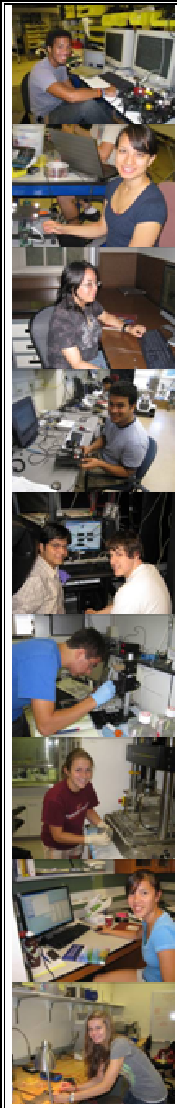


SUNFEST

Symposium

Thursday, August 6, 2009

10:00 A.M.

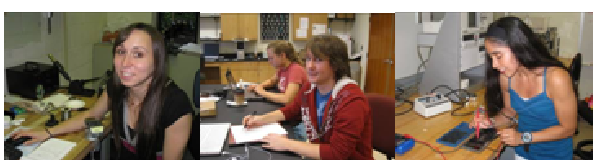
Wu and Chen Aud., Levine

Program

A NSF-REU program

University of Pennsylvania

Center for Sensor Technologies



Penn Engineering

SUNFEST Symposium

August 6, 2009

Schedule

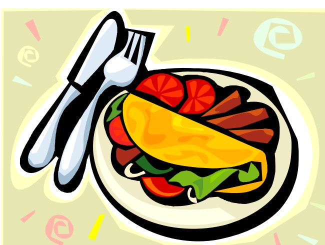
Welcoming remarks,	Jan Van der Spiegel
10am: Hank Bing	*Analog Circuit Design Using Unipolar and Ambipolar Organic Pentacene Transistors and Patterning Methods on Parylene-Coated Transistors* (Prof. Cherie Kagan, Sangam Saudhuri)
10:15: Allison Connolly	*An Electrophysiological Heart Model for Formal and Functional Medical Device Verification* (Prof. Rahul Mangharam)
10:30 Willie Gonzalez	*Stability Control System for the Bioloid Humanoid Robot* (Prof. Dan Lee)
10:45 Andrew Townley	*Vibrational energy harvesting with MEMS piezoelectric generators* (Prof. Gianluca Piazza)
11:00 Valerie Walters,	*Design of a System to Study Human Disc Strains in Torsion and Compression Measured Noninvasively* (Prof. Dawn Elliott, Jonathan Yoder)

11:15 Jeffrey Perreira , *Micromechanical Imaging Analysis of Bulk vs. Local Properties Concerning Mesenchymal Stem Cell Heterogeneity* (Prof. Robert Mauck, Megan Farrell)

11:30 Sarah Koehler, *Automated Gait Optimization for a Centipede-Inspired Modular Robot* (Prof. Mark Yim and Dan Koditschek)

11:45 Phillip Dupree *Autonomization of a Mobile Hexapedal Robot Using a Global Positioning System Module* (Prof. D. Koditschek and Galen Clark Haynes)

12:00: **Lunch**
Levine Hall



1:00 Desiree Velazquez *MIMOSA: Mine Interior Model of Smoke and Action* (Prof. Norm Badler and Jinsheng Kang)

1:15 Katherine Gerasimowicz, *Pediatric Physical Activity Dynamometer* (Prof. Jay Zemel)

1:30 Linda Mclaughlin, *Modular Photovoltaic-Millifluidic Algal Bioreactor System* (Prof. Jay Zemel, J. Santiago, D. Graves)

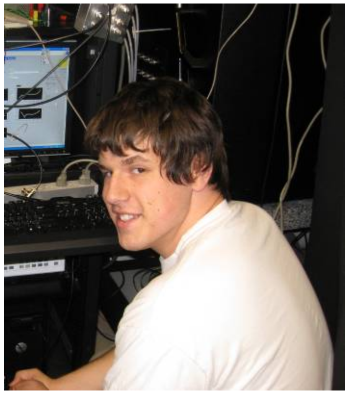
1:45 Narkeviciute Ieva *Analysis of light and dark cycles on chlorella growth* (Prof. Jay Zemel, J. Santiago, D. Graves, M. Mauk))

Concluding remarks

2:00 Wrap up meeting with Valerie Lundy-Wagner

Abstracts

SunFest 2009



Amplification circuits and patterning methods of organic field-effect transistors

