as it passes through the solution because the light gets scattered from its directed path by the precipitating calcium carbonate particles. The beam attenuation data are correlated with the Beer-Lambert law. Using the solids formation rate obtained in the second step below, the attenuation data suggest that the existing particles are likely growing in size as initial particles continue to form.

Figure 1

Beer-Lambert law: $I_t = I_o exp(-\sigma_s C_s l.)$

Figure 2
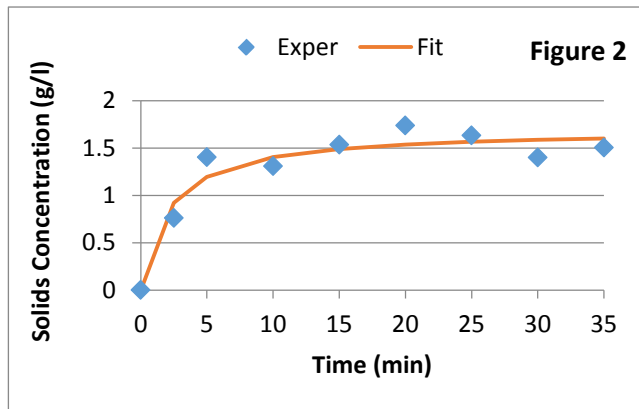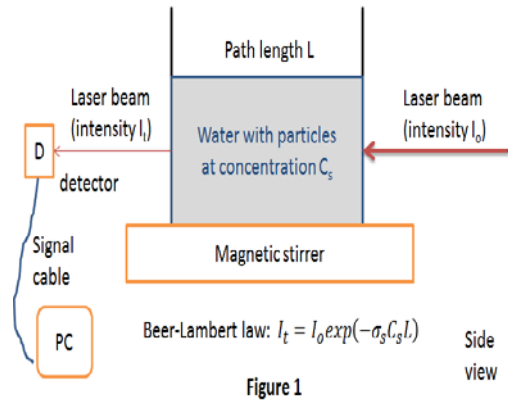
In the 2nd step, the reaction is run in an agitated batch vessel, from which small sample volumes of reaction fluid are withdrawn for solids content determination by filtration. The solids content C_s vs time data are correlated assuming a second order solids reaction rate. An overall rate constant for the precipitation reaction is obtained from a regression (Figure 2). $C_s = \dfrac{C_{Ao}^2 kt}{1+2C_{Ao}kt}$

In the final step (Figure 3), the reaction is run in a bench-scale continuous stirred tank reactor (CSTR). The dissolved salt solutions are pumped, metered, and fed into the CSTR. Manual control of the effluent flow maintains the liquid level in the flow vessel. Effluent samples are drawn for filtration to determine the solids concentrations. In a typical run, the CSTR is filled with plain water. Then, the salt solution flows begin, as does the effluent flow. Effluent samples are collected at regular intervals in order to capture the transient to steady state solids concentration. *We acknowledge the contributions by Hien Vu and Allison Guajala.*
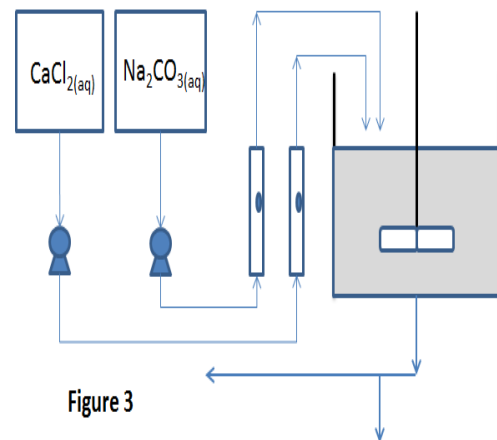
Figure 3

Integrating the Kinect, iARM, and Optitrack Motion Capture System into a Low-Cost TMS Stimulator Positioning System

Jordan Sorg, Prasad Tendolkar, Phil Tomaro, Jared Bloom, Dr. Sergei Adamovich

Department of Biomedical Engineering

New Jersey Institute of Technology

Abstract: Transcranial Magnetic Stimulation (TMS) is a useful modality for movement science research. In order to conduct a TMS experiment, a researcher must monitor a handheld stimulation device so that it only activates a specific region over a subject's head. The area of stimulation is very small, so the researcher must make sure the stimulator remains oriented properly at all times. This spreads the researcher's attention between monitoring the stimulator's position and monitoring the recorded data (such as brain and/or muscular activity). If the subject's head moves slightly, the researcher must relocate the stimulator on the fly, which can lead to bad data. The subject-monitoring portion of a TMS experiment could be completely autonomous, which would effectively replace the researcher's arm with a robotic arm. Such technology could improve several other aspects of a TMS experiment, such as determining the sweet spot of stimulation automatically through searching algorithms. We have developed a cost effective design of an autonomously controlled TMS stimulator that aligns with the subject automatically. Using a robotic arm, a Kinect sensor, and an OptiTrack motion capture system – all available through the NJIT Biomedical Engineering department – we plan to perform a robotized TMS experiment in real time.
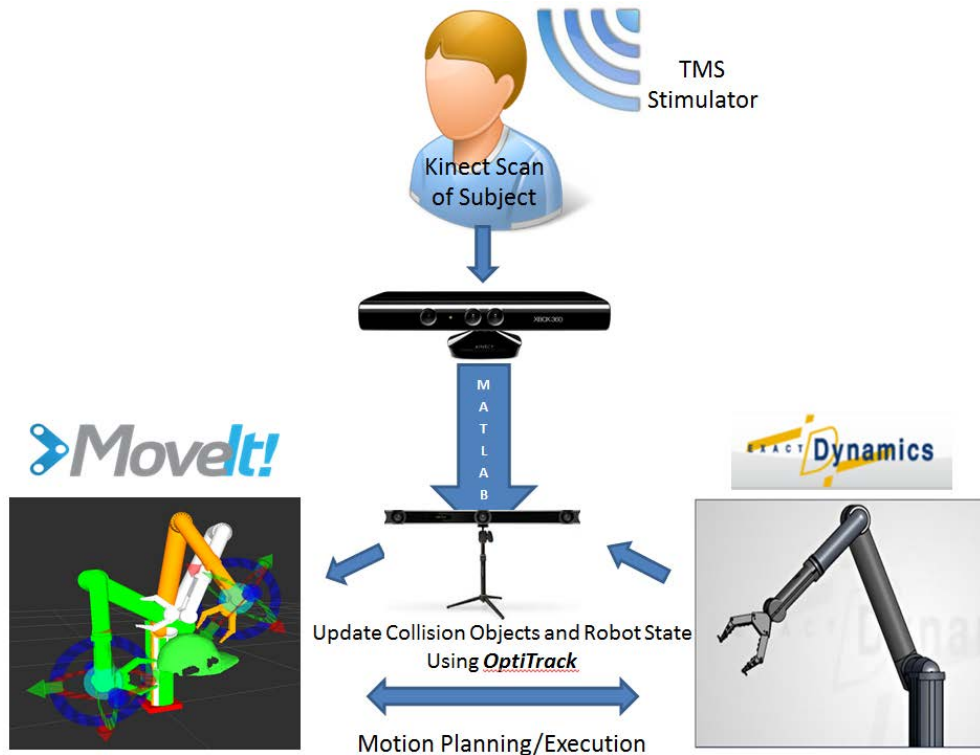
Fig. 1 – Component interaction of proposed TMS system

Induced Plurpotient Stem Cells

Maya Woods and Advisor: Dr. Ruby J. Sampson, MD, Gastroenterology, Internal Medicine
106 Valley St, South Orange, NJ 07079

Abstract: Blastcysts synthesizing derived from embryonic stem cells directly relates to proteins. Specifically enzymes and PG synthetase capable of synthesizing progesterone and testosterone are found in early blastocysts. Embryonic stem cells are cells derived from the inner cell mass of developing blastocysts. Based and revolved around effective stem cell production, effective and collected data on protein was conducted through radioimmunossays analysis. Collective data on micropuncture of blastocysts has also indicated that over ninety percent of the progesterone in embryo is located in the blastocoelic fluid.
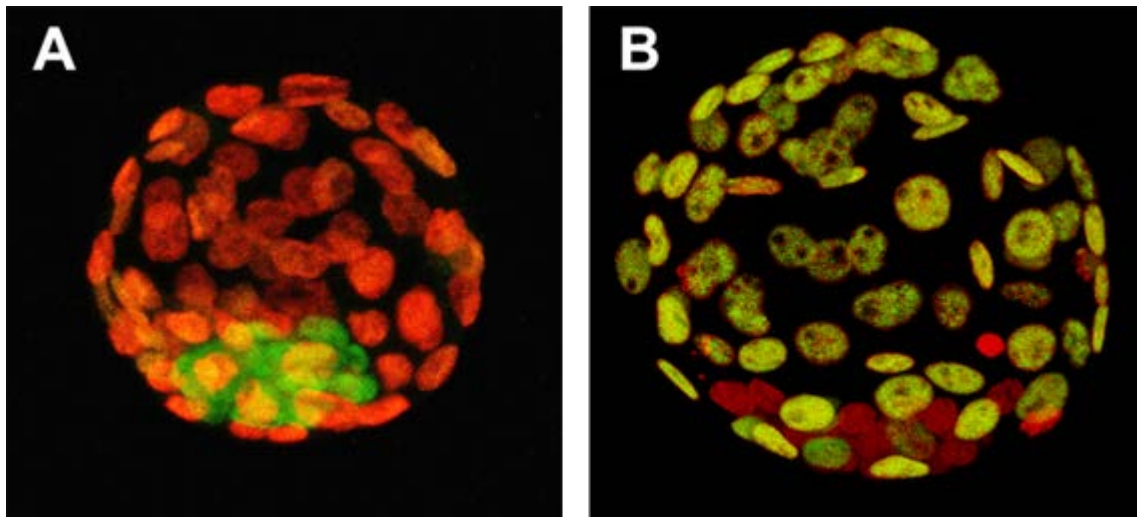
Immunofluorescently stained blastocysts, showing expression of transcription factors essential for cell-type commitment. (A) OCT4 (green) protein is localized in inner cell mass. (B) CDX2 (yellow) protein is localized in trophectoderm. Nuclei are stained red with propidium iodide. Images were taken using confocal microscopy, School of Medicine, Institute for Biogenesis Research

Mathematical Modeling of Daily Rhythms and Cardiac Arrhythmias

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Abstract: The cardiomyocyte circadian (~24-hour) clock influences multiple intracellular processes, including transcription and contractile function, and has recently been linked to ventricular arrhythmias in mice (Jerayaj *et al.* (2012) Nature 483:96-100). Circadian oscillations have been observed in transient outward potassium current (I_{to}) – a current which dominates mice action potential (AP) repolarization, and when downregulated is related to arrhythmias in humans. However, due to differences in shape and duration, mice cardiac APs are a poor approximation to human ones, and in humans, more currents besides I_{to} play a role in repolarization. Compared to mice, guinea pig cardiomyocytes exhibit APs that are closer to those of the human cardiac cell. Thus, our project focused on a mathematical model of guinea pig AP generation:

$$C\frac{dV}{dt} = I_{app} - I_{Na} - I_{CaL} - I_{Ks} - I_0(V)$$

$$I_{Na} = g_{Na}m^3hj(V - E_{Na}), \quad I_{CaL} = g_{CaL}df(V - E_{Ca}), \quad I_{Ks} = g_{Ks}xp_\infty(V - E_K) \qquad \frac{dy}{dt} = \frac{y_\infty - y}{\tau_y}, y = m, h, j, d, f, x$$

First, we studied the dynamical mechanisms underlying secondary oscillations during the repolarization phase of the AP. These oscillations, called early afterdepolarizations (EADs), have significance because they are associated with heart failure and arrhythmias. Since the above model has multiple time scales, we use fast-slow decomposition techniques. Treating the slowest variable x as a bifurcation parameter, it can be shown numerically and analytically that EADs arise from a Hopf bifurcation (Tran *et al*. (2009) Physical Review Letters 102:258103). We then investigated how variation of calcium and potassium conductances (g_{CaL} and g_{Ks}) affects the formation of EADs. This allows us to predict the role circadian regulation of currents other than I_{to} could play in guinea pig cardiac activity. Finally, we used our results as an incentive to vary these parameters in a model of human cardiac APs, obtaining more insight on the formation of EADs and their potential relationship to known circadian rhythms in sudden cardiac death.
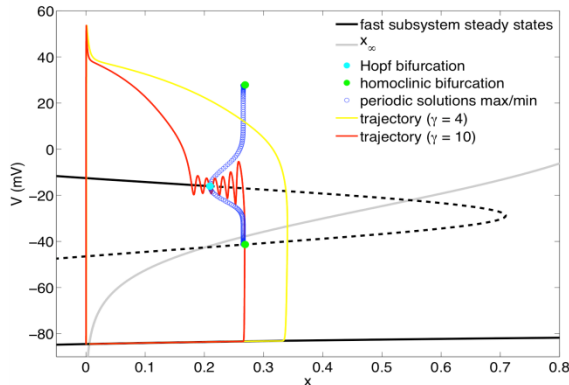
Phase-plane trajectories of the model overlaid on a bifurcation diagram of the fast subsystem. EADs occur when the trajectory is between the Hopf and homoclinic bifurcations points.

Lean Startup

Accelerator Program

QuikGraft: Gimme Some Skin
A 3-D Bioprinter that Prints Infection-Resistant Skin Grafts

Ilesha Sevak, Matt Armanious, Sayali Kulkarni, Evan Tyerman, Ashas Pathan
*Advisor: Atam Dhawan, Ph.D.*
Provost Summer Research Program
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Abstract: Each year in the United States, up to 10,000 people die of burn-related infections each year. These burn wounds do not usually affect only small areas. Major burns result in large area of irreparable skin. A majority of these burns are treated with skin grafts. Conventional skin grafts use the patient's own healthy tissue to cover the affected burn area. The tissue is surgically cut from another area on the patient's body and transplanted to the wound site, ideally creating two open wounds on the patient's body. If the wound is too large, and there is not a large enough donor site, the skin graft is meshed to spread it out, therefore increasing its surface area. What these methods ultimately lead to is a very high chance of infection. Such infections can only be prevented through antibiotics and better skin graft methods. Our product utilizes a 3-D bio-printer that will create an infection-resistant skin graft. By integrating a bioprinter with skin cells, it allows users to parameterize skin grafts when integrated with existing monitoring and control systems, as well as decreasing chances of infection and rejection due to the presence of antibiotics.

Our current prototype consists of a bioprinter that can print using plastic materials through a melting mechanism. Our current work is focused on configuring the printer into using a combination of injecting antibiotics into cells and then printing them out into layers to make a skin graft. The first portion will use cells from the wounded person to replicate and create multiple cartridges until the machine can use it easily. The antibiotics will be injected into cells and allowed to culture and grow, thereby creating resistant cell cultures. While these cells are being cultured, a temporary antibiotic artificial graft will be printed out and adhered to the patient as a short-term solution. Once done, the cell cultures will be loaded into cartridges for the bio-printer. The bio-printing portion will use the cell cartridges and run it over plates as the cells are printed out in layers to create the skin graft in the sample. The thickness and shape will be dependent on the cell medium upon which the printing is happening.

References:
"3D Organ Printer Creates Kidney On-Stage at TED Conference." *The Utopianist – Think Bigger*. N.p., n.d., Web. 11 Mar. 2013
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http://www.bbc.co.uk/news/technology-12520951
"Using Ink-Jet Technology to Print Organs and Tissue." - Wake Forest School of Medicine. N.p., n.d. Web. 11 May 2013.
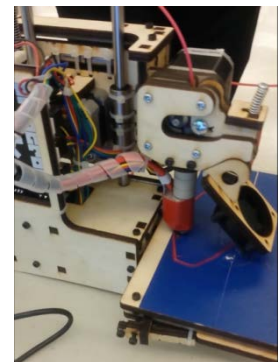
A STRATEGY FOR ESTABLISHING AN ELECTRONICS-BASED (COMPUTERS) RECYCLING COMPANY

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Abstract: There is a need to increase the number of recycled computers, in order to decrease the load on landfill, lessen the problem of raw materials scarcity, and reduce the amount of pollution created during the manufacturing process. Also, by recycling computers, consumers who cannot afford buying them at regular tag price will have the opportunity to buy these commodities at affordable pricing. The company is planning to alleviate the problem by serving as a checkpoint stage to filter all computers once there is a need for them to be recycled and then passes identified first-level recyclable computers to marketing channel and redistribute the rest to appropriate advanced recycling companies to have them recycled efficiently.

The main challenge for the business is to gain clients' (e.g., Universities, government agencies, and businesses) trust to give us their computers to recycle them. Many recyclers charge their customers fees to recycle their computers, while the company's plan is to offer the service for free. The company will initially market its services through direct selling: sending representatives to these clients (e.g. colleges, businesses) to educate them about the proper way of recycling their products; along the following selling methods: Cold Calling and Target Account Selling.

Competition will be from recycling companies that already exist in the market. However, the lucrative mentioned features that every business is looking for to promote its services (e.g. national recognitions); the money incentives (e.g. giving them a portion of the value of their recycled electronics); and decommissioning services (The founder had designed a decommissioning service for a college he worked for) that the company exclusively planning to offer, will give it a competitive edge against its rivals.
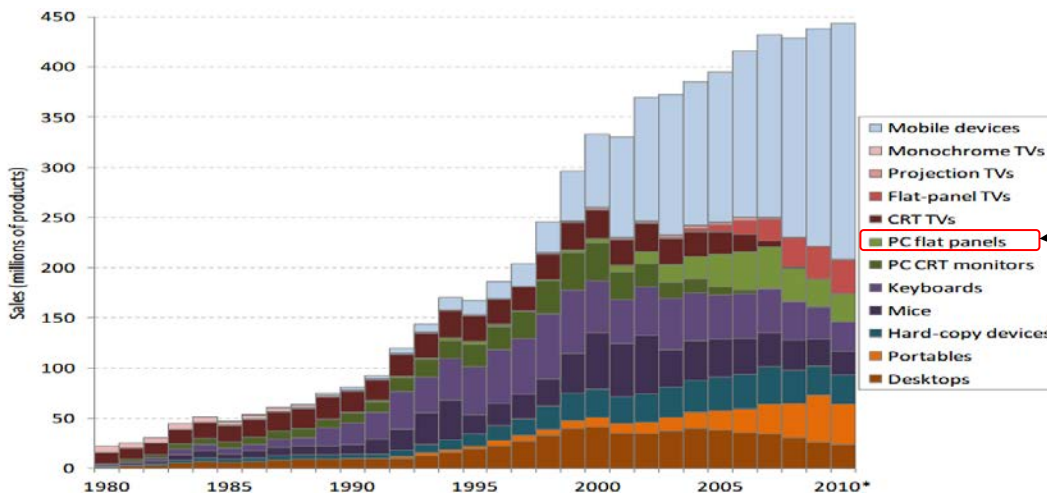
Sales of electronic products by model year, in number of units sold. *Results for 2010 are projected based on estimates from previous years.

S&D: Science & Dermatology - A scientific Solution for Stretch Marks Morphologic Analysis of Human Dermal Fibroblasts under Exposure to High Amounts of Strain in a Very Fast Time Frame

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Abstract: Science & Dermatology is a new Research and Development company whose main objective is to find a scientific solution for both the prevention and correction of stretch marks in pregnant women, adolescents, and people with Cushing's syndrome. The main function of dermal fibroblasts is to produce the essential fibrous components of the extracellular matrix (ECM) of the skin. It is hypothesized that these cells undergo a morphological change when they are exposed to high amounts of strain at critical strain rates.

Experimental: In order to study the mechanism of stretch mark formation, human dermal fibroblasts were seeded on a silicon membrane for controlled deformation. Upon reaching a confluence of 40-70%, they were uniaxially stretched using a device graciously provided by Dr. Bryan Pfister's laboratory at NJIT. A total of thirteen samples were analyzed, which were exposed to 40%, 60%, and 80% strain at a rate of 10/s and at a rate of 8/s. The strain rate employed are significantly higher than associated with stretch mark formation but are effective for showing proof of concept.

Results: Cells presented severe morphological changes, significantly different from low strain rate data available in the literature [1, 2 and 3]. In the published literature, a decrease in the length of stress fibers, is generally noted [2]. In my experiments, for instance, under 60% strain at a rate of 10/s, the length of the cells increased 3% upon immediate deformation; after 24 hours, their lengths increased 27% of their initial measurement prior to deformation. This length increment pattern was observed throughout the analysis of all samples, though the percentage increment varied per sample. Moreover, after stretching the cells, some granulation was observed within the cells, and 1 week after deformation, the body of the cells became bigger and the lamellopodia extended towards injured cells.

Conclusion: It has been shown that dermal fibroblasts show significant morphological changes when subject to deformation; and the observed changes are a function of both total strain and strain rate. Future experiments will focus on the simulation of mechanical deformation experienced by dermal fibroblasts under known stretch mark formation conditions.
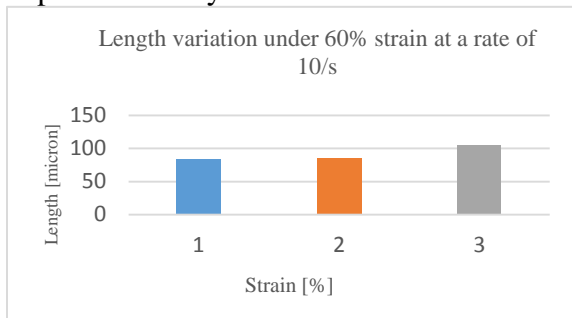
This graph describes the variation in length of cells under 60% strain at a rate of 10/s Blue bar 1: 0% strain, 83.1 microns prior to deformation. Orange bar 2: 60% strain, 85.8 microns post-deformation, 3% increment in length. Gray bar 3: 105.1 microns, 24 hours after deformation, 27% increment in length.

# *Biophysics Summer Research Program*

Capacitive Measurements Showing Success of a Sensor for Aiding Brain Injury

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Abstract: The objective of this research is to provide a more effective way of monitoring and studying the medical condition known as Hydrocephalus. Hydrocephalus is caused by an excess accumulation of cerebrospinal fluid. Currently the main method of treatment is the implementation of a "dumb" shunt which drains this excess fluid into the Peritoneal Cavity. However there can be complications with the device such as clogging. Our main goal is to create a new "smart" shunt in order to alert us to such complications. Using three chips of 500µm diameter with flexible membranes along with a chip with a non-flexible membrane will allow us to obtain readings in absolute pressure and differential pressure. These readings will allow our "smart" shunt to inform the patients doctors whether or not there is a problem with the flow inside the device.

Below is the average of the data obtained the day after we received the package designed by Vivonix. Data was obtained and analyzed using a Spectrum Analyzer with the use of the computer software Origin. Using the equation $C = \frac{\varepsilon_0 \varepsilon A}{d}$ where C is capacitance, ε is the dielectric constant, ε_0 is the electric constant, A is the Area Overlap, and d is the separation between plates. With $\varepsilon = 1$, $\varepsilon_0 = 8.854 \times 10^{-12}$ F m^{-1}, $A = 4\pi(250 \ \mu m)^2$, and $d = 10^{-6}$ we were able to calculate the capacitance to be approximately 4.36pF. This number comes very close to what we measured experimentally by back calculating using the measurements acquired preforming the Resonant Measurement which was approximately 6pF.
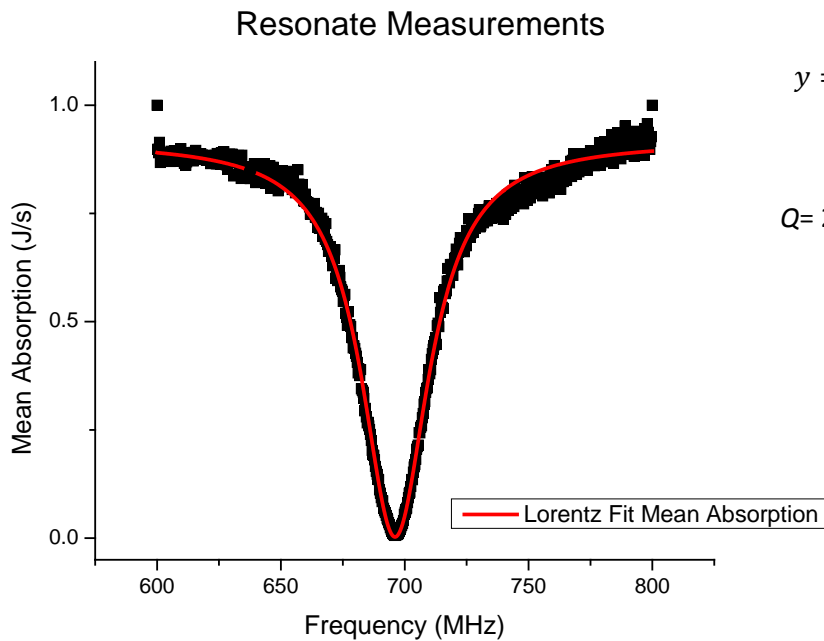
Lorentz Equations Used to Fit

$$y = y_0 + \frac{2 * A}{\pi} * \frac{w}{4 * (x - x_c)^2 + w^2}$$

Q= 20.87

Toward a cancer treatment: Optimizing the conformation of Microtubules

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Abstract: The primary goal is to find the optimal dilution of microtubules at 30 μm. Once the optimal dilution is acquired, the goal is to grow microtubules in vesicles to have a better understanding of how medicine enters into cells through the ion channels in heart cells. Growing microtubules establishes our understanding of the relationship between taxol, a chemotherapy drug, and the growth of microtubules which is advantageous in cancer research.

The graph below is a histogram with a log-normal distribution curve of the length of microtubules versus the count (frequency) in which a length appears in a .5 mg/ml concentration sample that is an ideal solution of growing microtubules. The length of the microtubules were measured by viewing the sample using an optical microscope in which pictures of the sample were taken by an attached camera using a software called Camware Pro. Then another software called ImageJ was used in which the lengths of the microtubules were acquired through a conversion factor of pixels to micrometers. With this particular sample, 80 measurements of microtubules were taken from multiple pictures of different areas around the sample.

The protocol to grow microtubules begins with a PEM_5 buffer containing 80mM PIPES, 1mM of EGTA, 5mM of $MgCl_2$, 5% of the total volume of DMSO, 200 mL of H_2O kept at a PH of 6.85 refrigerated.[1] Using porcine tubulin at 50 μM, it is diluted to 5 μM with HiLyte Fluorescence, $GPEM_5$ (has PEM_5 with Guanosine-5' triphosphate known as GTP), Paclitaxel or referred as taxol with a 10 μM concentration, is mixed together then incubated at 37° Celsius for 30- 40 minutes. Afterwards, another solution, containing PEM_1 Taxol, taxol at 10μM concentration, HiLyte combination, is added to the incubated microtubules. The protocol for this PEM_1 is the same as the PEM_5 with the omission of DMSO and kept at a PH of 6.9 refrigerated. The concentration of tubulin in the general purposes of this experiment varies by the ratio of PEM_1 taxol and incubated microtubules, but for this sample, the ratio was 9μL of PEM_1 Taxol and 1μL of the microtubules. This then was added onto a slide then covered with a cover slip with BSA that is dried, which helps prevents the microtubules from "sticking" onto the slide preventing them from its vibrating motion and sealed for viewing.

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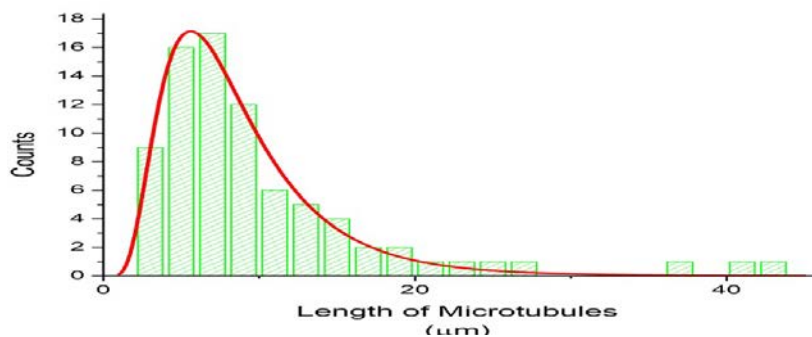
[1] Gittes, F., B. Mickey, J. Nettleton, and J. Howard. "Flexural Rigidity of Microtubules and Actin Filaments Measured from Thermal Fluctuations in Shape." *The Journal of Cell Biology* 120.4 (1993): 923-34. Web.

# Development of Software for a Tonometer to Prevent Blindness

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Abstract: Glaucoma is the death of optic nerve cells, diagnosed through tonometry. The device being developed is a non-invasive , self-operated tonometer to diagnose glaucoma and treat it before the the patient goes blind. The device works by measuring intraocular pressure(IOP) which is shown to have a correlation with glaucoma in patients. Current tonometers, like the Goldmann tonometer or Accupen, are invasive and must be administered by the ophtamologist. Since IOP varies throughout the day, a single reading taken at the doctor's office may not be sufficient to diagnose glaucoma. This is why our device is necessary. The device can be taken home and administered throughout the day, ensuring an accurate diagnosis and treatment before the patient loses vision. Our method uses the eyelid as part of a linear system of springs, pressing on the eyelid instead of the cornea as other tonometers do.

The short-term goal of this project is to finish the device and begin clinical trials. The software for the graphical user interface (GUI) and the computer to microprocessor communication is complete. The inputs into the microprocessor are the number of trials and the time the motor will run for. The ouptuts are a graph, a text file with the patients name on it, and the maximum values for each trial. The software runs without a problem, and we are recieving data, as shown below. The data was obtained by testing the tonometer aganst a subject's eye for 28 trials.The Gaussian fit, or normal distribution, indicates that the error is evenly distributed on both sides of the mean, and the device is repeatable. This is also indicated by the low standard deviation from the mean (24.6) , which was about 1.2. This means that the reproducibliity is 5% which is much better than the 10% industry standard. Therefore, this device, the TransPalpebral Self-Tonometer, is the perfect method to measure IOP throughout the day.

Distribution of Repeated Measurements
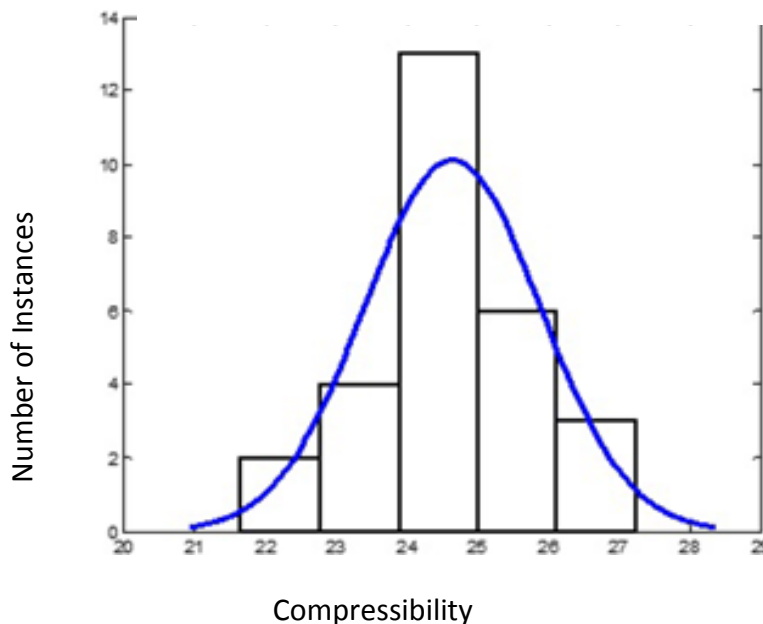
A step to Cancer Treatment: Determination of the Average Young's Modulus of Taxol-Stabilized Microtubules using Thermal Fluctuations of Vibrations

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New Jersey Institute of Technology, Newark, NJ 07102 USA

Of the major structural elements in the cytoskeleton of a eukaryotic cell, the most prevalent is the microtubule. Microtubules are hollow cylinders that help form mitotic and meiotic spindles that aid the movement of chromosomes during mitosis and meiosis. Because of microtubules' assistance with cell division, cancer cells multiple more readily. Taxol isan anti- cancer drug that causes free tubulinto assemble into a microtubule. This causes microtubules to stabilize and block dividing cells in mitosis. Our research focuses on analyzing the effects of Taxol on the dynamic instability of microtubules. As a long-term goal, we propose to observe the changes in vibrational modes in microtubules caused by Taxol. Then, we can relate the dynamic instability of microtubules to the changes of the vibrational modes. By understanding Taxol's effect on the dynamic nature of microtubules, we can ultimately use this information to discover more effective cancer drugs with fewer side effects.

Currently, we are determining the Young's modulus, E, of microtubules stabilized with Taxol. The Young's modulus is a measure of the ration between force and the distance reponse of of any flexible object. We will observe, under a fluorescent microscope, the bending of Taxol-stabilized microtubules grown and diluted in an aqueous bufferThe average of the data set below of the Young's modulus is 1.3 GPa. Comparing our estimated mean of the Young's Modulus resolved to the Young's Modulus in a peer-reviewed published paper (1.2 GPa), the percent error was 8.3%. The Young's modulus of standard GDP microtubule is 0.5 ± 0.1 gigapascals. The data shows that Taxol-stabilized microtubules are stiffer than standard microtubules. Thus, Taxol does stabilize microtubules in cells
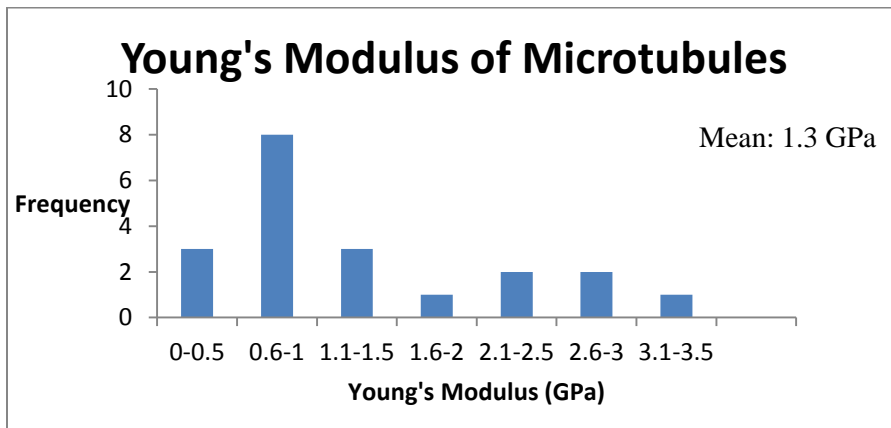
73

Fabrication of a high-power density, implantable fuel cell using functionalized nanotubes

Dylan Renaud, Alokik Kanwal, Reginald Farrow, and Gordon Thomas
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New Jersey Institute of Technology, Newark, NJ 07201 USA

ABSTRACT: This goal of this project is to study the effects of nanoscale enzymatic biofuel cell operation environment on fuel cell activity. A single cell consists of a series of single walled carbon nanotubes (SWCNT) deposited in 30-40 nm deep wells (vias) in an insulating layer of SiN_x over Ti electrical leads. Functionalization of nanotubes as biofuel cell electrodes with glucose oxidase and laccase enzymes was achieved through cyclic voltammetry. The device is fabricated on a silicon wafer and housed in a14-pin dual in-line package. Past studies have demonstrated discrete devices producing power and current densities of $90mA/cm^2$ and $18mW/cm^2$ respectively. Analysis of performance measurements of mega-cell devices (each consisting of over 3 million fuel cell pairs) suggest peak power and current densities for single cells could increase by two orders of magnitude. The aim of this project is to analyze the effects of the operating parameters of the device, namely the intense electric field present and solution ion concentration experienced under physiological settings, on overall fuel cell activity.

The figure below demonstrates SWCNT deposition by analyzing alterations in the chip's via contact impedance before and after nanotube deposition. The resistance of a single lead from a chip with SWCNTs deposited (OTB) and a chip with no SWCNTs deposited (Tortilla) is compared. OTB data magnitude range is approx. MΩ. The maximum difference in impedance values between the leads reaches roughly 4 orders of magnitude.
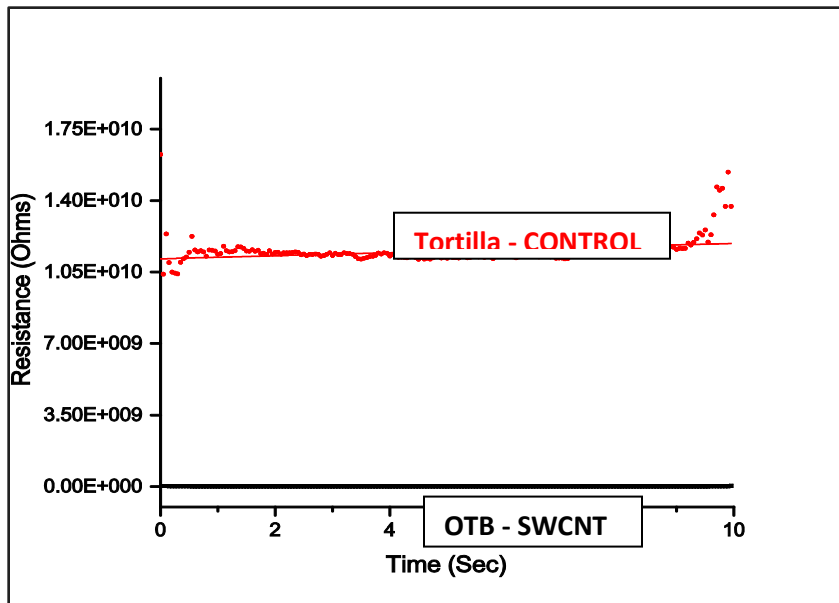

Fig. Lead resistance versus time before (Tortilla) and after (OTB) deposition.
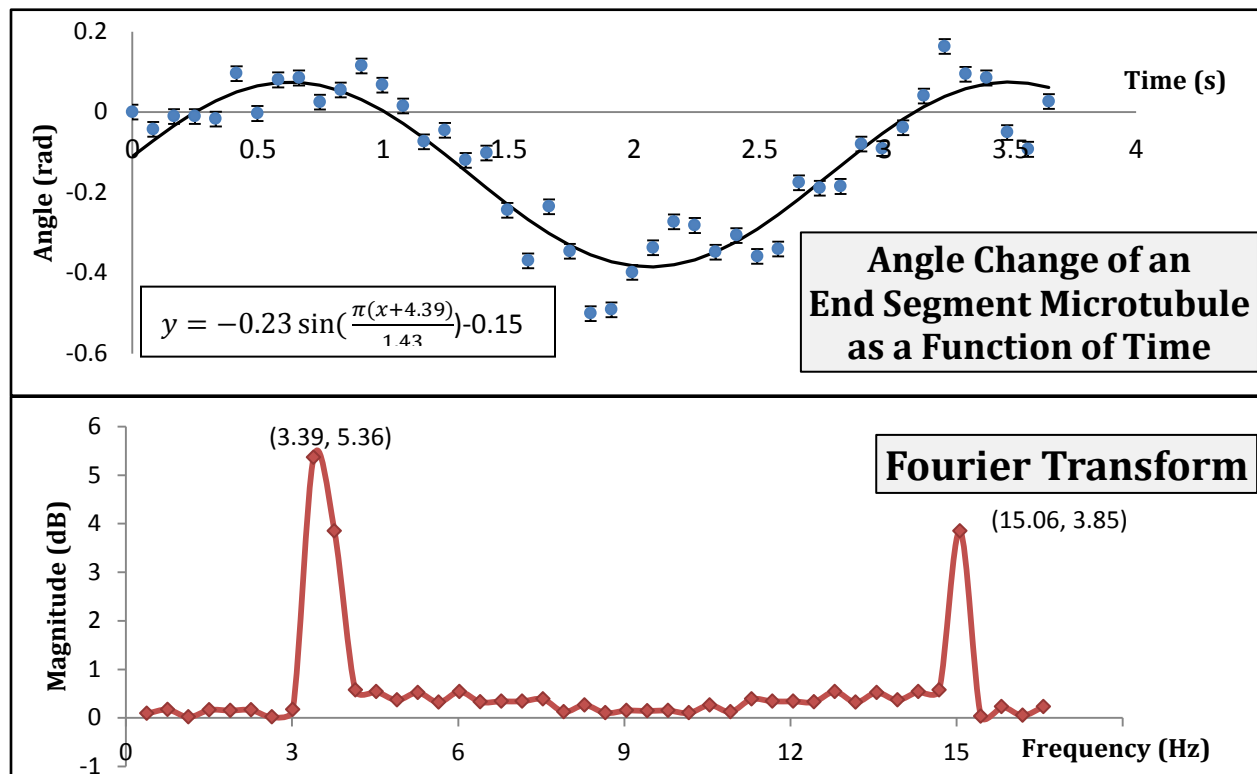
Analyzing the Frequency of Thermally Fluctuating Segments of Microtubules and Its Possibility of Controlling Cancer

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Abstract: Paclitaxel (Taxol) is a drug used to treat cancer by stabilizing microtubules. The purpose of this research is to first explain how Taxol stabilizes microtubules and then find a possible drug that shares properties similar to those of Taxol, but with fewer side effects. By hypothesizing that Taxol affects the vibrational modes of microtubules, we can compare the frequencies of Taxol-stabilized microtubules to those of microtubules without Taxol.

Microtubules are grown, imaged, and analyzed by measuring the angle in radians of the end segments at 83ms intervals. Below are the results of a 19.6μm microtubule incubated with Taxol, which depict a sinusoidal movement of the end segment of the microtubule. From this, we can find the resonant frequency by taking the Fourier Transform of the data and analyzing where the maximum peak occurs, which appears to be at 3.39Hz. The smaller peaks in the transform may be a result of the surrounding solution or internal fluctuations of the microtubule and will be examined with further analysis. The process is repeated with microtubules of similar lengths, incubated either with Taxol or without Taxol. We can then compare the resonant frequencies of both microtubules to see if Taxol affects the vibrational modes. Once verified, we can open new doors in the realm of science and enhance treatment of cancer.

Angle Change of an End Segment Microtubule as a Function of Time

$$y = -0.23 \sin\left(\frac{\pi(x+4.39)}{1.43}\right) - 0.15$$

Fourier Transform
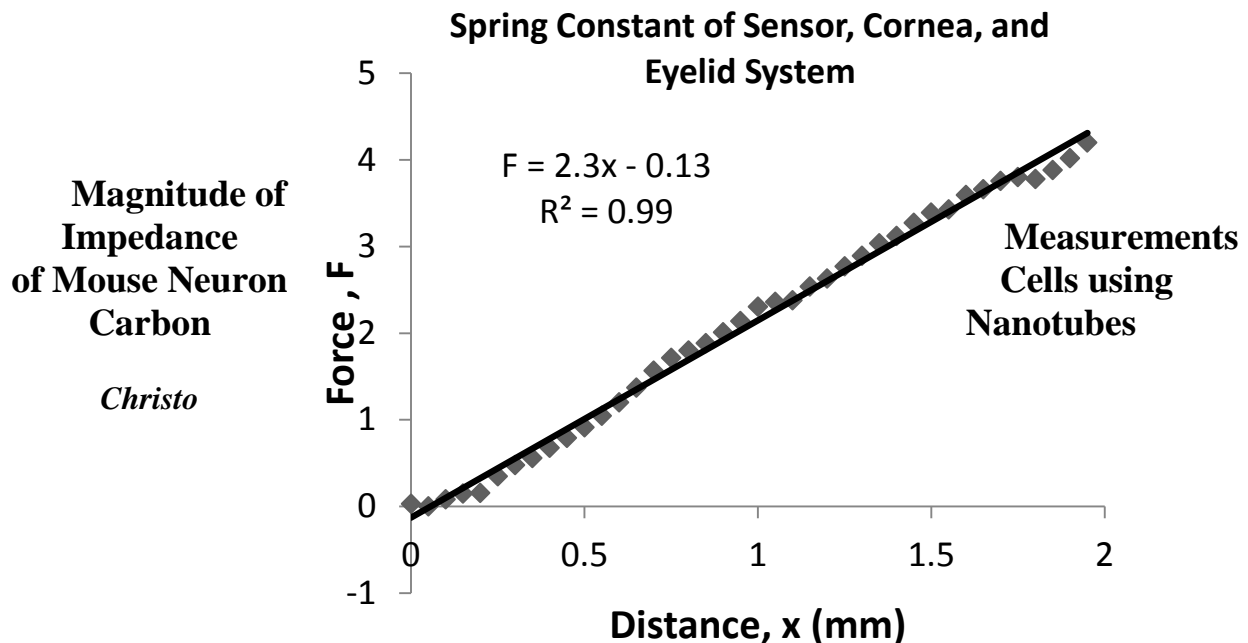
(3.39, 5.36)

(15.06, 3.85)

Successful Fabrication and Testing of a New Tonometer for Preventing Blindness

Anthony SanFilippo, Hassan Muhammad, Dr. Al Kanwal, Dr. Gordon A. Thomas
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New Jersey Institute of Technology, Newark, NJ 07102 USA

Abstract: Glaucoma is a group of eye conditions that lead to a damaged optic nerve which can result in loss of peripheral vision and possibly blindness. In most cases the damage is caused by increased eye pressure or intraocular pressure (IOP). Early detection of glaucoma is important because treatment can delay the progression of the disease. The current standard of tonometry, eye pressure measuring, must be administered by an ophthalmologist under sterile conditions required by the FDA. This does not allow for frequent measurements and because IOP varies throughout the day the doctor may misdiagnose the patient. Our self-tonometer only touches the eye lid and can be used for screening in non-clinical environments. This allows for frequent measurements throughout the day leading to a more accurate diagnosis and better administration of prescribed medicine.

A new trans-palpebral self-tonometer was developed, fabricated, and tested using an artificial eye in collaboration with INSYNC Design. This device will require calibration at the doctor's office before in home use to determine the patient's eye lid's spring constant. The devices spring constant can be found by testing it against a rigid wall and finding the slope of the resulting force vs. distance graph. By modeling the sensor, eye, and eyelid as a linear spring system and knowing the spring constants of the sensor and the eye, the spring constant of the eyelid can be found. With this and the cross sectional area of the rod making contact with the eyelid, eye pressure can be determined. To ensure that the system is in fact a linear spring system the device was tested using an artificial eye. The below graph shows the force required to push the sensor further against the artificial eye. The R^2 value of .99 confirms that this new tonometer system is linear and can be used to diagnose glaucoma at home.

Magnitude of Impedance of Mouse Neuron Carbon

Christo

Spring Constant of Sensor, Cornea, and Eyelid System

F = 2.3x - 0.13
R² = 0.99

**Measurements Cells using Nanotubes**

Magnitude of Impedance Measurements of Mouse Neuron Cells using Carbon Nanotubes

Christo Videlov, Gordon Thomas, Reginald Farrow, Alokik Kanwal

School of Theoretical and Applied Sciences, Department of Biophysics
Ramapo College, New Jersey Institute of Technology, Newark, NJ

Abstract: This research project was focused on the use of carbon nanotubes for the purpose of measuring minute electric and chemical changes in cells. This technique allows for this small scale of measurement, and a closer look than ever before. The nanotube is 1 nanometer in diameter, smaller than a cell, allowing for such small changes to be measured. Because the electric field is also focused to the point of the nanotube and not the relatively larger hole it is deposited in, a more accurate measurement is taken. Once the nanotubes have been deposited on a chip, a bond is formed between the nanotube and the platinum substrate so that the deposition is relatively permanent unless removal of the nanotubes is explicitly desired. By measuring small changes in the impedance of cells, we can possibly detect the presence of certain cells in addition to measuring any changes that occur inside a cell during any process we wish to record. In addition, by finding the characteristic AC frequencies which cells respond too, we can distinguish cells. A frequency sweep measures from 10 Hz to 104.3 GHz. Distribution graphs are used to determine any areas of interest.

The following data uses mouse neuron cells $5.8x10^6$ cells per ml in DRG media. The cells were not directly on top of the nanotubes, but were in very close proximity. This histogram is the number of magnitudes of impedance that occur at intervals of 100. There is a peak at the magnitude of -749. The negative impedance is caused by the linear fit which was subtracted from the previous data in order to normalize, causing some negative magnitude to appear. By measuring the impedance of the mouse neuron cell buffer solution without any cells, we can extrapolate which data is from the buffer and which is from the cells.
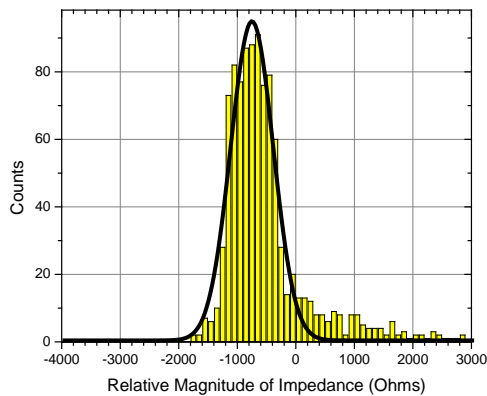
Measuring the membrane potential through impedance spectroscopy to test for drug toxicity

David Villacis and Professor Gordon Thomas
BioPhysics Department
New Jersey Institute of Technology

Abstract: During this research project membrane potentials will be derived from impedance spectroscopy. In impedance spectroscopy a current is run through a substance at different frequencies and the data, in our case, will be collected by a 2-channel signal analyzer and then analyzed using the MAT Lab computer program. Two electrode systems will be used in order to conduct the experiments, a vertical orientated capacitor and a horizontally oriented capacitor. The purpose of this project is to try to collect data using the larger, vertically orientated capacitor, and then reproduce the data by using the smaller, horizontally orientated capacitor.

The membrane potential of a cell is the electronic difference between the interior and the exterior of the cell. Drug companies tend to target the fluctuations in the membrane potential because it dictates the location of different ions or substances that permeate through the membrane of different cells. This allows drug companies to test the drug toxicity of their chemical compounds on cell cultures. The goal of this project is to design and successfully test the horizontally orientated electrode system in order to be later used in High Throughput Screening; a method of being able to collect very large amounts of data at one time. The horizontally orientated system should ideally be able to fill in a 96 well plate and function successfully and efficiently.

The data collected below is of tests conducted on mouse neuron cell buffer solution. The experiments were done on both the vertical and horizontally oriented electrode systems. The solution was tested at four different voltages and frequencies ranging from 10 Hz to 100 MHz. We have been able to conclude that the horizontally orientated electrode system results in less noise as well as having less polarization error than the vertically orientated system. Further tests will be run in order to understand why and how the horizontally orientated system is able to produce such results.
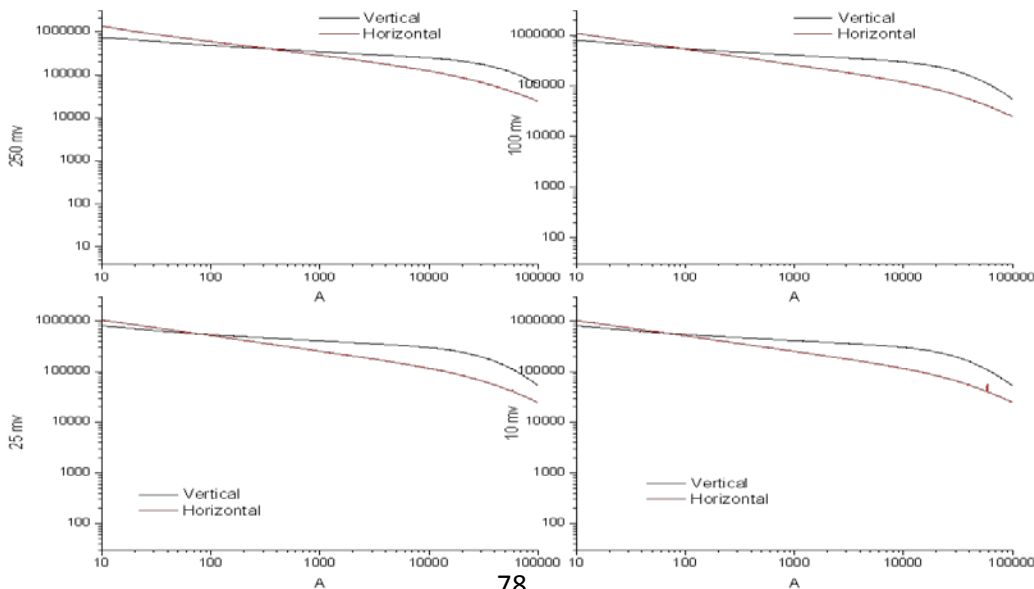
Determining the Health of a Cell: Using Carbon Nanotubes to Measure a Neuron's Ion Channels

Josh Wang, Reginald Farrow, Gordon A. Thomas, and Alokik Kanwal
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Abstract: The first goal of this project was to use electrophoresis to deposit single-walled carbon nanotubes (SWCNT) into holes in titanium electrodes, also known as "leads," on a specialized chip. Control tests with phosphate buffer saline (PBS) solution were run; this solution is similar to the ion content of the carbon nanotube solution used for deposition. Using a V-I sweep from 0 volts to 1 volt back to 0 volts, a battery effect was noted in which 0 voltage had some current due to the different materials of the two electrodes (platinum and titanium). The data was transformed such that the two endpoints at 0 volts corresponded to 0 amps. Using these adjusted current values, the conductance versus time graph for each lead was plotted with a linear fit on Origin. However, the conductance for the first lead tested in PBS solution was different from the other leads since it was much lower and more constant. This graph demonstrated that for an electrode in PBS solution with no nanotubes deposited, its resistivity would be very high, while each subsequent lead tested would have some preexisting deposition of atoms in the holes for the nanotubes, leading to a connection to the titanium electrode and lower resistivity up to three orders of magnitude.

This project will apply nanotube technology to probe cells, using an impedance spectrometer to measure the impedance of yeast and neuron cells as a function of frequency. These probes can also determine the dielectric constant of a neuron to determine its healthiness both before and after ion channel blockers are introduced. This technology can be used to medically determine if a person's cells are healthy and be treated accordingly.
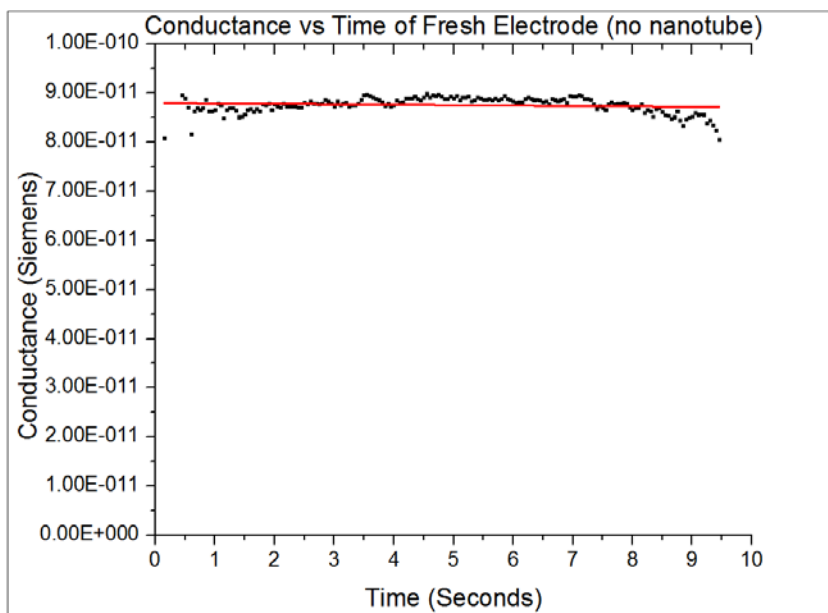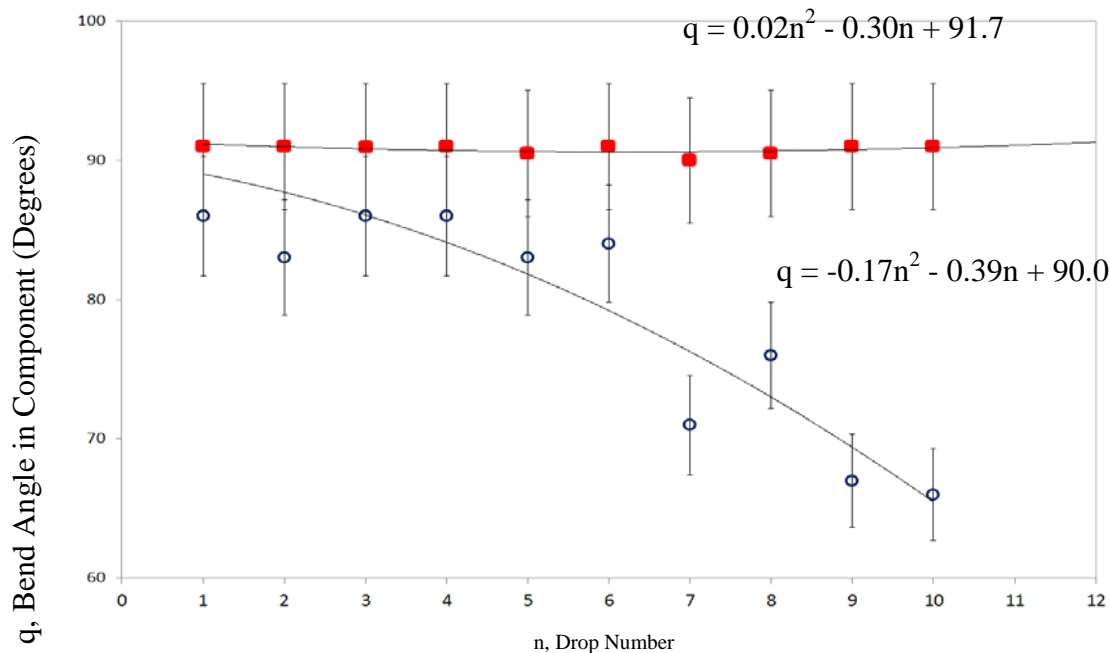
The Fabrication of a Faster, More Durable Vibration-Powered Impact Recorder for Warfighter Safety

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Abstract: During the transportation of ammunition boxes, any impact or vibration that the rounds are exposed to may be harmful to the ammunition inside if any severe damage is inflicted. If ammunition rounds are stressed, they may become unstable and can combust while soldiers are loading military weaponry. The Vibration-Powered Impact Recorder (VPIR) was designed to monitor any damage inflicted on the ammunition rounds in order to make sure they are stable and ready to use when delivered to military personnel. The goal of VPIR is to create an impact recorder that does not use an external battery, yet utilizes a piezoelectric transducer to produce a voltage and activate the VPIR. Originally, the VPIR was designed to use a digital MEMS accelerometer to record acceleration data from the on-chip EEPROM memory. Although this worked, the chip was taking approximately 100 milliseconds to start up, causing the initial impact to go un-recorded. During the re-design of the VPIR, the main goal is to create a chip without an accelerometer to minimalize the start-up time; as well, the chip will need to be ruggedized to withstand any fall it may encounter.

As a step towards making the VPIR more rugged, a test was run to determine the best kind of padding to use for the VPIR chip to keep it from getting destroyed due to any impact. Below, the new, denser padding (solid square) can be seen in comparison with the old, thin padding (empty circle). Each point represents the bend in the support wires of a single component on the VPIR, displayed on the y axis, which was repeatedly dropped from 2.56 meters, as shown on the x axis. The change in the linear coefficient indicates that the denser padding produced an approximate 8 times more durable VPIR than originally designed.

$$q = 0.02n^2 - 0.30n + 91.7$$

$$q = -0.17n^2 - 0.39n + 90.0$$

q, Bend Angle in Component (Degrees)

n, Drop Number

Glucose Oxidase and Laccase Enzyme Functionalization of a Nano-scale Device for the Development of an Implantable Glucose Sensor for Diabetes Treatment

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Abstract: A nano-scale glucose sensor device consisting of single-walled carbon nanotubes (SWCNT) functionalized with glucose oxidase (GOx) and laccase (Lac) is presented, which has the potential for further application in diabetes treatment as part of an implantable glucose monitoring system. Silicon wafers with fourteen 30-40 nm Ti electrode windows etched through a SiN_x insulating layer were mounted and wirebonded in 16-pin dual inline packages. A solution consisting of SWCNTs was placed in contact with a package and linear sweep voltammetry performed to deposit single nanotubes onto the Ti electrodes. Linear sweep voltammetry with phosphate buffer saline solution (PBS) was performed on devices before and after deposition. A constant voltage method using a DC power source and a current logger was also used. Enzyme functionalization of the deposited SWCNTs was performed through cyclic voltammetry with respective solutions of GOx and Lac. The objective is to design a high-endurance, nano-scale device which can accurately measure glucose levels in human interstitial fluid from the enzyme-catalyzed oxidation rate of glucose with Lac as an initial electron acceptor.

Results from linear sweep voltammetry with PBS indicate a change in current of at least three orders of magnitude before and after nanotube deposition attempts. Linear regression analysis between the deposited and control devices indicate a conductivity ratio of 2:1, which clearly demonstrates successful attachment of SWCNTs to Ti electrodes.
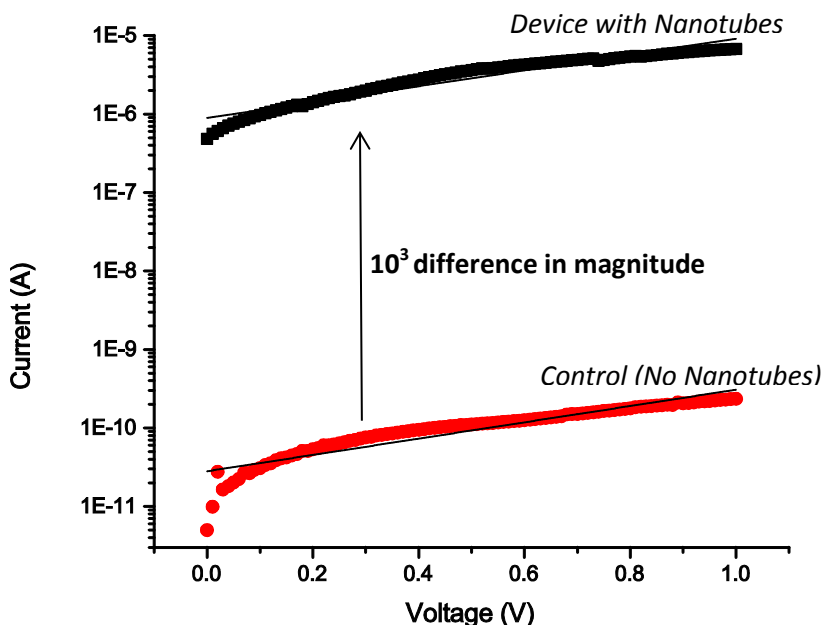
International Summer Student Exchange Program

with

Pontificia Universidad Javeriana

Early Diagnostic Tools for Ulceration of the Diabetic Foot

Karen Garcia, Jessica Marfo, Dr. Martha Diaz
New Jersey Institute of Technology, Biomedical Engineering Department
Pontificia Universidad Javeriana, BASPI Research Group

Abstract: Diabetes Mellitus leads to complex problems in the human body; a common complication of Diabetes is ulceration of the diabetic foot. Although it has many factors this study focuses on only three; narrowing blood vessel, peripheral neuropathy and increase plantar fascia pressure. Reduced Nitric Oxide leads to vasoconstriction of the blood vessels, these narrowing blood vessels reduce flow to tissue and neurons in the lower extremities leading to cell injury and death. Without vital blood supply the neurons are not able to perform their functions. Motor neurons are said to have delayed signals, delaying reaction time in the muscle and in some cases over compensation. The over compensation of the muscle leads to irregular force distribution on the plantar fascia.

The plantar fascia, comprised of mainly collagen, changes as a result of hyperglycemia. Hyperglycemia can form advanced glycation end-products which eventually cross-link with collagen, and can cause the tissue in the plantar fascia to stiffen. The stiffer the plantar fascia gets, the less ability it has to absorb and distribute the shock. Which can cause pressure to become higher in certain areas under the foot, leading to ulceration. A device has been proposed that measures nerve signals in certain lower leg muscles using EMG, and the plantar pressure using a pressure sensor mat in dynamic conditions. Dynamic conditions will be used to observe the proposed changes in real time as the subject walks. This will help Physicians with early detection and prevention of diabetic ulcers.
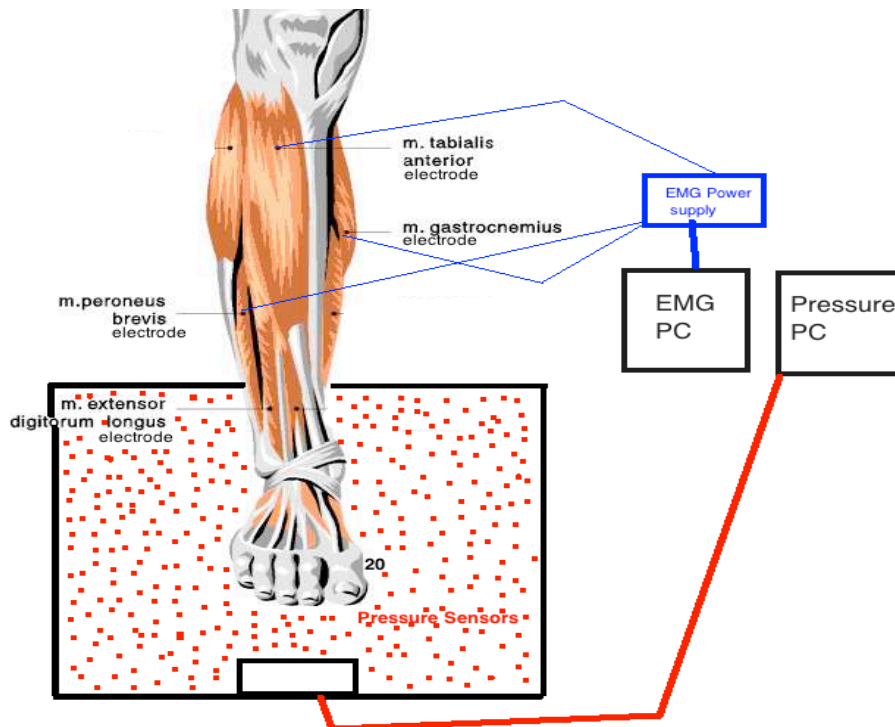
Figure 2: Connection of EMG electrodes, Pressure Mat and Computer

Modeling and Control of the Oxygen Transfer Process in a Bioreactor

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Abstract: The overall oxygen mass transfer coefficient (K_La) within a bioreactor is essential to the development of aerobic bacterial cultures. The coefficient is more specifically used in the process scale up of bacterial metabolic systems such as fermentation. The term changes according to type of bioreactor, and impeller design, as well as agitation speed, type of media, and air flow rate. This causes an issue, when designing bacterial growth models, which can only be solved by empirical analysis. Equations used to calculate the mass transfer term utilizes both mass balances and probe dynamics to create an accurate estimation. The classic least squares method is usually used to estimate the coefficient but suffers from under modeled effects. Utilizing the dynamic gassing out method, as well as modelling by deterministic estimation, the K_La coefficient can be estimated with minimal error due to sensor noise and under modeled phenomena. Using data obtained at different agitation speeds and air flow rates, a figure is created and can be used to maintain a constant K_La term throughout the bacterial growth process. The term can then be kept constant by changing the set point of parameters throughout the utilization of the bioreactor.
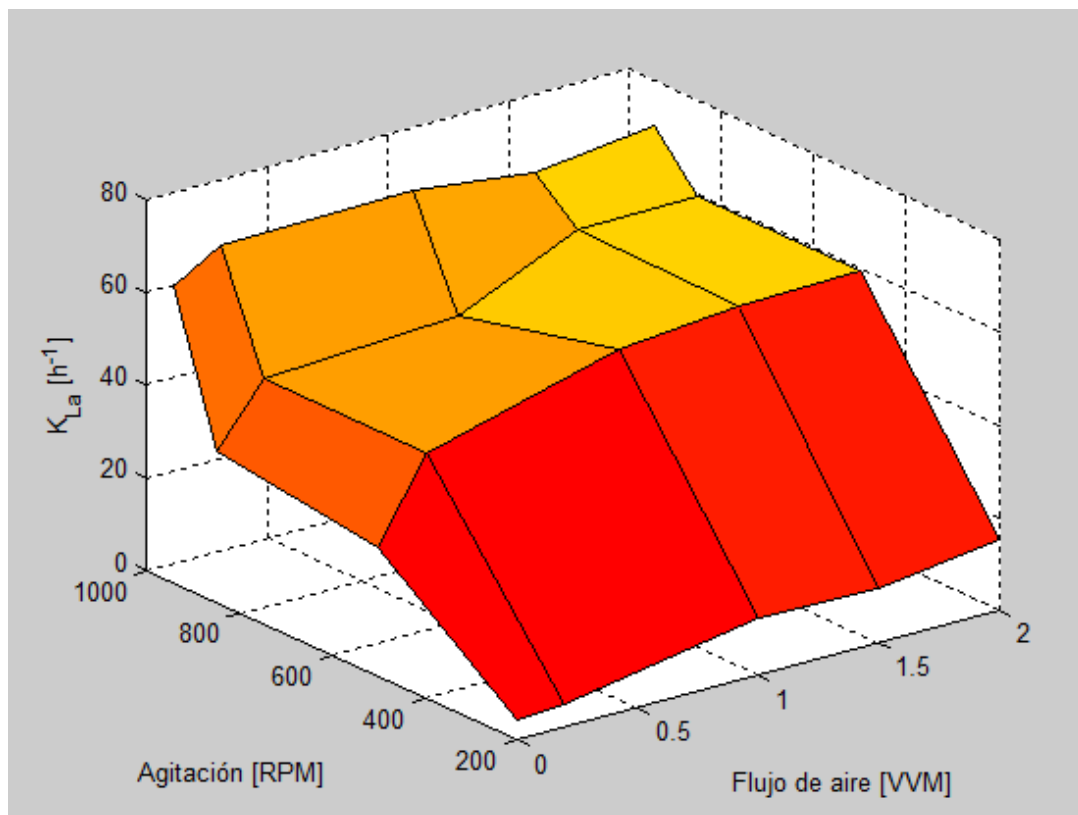
Figure comparing mass transfer coefficients at different agitation speeds and flow rates.

Functional brain mapping using high frecuency FMRI signals

Juan Manuel Vasquez

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Abstract: Functional Magnetic Resonance imaging (fMRI) due to its high spatial and temporal resolution, in addition to non-invasiveness has become a popular method for mapping human brain function. In fMRI a series functional images of the brain are obtained while subjects perform a specific task during a short period of time (usually 4-6 minutes). fMRI is based on BOLD (Blood oxygen level-dependent) contrast and is based on the fact that neuronal activity in normal conditions is related with the regulation of blood flow and oxygenation. In fMRI scanning, when a person performs a task results in the changes in blood flow in specific brain regions which is detected by BOLD contract in fMRI

The goal of this project was to perform fMRI while is the subjects are performing specific tasks. Performance of a task typically results in the changes in blood flow and in this study we investigate differences between young and older subjects. In order to determine these differences, 31 subjects (18 Young and 13 Old) performed this two distinct task under fMRI. The age range for the young subjects is between 21 and 31 years and for the older ones is between 61 and 74. Breath holding task consisted of holding their breath for 16 seconds and then breath normally for other 16 seconds. The complete task was performed for approximately 260 seconds. The visual checkerboard stimulation task consisted in a visual cortex stimulation each 20 seconds during a period of approximately 137 seconds. The pre-preprocessing and analysis of the obtained data was performed using SPM. For each of the subject, fist level analysis was performed to derive subject level activation maps for both the task. A second level analysis was performed to compare task activation between young subject and old subjects.
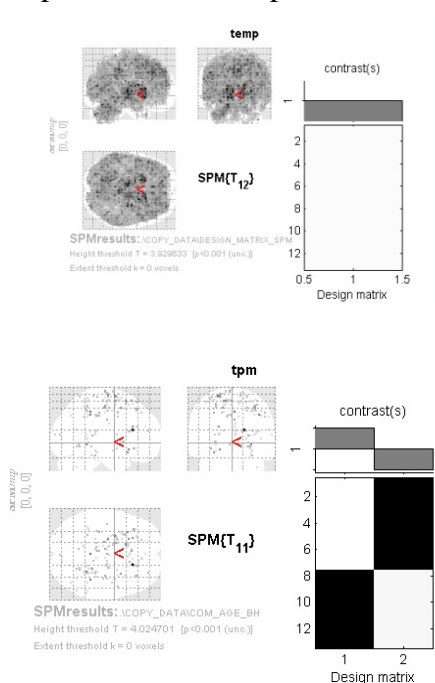
*Top, breath hold activation, bottom second level comparison*
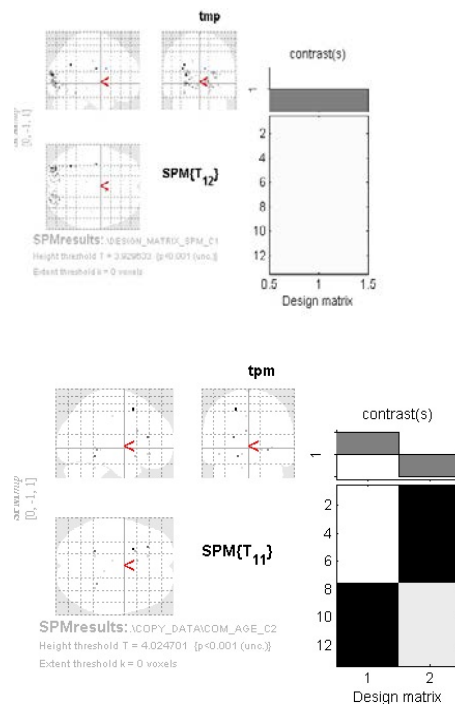
Top, checkerboard activation, bottom second level comparison

A 3-DOF Admittance Control Device for Distal End Rehabilitation

Juan Sebastion Adame, Kevin Abbruzzese, Kiran Karunakaran, Richard Foulds
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New Jersey Institute of Technology, Newark NJ 07102

Abstract: Admittance control paradigms translate user applied force into motion. The positive features associated with admittance control include: force amplification, intuitive control, and proportional control. A 3 degree of freedom (DOF) admittance control device was constructed using three strain gauges (Phidget Force Sensor) and three motors (Dynamixel) to provide movement in three dimensional Cartesian space. Position values were computed from the differential equations and solved using CVode (Ordinary Differential Equation Solver) developed at Eindhoven University. Inverse kinematics was applied to the ODE position values and the angles were converted to motor angles. Future work involves implementing haptic feedback to provide proprioception through rendered forces.
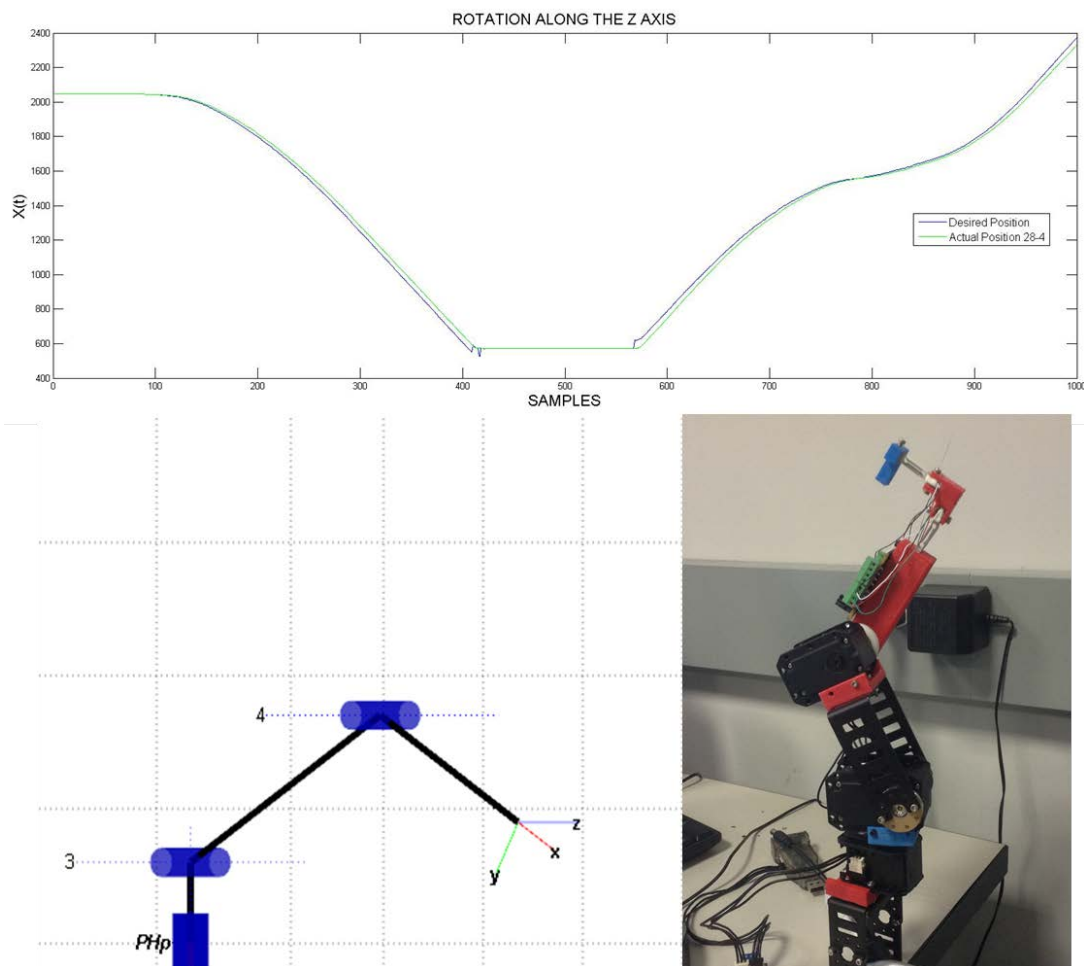
Figure 1. Top: Desired trajectory for motor position vs actual trajectory for Dynamixel. **Left:** Kinematic joint representation for end effector.
Right: 3 DOF admittance control device with force sensors at end effector

NSF
Nanotechnology

The use of single glucose oxidase molecules and carbon nanotubes to construct an artificial pancreas

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Our long term goal for this research project is to make an implantable, artificial pancreas which can automatically pump out dosages of insulin based on the glucose concentration measured in the surrounding cells. Right now, in the preliminary stages of this project, we are working on a method to effectively measure the glucose concentration using sensors which will lay on the surface of our hypothetical device. Our sensors will be composed of a microchip which will be the surface of our device, carbon nanotubes which will be deposited on the microchips, and glucose oxidase molecules which will lie on top of the carbon nanotubes catalyzing the reaction of glucose in the body. This reaction between enzyme and substrate will allow us to measure fluctuations in current. These fluctuations will hopefully correlate to how high or low the glucose concentration is in the surrounding cells. This information is very useful and can be applied in particular to diabetic cases. So far, we have run several tests simply trying to refine the process in which we deposit carbon nanotubes into microchips. To confirm deposition, we measure current during these tests. If nanotubes or other particles are deposited into the nano-windows of the microchip, then the current should increase and resistance should decrease. During this process we have also discovered other factors involved with this process including electrode breakage due to excessive voltage or stress and the deposition of particles in other electrode nano-windows when they are not being tested(which can particularly be seen on the graph below).
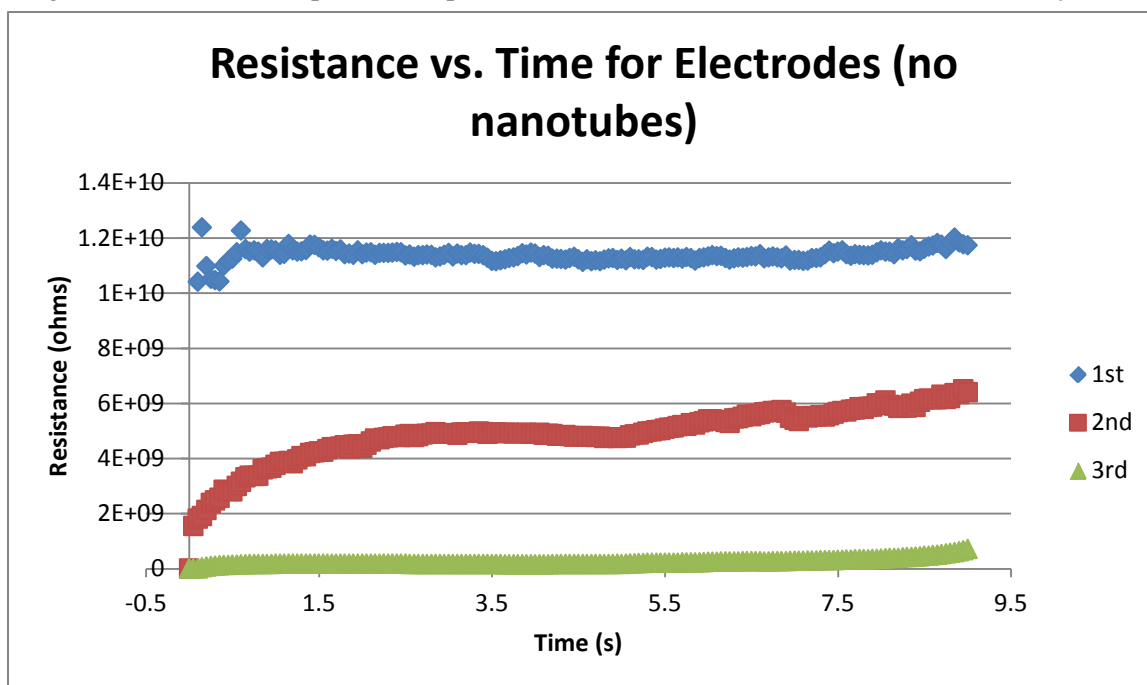
Figure 1. Above is the graph for resistance vs. time for 3 electrodes tested consecutively by an IV, or Current-Voltage test. We ran each electrode through this test with a voltage that ranged from 0 to 1V and back (with a step size of 50 milliseconds) and noted the time it took to achieve our data points which can be seen on the x-axis above. We normalized our data points that measured current as a function of voltage to correct for initial current due to either the battery effect or excess noise. Using the new points, we then used Ohms Law(V=IR) to solve for the resistance, R, of the electrodes which can be seen on the y-axis. The results of the graph above suggest that while we attempt to deposit molecules on the first electrode, other particles and ions are being deposited on the other electrodes. Then, when measuring the second electrode during the second measurement, we can see the decreased resistance due to initial particles already deposited from the previous test on the adjacent electrode. This can also be seen on the third test above.

Deposition of Aptamers on Carbon Nanotubes to Detect Target Molecules for a Blood Sensor

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Abstract: Blood tests are a common procedure done in hospitals today. There are well over 20 different types of tests that can be done on blood. This process costs both time and resources requiring many personnel to carry out these procedures. Ultimately the system conveys an inefficient use of manpower which is crucial in a location where lives are at risk. The goal of the blood sensor is to create a device that can detect the levels of multiple molecules with a single drop of blood. This will minimize the amount of blood drawn, shorten the time for analysis and increase the efficiency of obtaining a result. Molecules called aptamers are utilized for the sensor. Aptamers are short single-stranded DNA or RNA nucleic acids that can bind to a specific target with high affinity by folding into three-dimensional structures. They are also more stable at higher temperatures compared to antibodies and enzymes, which have also been studied for molecule detection but denature easily. The sensor involves a process of depositing carbon nanotubes into nano-scale windows on metal electrical interconnects. An electric circuit is built between a platinum electrode and the metal structure immersed in an aqueous suspension of carbon nanotubes. Once a voltage is applied the nanotubes will be attracted towards the metal cathode due to the nature of the electric field. After the nanotube is deposited the electric field will then be changed and limit further deposition at that window. Once the nanotubes are deposited, the aptamers can be attached to the nanotubes using a similar process which will eventually lead to the attachment of the target molecule.

Results have shown successful deposition of carbon nanotubes onto metal electrical interconnects (Figure 1). The graph of current vs. voltage on a metal interconnect before nanotubes are deposited shows a constant slope whereas the graph after nanotubes are deposited shows a rapid increase in current demonstrating how the electric field is altered. Several runs were done on the same interconnect in the same solution at identical conditions. This deposition process is the first step to towards optimizing the deposition of aptamers on carbon nanotubes.
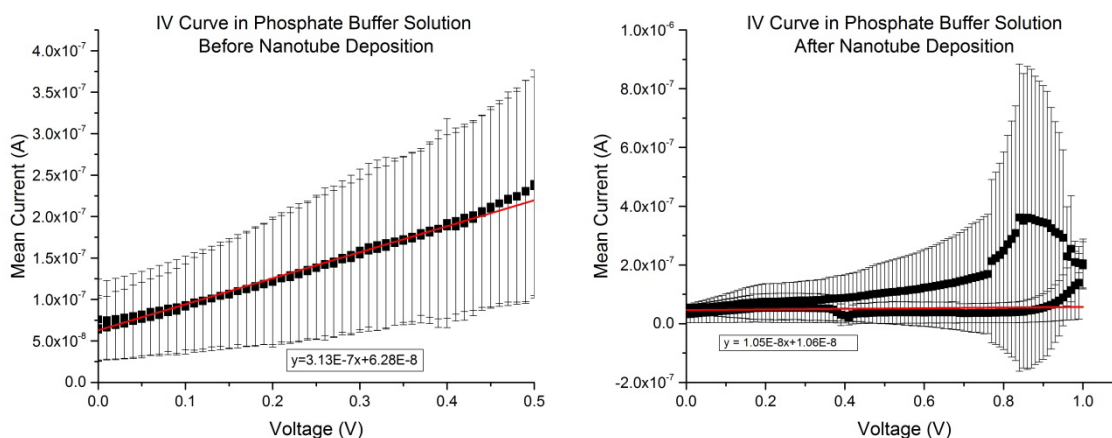

Figure 1. Comparison of IV curves before and after the deposition of nanotubes.

Effects of Dry Coating with Nanoparticles on Drug Release Rate from Ibuprofen Tablets

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Abstract: Although Ibuprofen is classified by the Biopharmaceutics Classification System (BCS) as a poor water soluble class II drug, simultaneous micronization and dry coating Ibuprofen 50 particles with hydrophilic silica (M5P) has been shown to improve dissolution rates and drug release. However the effects of dry coating Ibuprofen 50 with hydrophobic silica (R972P) on dissolution rates have yet to be investigated. Ibuprofen 50 samples were micronized with the use of a fluid energy mill (FEM) using different grinding and feeding pressures to yield samples with median particle sizes of ~3 μm (mIBU 3) and ~20 μm (mIBU 20). Blends with 60% drug loading of mIBU 3 and mIBU 20, both coated and uncoated with either M5P or R972P, were analyzed. Bulk density tests conducted by a Freeman FT4 powder rheometer indicated directly coated drug samples had higher conditioned bulk densities than uncoated samples. However, blends showed no such difference. On the other hand, drug samples and blends that contained M5P had significantly higher bulk densities than samples that contained R972P. The difference between the two host particles (M5P and R972P) had little to no effect on the dissolution rates. While dry coated samples of mIBU 3 and mIBU 20 showed similar dissolution rates to that of the uncoated mIBU 20 tablets, uncoated mIBU 3 demonstrated the slowest dissolution rate with a t_{80} of about 15 min, which can be due to the small size of the particles introducing agglomerates in the blends and thereby decreasing the dissolution rate.
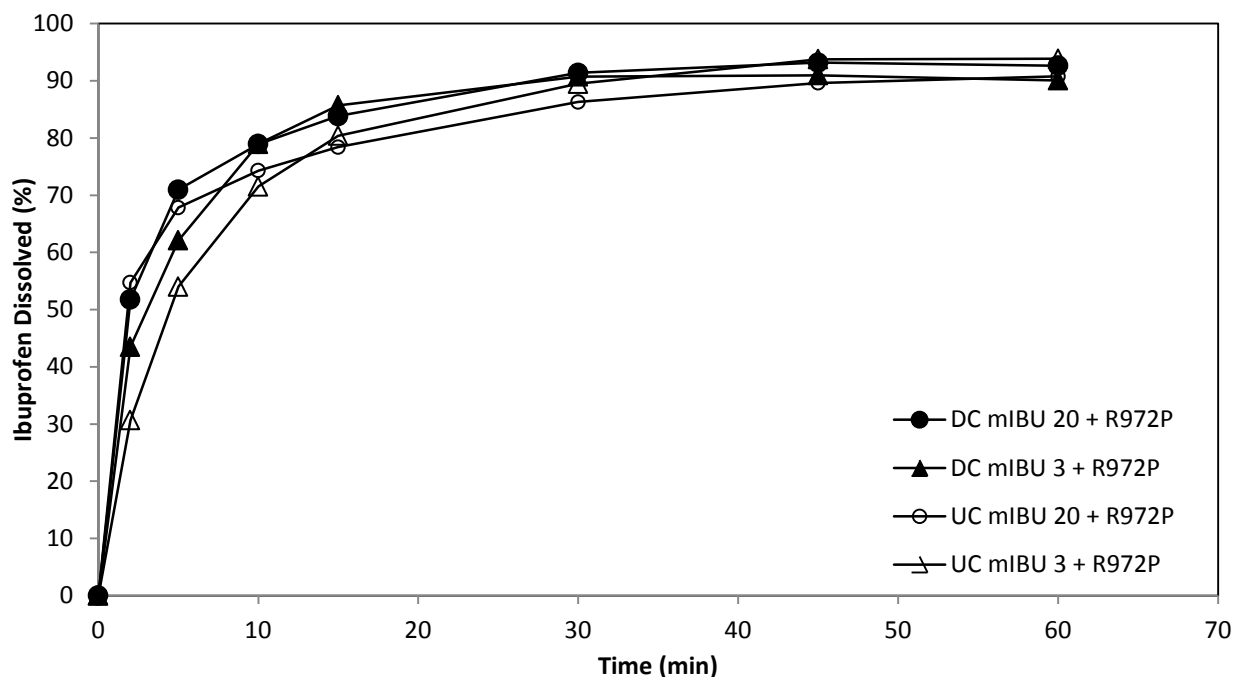
Study of Electrochemical Cells with Nano - Interfaces

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Abstract: A battery is an example of an electrochemical cell and its way of operation has not changed much during the past 200 years. A battery is interfaced with two electrodes: the anode and the cathode. Our goal is to electronically regulate batteries by controlling the ions flowing between the anode and the cathode. For this, we introduce a third electrode, called gate electrode, between the cathode and the anode. By applying voltage to this gate electrode we are able to control the local potential of the electrolyte, thus controlling the flow of ions. In turn, the flow of ions will regulate the current in the external circuit. The requirements for a good gate electrode are high electrical conductivity, permeability to ions at nanometer scale and low oxidation rate. Materials for gate electrodes could be multi-layer graphene and layers of functionalized carbon nanotubes.

Below we show the change in the electrolyte potential near the gate electrode in an electrochemical cell. As the gate voltage is increased so is the electrolyte potential. No chemical reaction is taking place at the gate electrode. This is the first step towards controlling the current produced by a battery and in essence, a demonstration of an ion transistor.
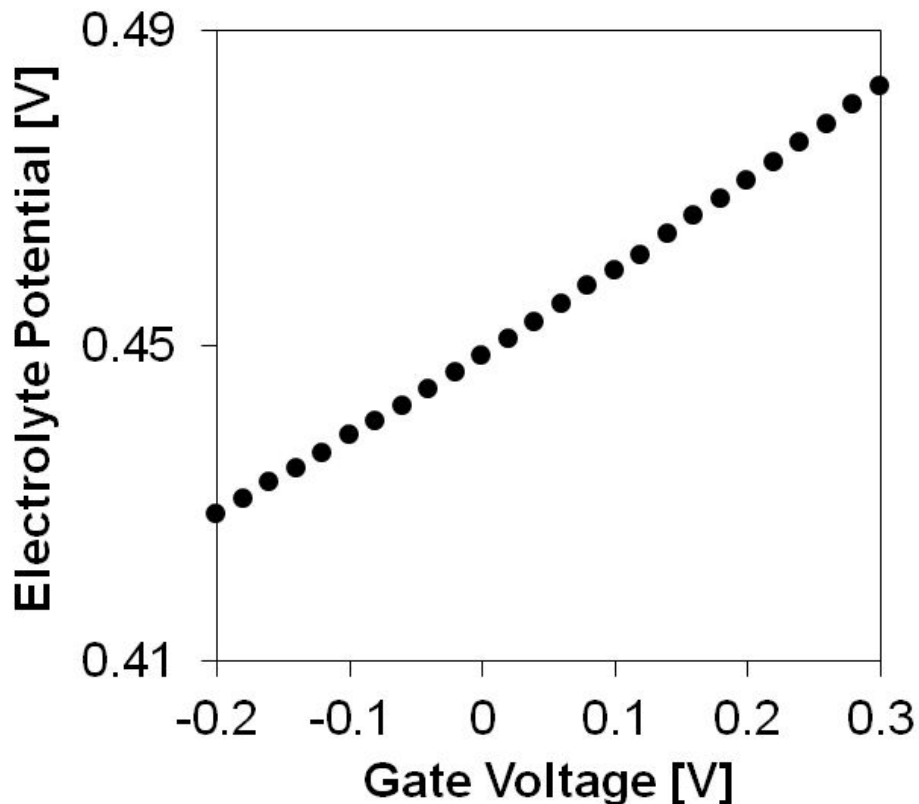
Oxidation and combustion of mechanically alloyed nanocomposite Al·Mg powders in water

Danielle Quijano, Research advisor: Prof. E.L. Dreizin
New Jersey Institute of Technology

Mechanically alloyed nanocomposite Al·Mg powders with tailored particle size distributions have been prepared and characterized at NJIT (Aly et al., 2014; Aly et al., 2013). Compositions of these powders can be varied to include 10 to 50 wt % of Mg. These materials are of interest as potential reagents for the metal-water reaction aimed to generate hydrogen for fuel cells (Crabtree et al., 2004); they can also be used for underwater propulsion (Waters and Cadou, 2013). The unusual reactive properties of these materials are due to their unique morphology and nano-structure achieved through mechanical alloying.

The focus of this study will be to characterize experimentally reactions of the nanocomposite mechanically alloyed Al-Mg powders with water vapor as an oxidizer. In a set of experiments using a mini-calorimeter, Al·Mg powders will be isothermally oxidized at a controlled humidity at several selected temperatures. In complementary experiments, oxidation of these powders in water vapor will be studied at controlled heating rates using thermo-gravimetry. In combustion experiments, the powders will be fed into the products of an oxygen-hydrogen flame, where they will burn in the produced water vapor. Burn times and combustion temperatures of the particles will be studied optically. The particle size distribution will be directly correlated with the measured distribution of durations of the recorded emission pulses. This correlation will enable us to recover the effect of particle sizes on their burn times, and thus determine their burn rates. Results will be compared to recent measurements of burn rates and oxidation kinetics for pure aluminum and magnesium. It is expected that the results will be useful for development of a comprehensive reaction model for the Al·Mg alloys with water vapor.
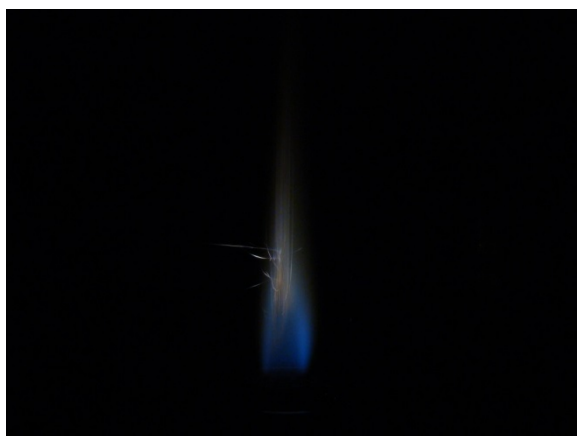
References

Aly, Y., Hoffman, V.K., Schoenitz, M., and Dreizin, E.L. (2014). Reactive, mechanically alloyed Al · Mg powders with customized particle sizes and compositions. Journal of Propulsion and Power *30*, 96-104.
Aly, Y., Schoenitz, M., and Dreizin, E.L. (2013). Ignition and combustion of mechanically alloyed Al-Mg powders with customized particle sizes. Combustion and Flame *160*, 835-842.
Crabtree, G.W., Dresselhaus, M.S., and Buchanan, M.V. (2004). The hydrogen economy. Physics Today *57*, 39-44.
Waters, D.F., and Cadou, C.P. (2013). Modeling a hybrid Rankine-cycle/fuel-cell underwater propulsion system based on aluminum-water combustion. Journal of Power Sources *221*, 272-283.

NSF Undergraduate Research Program – EXTREEMS-QED

Identifying and Tracking Multiple Underwater Acoustic Sources Using Characteristic Signatures

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Abstract: Passive sonar is used for locating acoustic sources alongside, or in place of, active sonar. Passive sonar is very similar to active sonar except there is no sound emission phase in passive sonar. This makes passive sonar especially suitable in situations where the environment cannot be disturbed.

The location and tracking procedure involves using signal detection techniques on audio streaming from arrays of receivers to determine at what time signals arrive at each receiver. Once arrival times are known, source positions are approximated preliminarily using multilateration, which involves finding the intersections of hyperbolas defined by pairs of receiver positions and arrival times. An arrival time likelihood function is then used to approximate the probability density function of the source location in the surrounding area. From there, a multi-model sequential importance resampling filter is used to track a varying number of potentially different sources with position, velocity, acceleration, and source type as parameters.

Previous work used smoothing algorithms to reduce uncertainty in the probability density functions in order to improve signal detection and source localization. Smoothing techniques may, however, perform poorly in situations with low signal to noise ratios. Smoothing may also distort or conceal important characteristic information about the received signal. When tracking multiple sources, such characteristic information is employed to differentiate between source types and smoothing algorithms may not be directly applicable under these circumstances. The potential of particle filters with and without smoothing is investigated with emphasis on source type identification, a challenging topic in tracking.

For the latter problem, that is, differentiating between source types, discrete traits are associated with each source based upon its behavior and the waveforms it emits. As signals are received at a specific time instant, their characteristics are compared to traits of the sources tracked and identified up to that time to determine from which source type, if any, the signal is likely to have been emitted. To quantify uncertainty in the identification process, probability mass functions will be calculated for each source type.

NJ Space Grant Consortium Summer Research Program

Construction of a Handheld Multispectral Imaging Device in the Near Infrared, Visible, and Ultraviolet – Proof of Concept

Angelo Taranto, Barkley Xu, Ian Gatley, John Federici
Department of Physics
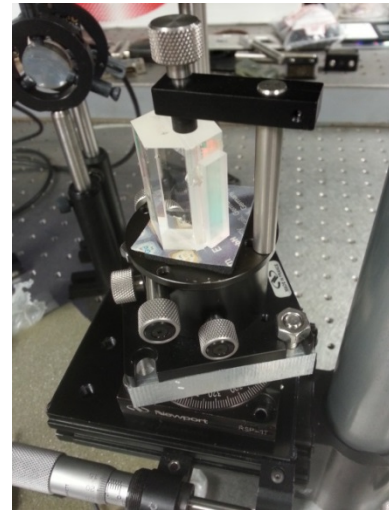New Jersey Institute of Technology, Newark NJ 07102

Abstract: Currently, multispectral imaging cameras (i.e. cameras that can detect light beyond the standard Red-Green-Blue (RGB) representation of the visible spectrum) are large, unwieldy, and require too much power to be usable as hand-held units. A multispectral imaging device that could be carried as easily as commercially available cameras could be used for quick and efficient forensic inspection of crime scenes. This would enable 'invisible' evidence such as blood stains on dark clothing and latent fingerprints to become visually apparent by imaging the evidence in different spectral or color bands.

This camera is made by using a spatially varying spectral filter which is encased in a hexagonal prism. This filter is specially made to act as a wavelength splitter which reflects all light except a narrow band of color. Each discrete band of light (from the ultraviolet up to the near-infrared) meets its own resonance condition at some spatial position inside the filter. If the band does not meet the resonance condition, then it will reflect off of the filter and the surrounding walls until returning to a lower position on the filter. When the light meets its resonance condition on the filter, it passes through it. As such, light is separated by wavelength as it travels down the filter and then passes through it and out of the prism. At the points where it leaves the prism, small cameras without RGB filters are placed to detect each wavelength. Then, the pictures of each camera are overlaid to produce one image that accounts for all wavelengths in the given range.

A laboratory proof-of-concept prototype is in progress. Three Raspberry Pi NOIR cameras have been synchronized and take pictures concurrently using python scripts run by a fourth server Raspberry Pi. A lens system has been created to collimate the light entering the prism, and a mirror system using a beam splitter was made to ensure proper alignment of the discrete exiting light. This has been tested using an 850 nm and a 780 nm laser.

Left: The mirrors and beam splitter set up to make the lasers incident on the prism's surface.

Right: The prism in its adjustable mount.

# Absorption in the Terahertz Frequency Due to Rain

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Abstract: Based on Edholm's law of bandwidth, the need for new methods of wireless communications providing data rates of 5-10 GB/s is estimated to arise in about 10 years. Thus, it will be necessary to use the lower end of the Terahertz frequency range as the wireless carrier signal since there is approximately 100GHz of bandwidth available to meet the projected data rate demands. However, the interaction of wireless Terahertz waves with atmospheric conditions, such as rain, is not well understood.

The goal of the experiment is to record the attenuation of a Terahertz signal due to the rain. The rain is created using a pressurized rain chamber capable of simulating a constant, measurable rain rate as a function of pressure. Upon initial observations, it can be seen that the attenuation is: 1) independent of the Terahertz frequency 2) increases with each pass through the chamber (longer path length through rain) and 3) increases with rain rate. Comparison of experimental measurements and theoretical predictions will be highlighted.
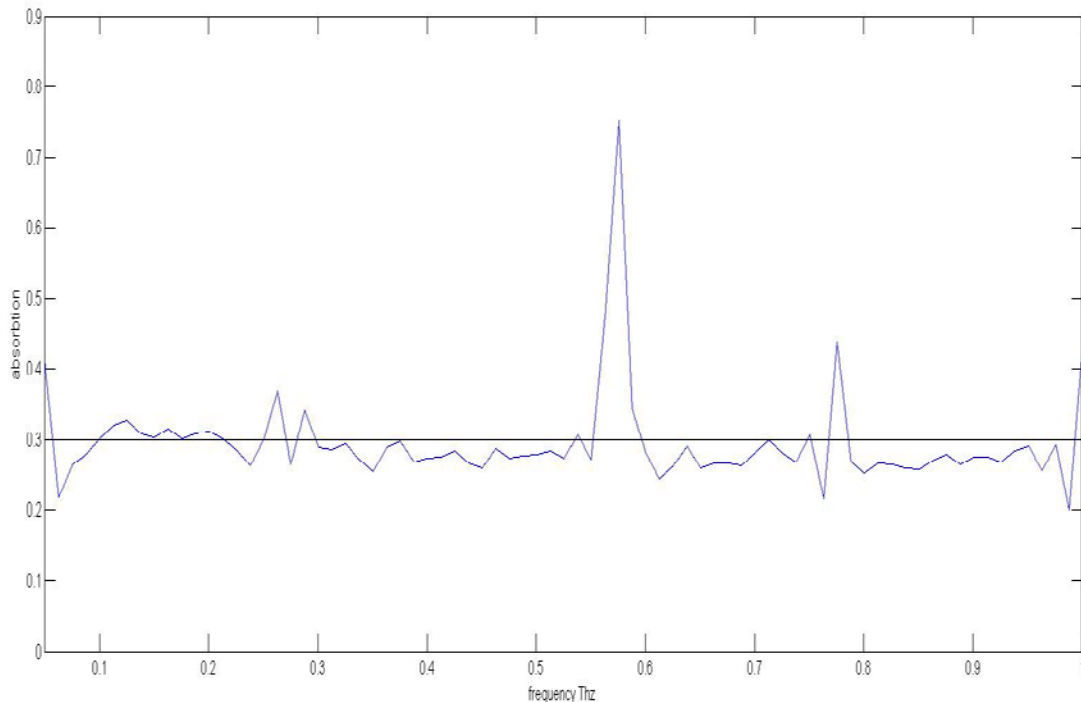
A plot of the absorbance vs the Terahertz frequency. The line drawn across the plot highlights the value of a 0.3 absorbance. That value corresponds to the mostly linear trend, despite some noise across the plot.

# Effects of Trimethylamine N-oxide (TMAO) on proteins

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Ramapo College, New Jersey Institute of Technology, Newark, NJ

Trimethylamine N-oxide (TMAO) has been heavily studied in recent years due to its prevalence in sharks, rays, and other deep-sea creatures. It is believed that these increased levels of TMAO are meant to counter the destabilizing effects that the increased underwater pressure applies to the proteins; therefore it is of interest to observe the effects of TMAO on a protein's structure.
This study will observe the effects of a TMAO cosolvent on a protein's secondary structure through an observation of the Root Mean Square Deviation (RMSD), radius of gyration, solvent-accessible surface area (SASA), and by following the secondary structure over time.

The protein and cosolvent will be set up and observed using the GROMACS simulation and analysis software using the AMBER Force Field and visualized with Visual Molecular Dynamics (VMD). The short-term goal of this study will observe 15 differently-seeded simulations at different cosolvent concentrations of TMAO, a flexible biomolecule in a water solvent around a protein. Observations will be made for Zero-Molar, Three-Molar, and Six-Molar concentrations. Though the end-goal is to observe data from 150 nanoseconds worth of simulation for each run, 100 nanoseconds of simulation-time will be given to each concentration. This time will allow for the best combination of efficiency in doing many simulations while maintaining The 15 different generation-seeds break down to 5 seeds per concentration, which will ensure that the data collected will represent a fairly normal initial state for the system.

The long-term goal is to add the molecule Trifluoroethanol (TFE) into the OPLSAA Force-Field in order to allow for a similar cosolvent setup for simulating. This involves porting a mathematical model of the TFE's structure to the OPLSAA Force Field since the structure files were originally written for the outdated Charmm26 force field. The same observations will be made, hopefully indicating a direct and recordable impact on the protein's secondary structure.
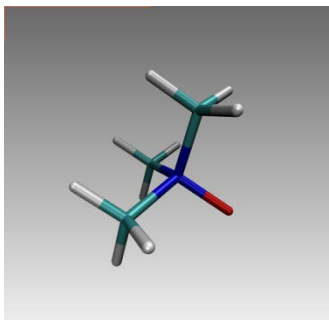
A Visualization of the Structure File for TMAO used in the Simulations
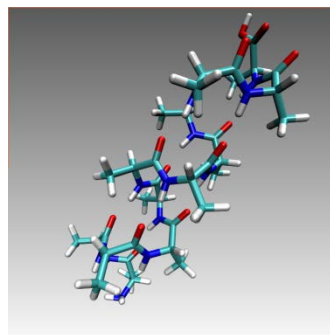
The Polyalanine Structure File visualized with VMD

NSF Faculty Research Experience

Undergraduate Supplement

Additional

Participants

A Preliminary Study on the Performance of Nested Virtualization

Venkata Harish Kajur, Kashifuddin Qazi and Andrew Sohn
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New Jersey Institute of Technology, Newark NJ 07102

Abstract: Virtualization is the act of creating virtual machine (VM) inside an operating system that can run an operating system within the VM simultaneously. In nested virtualization, a VM has the capability to run another VM inside of it. So theoretically, there could be many levels of nested virtualization but for the purpose of this study is to only focus on the first level of nested virtualization. One of the main concerns of nested virtualization in x86 architecture is the runtime performance cost and whether or not if it is efficient enough.

The purpose of this research is to analyze the performance cost of the host operating system, which is the main operating system, guest operating system, VM running inside host OS, and the nested guest operating system, which is running inside guest OS. The table below contains a sample of the results that have been obtained from performing Intel Lin Pack benchmark tests using the average of two trials 100 and 200. From the results below, the guest OS is slower than host OS but the nested guest OS is remarkably slower than then host OS.

No. of Equations/Leading dimensions	Time (s)		
	Host OS	Guest OS	Nested Guest OS
500/500	5.09	16.88	18.83
750/750	10.88	34.29	28.82
1000/1000	20.06	40.03	46.45
1250/1250	33.55	64.82	86.11
1500/1500	49.94	87.14	124.67
1750/1750	73.69	106.11	167.90
2000/2000	103.86	115.44	184

Biodegradation of Benzene in Contaminated Soil and Groundwater

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Department of Civil and Environmental Engineering
New Jersey Institute of Technology, Newark NJ 07102

Benzene contamination of soil or groundwater is a serious concern since it poses a health and environmental risk. Benzene spills may result from various sources of pollution, such as manufacturing and chemical plants. In this context, there are methods to clean up potentially contaminated areas using bacteria or microbes that naturally live in the soil or water. These microorganisms can break down benzene and other hazardous hydrocarbons into less harmful compounds. Such process, known as biodegradation, can be performed by respiring either aerobically or anaerobically. For respiration to occur, a compound capable of reduction, also known as a terminal acceptor, must be available to an organism. The most common and efficient respiration is aerobic, requiring oxygen as a terminal acceptor. The products of this are almost always carbon dioxide and water.

Unfortunately, most contamination sites are without oxygen, so most microbes must respire by less efficient anaerobic process. This is true for spills below the ground, where low oxygen levels are present. Products of anaerobic respiration are much harder to predict, as it can result in numerous intermediate and final products. There are a variety of compounds that can act as a terminal acceptor. From looking purely at the chemical reaction, the most stoichiometrically efficient electron acceptor is sulfate (SO_4^{2-}). When microbes decompose benzene using a sulfate reduction reaction, the major product is hydrogen sulfide, along with water and carbon dioxide.

This objective of this study was to examine the effectiveness of sulfate reduction for the biodegradation of benzene. This was carried out by constantly discharging contaminated water through soil columns. The latter were located in an anaerobic chamber in order to properly replicate in-situ soil and groundwater conditions. The benzene, sulfate, dissolved oxygen content, and levels of other nutrients were monitored. The completion of this study will present a lab-scale version of how to solve soil contamination problems in the environment.

Pollution Prevention for Small Businesses

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Jay Meegoda, Hsin-neng Hsieh and Dan Watts
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Abstract: The traditional approach to environmental protection has been to control pollution (e.g. hazardous waste, air emissions, wastewater discharges) in the various media after it is generated and to minimize its impacts on the environment through proper handling, treatment, and disposal. Experience has shown, however, that this end-of-pipe approach has had limited effectiveness in protecting the environment. In many instances, this approach has only served to transfer pollution from one medium to another, resulting in little or no net improvement in environmental quality. It is now apparent that the best way to protect the environment is not to generate pollution in the first place. This approach to environmental protection is called pollution prevention, and it is synonymous with source reduction. Pollution prevention consists of any activity that eliminates or proportionately reduces the use of toxic substances, or the generation of non-product output (NPO), hazardous waste, air emissions, wastewater, or the release of pollutants into the environment. Energy and resource savings are also considered as important components of source reduction as well.

In this research we targeted nine different types of industries, namely dry cleaning, printing, auto repair, auto painting, paint manufacturing industry, small chemical manufacturers, electro-plating and electroless plating. The main goals of the research are reduction of greenhouse gas emission, reduction or elimination of hazardous materials generation, reduction in water consumption and overall reduction in cost due to the pollution prevention designs and operational changes. The pollution prevention designs will include both short term designs or good housekeeping and long term designs involving the owner making manufacturing investments for process modifications. The long term plan will be developed after finishing analysis and research on a company's operations. The proposed process change for long term designs is expected to include computation of Return On Investment (ROI) and Life Cost Cycle Analysis (LCCA) to demonstrate to the owners the anticipated advantages from additional investments. For example: the dry cleaning industry typically uses the hazardous chemical, perchloroethylene (PERC) to clean cloth. A proposed long term solution for that would be to replace PERC machines with a wet washing machine, which uses water for cleaning the cloth. This will help improve quality of life of the dry cleaners while recovering their investments within a decade.

Boiling on Small Heaters under Earth and Low Gravity

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Miniaturization of electronic systems is challenged by a dramatic increase in the power dissipation per unit volume with the occurrence of localized hot spots where the heat flux is much higher than the average. Conventional methods of cooling by forced gas or liquid flow appear insufficient to remove high local heat fluxes. Boiling that involves evaporation of liquid in a hot spot and condensation of vapor in a cold region can remove a significantly larger amount of heat through the latent heat of vaporization than force-flow cooling can carry out. It is therefore considered as the most promising cooling technology for future microelectronic systems in terrestrial and space applications.

We will report on observations of intensive water boiling in which a stable bubble forms on a small heater, $L_h < L_c$, under earth gravity, g_0, and low gravity in flights aboard NASA Boeing 727, where L_h is the heater size and $L_c = \sqrt{\gamma / g (\rho_l - \rho_v)}$ is the capillary length with the liquid surface tension γ, liquid ρ_l and vapor ρ_v densities and gravity acceleration g. A flight provides two sets of some twenty consecutive parabolic paths, each with ~15s-period of ~$10^{-2} g_0$ preceded and followed by ~20s-periods of ~$1.8 g_0$. Regardless of the gravity level, a bubble remains anchored to heater edges up to about 230°C. The heat flux does not depend on the ambient water temperature and reaches 1.2 MW/m^2 that is the critical heat flux in boiling water at atmospheric pressure on a large heater under earth gravity. Application of high-voltage pulses to water via capacitive coupling to electrically insulated electrodes stabilizes flow around the bubble and increases heat transfer.
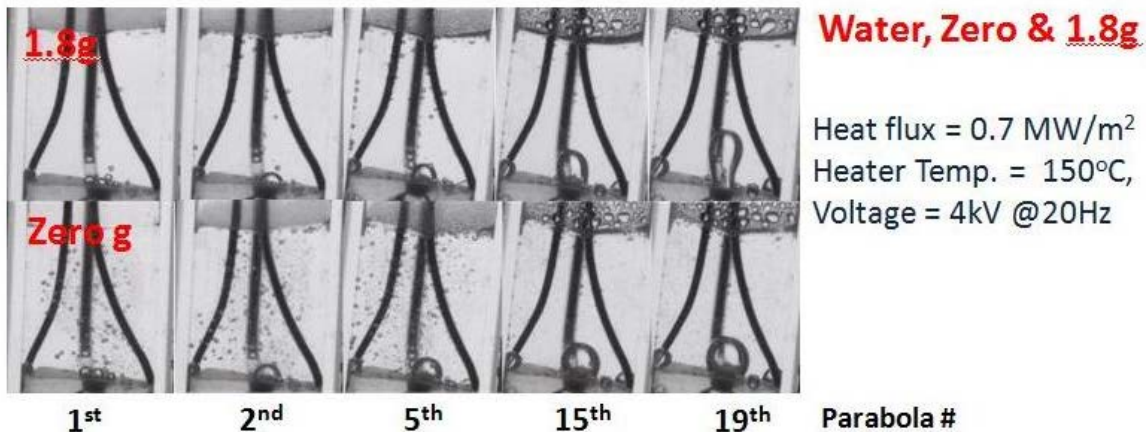
A large bubble rapidly formed over the heater. It did not detach during the acceleration portion of the parabola and remained on the heater for up to 19 consecutive parabolas.
In low gravity, the large bubble pinned to the heater sporadically emitted microbubbles, which were tracked to compute trajectories and velocities.

High School Summer Internship Program

Environmental Impact of Shale Gas Exploration, Can it be made Environmentally Acceptable?

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Abstract: Shale gas, which is mostly methane, is natural gas found deep (around 8,000 feet) underground. The largest deposit of shale gas in the US is called the Marcellus Shale field which covers parts of Ohio, Pennsylvania, West Virginia and New York. As of 2012, the US imported approximately 60% of its oil. As the United States produces more energy, especially with the extraction of shale gas, it becomes less dependent on other countries for energy. The shale gas trapped in the shale layer thousands of feet below the ground is extracted using a process termed Hydraulic fracturing or fracking. First, a well is drilled deep into the ground (around 8000 feet, depending on the depth of the shale) over a specified location. During this step, precautions are taken to prevent contamination of ground water. As the well nears its desired depth, the drill will start to move at a more horizontal trajectory until the drill is drilling the well parallel to the ground at the desired depth. This is a process called horizontal drilling. Horizontal drilling is a more efficient technique than vertical drilling (drilling straight down) for a number of reasons. First of all, the shale is usually a thin layer of ground, so horizontal drilling allows far more shale to be fracked than vertical drilling, even if the hole is the same depth.

Shale gas extraction, if done correctly, is an efficient, plentiful and relatively clean source of energy that can enable various countries including the United States to become less dependent on foreign imported energy (mainly oil) and can help to deter the energy crisis by acting as a "bridge" to clean energy. The purpose of this research is to investigate methods of decreasing the environmental harm to the surrounding and increasing the efficiency.

The primary environmental concern is methane contamination of water supplies around fracking areas. It is suspected that this contamination is due to the pipe casing leaking. Another environmental concern is the occurrence of earthquakes around fracking areas. The cause of these earthquakes is a mystery, but it has been noticed that they occur when the fracking fluid is injected. An economical concern is the loss of a large percentage of the fracking fluid which is comprised of water, proppants (solid material, usually sand, designed to keep the induced hydraulic fracture open) and some chemicals.

In this research we will investigate ways to solve or mitigate above environmental issues. We believe that with technological innovations most of the above issues can be resolved to make shale gas a major contributor to energy demand and also to improve the energy security of our nation.

An approach to determine the contact angles and the degree of hydrophobicity of multiple polymers via electrospinning

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Abstract: Electrospinning is a method in which nanofiber scaffolds are created using polymer solutions. The attraction between the positive charges and the grounded collection plate cause the polymer solution to be pushed out of the capillary. The interactions between the polymers within the solution create the nanofibers that collect on the grounded plate which form the scaffold. An important feature that the scaffold is tested for is if it is hydrophobic or hydrophilic and to what degree by measuring the contact angle. A contact angle is the angle that is formed at the point of contact between the water droplet and the surface and is tangent to the water droplet. When the contact angle is >90°, the scaffold is hydrophobic and when the contact angle is <90° the scaffold is hydrophilic. This process of electrospinning and finding the contact angle was performed on five different scaffolds. The polymers used were Polycaprolactone, Polyvinylidene fluoride, and two polymers from the Honeywell-company named polymer z and polymer y. Each polymer was dissolved with a specific solvent and spun in order to create five scaffolds. After spinning, all were tested to see how hydrophobic they were. Two of the five scaffolds' contact angles were compared to existing data which showed similar results to what was found. In addition to the five scaffolds, a Teflon film was analyzed to determine its contact angle and to see how the contact angle of the film differed from existing data on the contact angle of electrospun Teflon. In order to find the contact angle of the five scaffolds and the Teflon film, a 0.05ml water droplet was used in addition to the ImageJ software.

Contact Angle on Teflon Film

Contact Angle on Polyvinylidene
fluoride scaffold

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