Hank Bink (Electrical and Computer Engineering) – Lafayette College
Advisor: Cherie Kagan

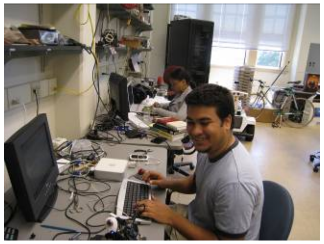
Organic transistor technology holds great promise for creating a conformal, human-safe electronic neural interface. These interfaces must amplify the low voltage brain signals and perform well in the aqueous brain environment. Silicon wafer-based organic transistors were used with a pentacene semiconductor in amplifying configurations including common source. Ambipolar transistors were also utilized for certain circuit topologies. Gains for common source amplifiers with resistors were up to 3.5V/V. Parylene C was used to encapsulate pentacene transistors and serve as a dielectric layer between the device and a sensing electrode. Using Oxygen and SF_6 plasma etching, etching was performed for access between the sensor and gate of the transistor. The process consisted of etching through parylene as well as different dielectric layer materials and checking the etch rate and depth. Parylene was etched at a rate of 0.2µm/min with O_2 plasma.

An Electrophysiological Heart Model for Formal and Functional Medical Device Verification

Allison Connolly (Biomedical Engineering) Johns Hopkins University

Advisor: Rahul Mangharam

Currently, there is no formal method for the development and testing of medical device software, such as that used in pacemakers and implantable cardioverter-defibrillators (ICD). A large majority of device recalls are due to failures in the software that went undiscovered during product testing. For example, safety recalls of pacemakers and implantable cardioverter defibrillators due to firmware (i.e. software) problems between 1990 and 2000 affected over 200,000 devices, comprising 41% of the devices recalled. In order to preempt these failures, the device companies and the regulatory agencies, such as the FDA, need a better way to formally and functionally verify these devices before bringing them to the market. The heart model outlined in this paper is a tool used to simulate, test and validate these devices across multiple modalities in a plug-and-play manner. By synthesizing a large number and variety of intra-cardiac electrogram and derived external electrocardiogram signals, the model will create a database well beyond the scope of the MIT-BIH ECG database, the current standard for most cardiac medical device algorithm testing. This heart model allows for more extensive formal and functional testing of pre-market cardiac medical devices to detect flaws before the devices are implanted in patients.



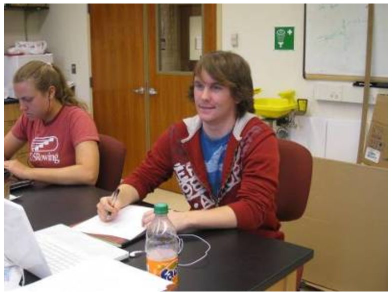
Stability Control System for the Bioloid Humanoid Robot

Willie W Gonzalez (EE) – University of Puerto Rico Mayagüez campus

Advisor: Dr. Daniel D. Lee

A key characteristic in any autonomous system is stability. Without stability robots could not work properly. To achieve stability first the robot needs the means to know its position with respect with its original so that a correction in position can be obtained if necessary. This is true for the type of INS (inertial navigation system) known as dead reckoning. In this INS the current position of the robot or system is calculated from measurements of the acceleration and knowledge of its original position.

Some IMUs (inertial navigational units) consist of a couple of accelerometers and gyroscopes. With this IMU acceleration can be obtained. On Strap-down navigational system, this IMU are directly attach to the system so that their measurements correlates with those of the system, so that they can be used to calculate the position of the system. Throughout this document a method on how to obtain the necessary measurements from the IMU and how to apply them, will be discuses.



Vibrational Energy Harvesting using MEMS Piezoelectric Generators

Andrew Townley – Electrical Engineering, University of Pennsylvania
Advisor: Gianluca Piazza

ABSTRACT

In recent years, energy harvesting using piezoelectric materials has become a popular research topic. Various device sizes and structures have been tested, but it is difficult to compare power measurements as device fabrication and experimental methods vary from paper to paper. In an effort to standardize these various parameters, the dependence of generator power output on device dimensions has been investigated.

Though MEMS scale devices have been produced, comparatively little work has been done using aluminum nitride (AlN). This project utilizes AlN due to its ease in processing and potential for on-chip integration. By operating at a MEMS scale, the benefit is that arrays of piezo generators can be placed on the same die. With the process advantages of AlN, a long term goal of an integrated power-harvesting chip becomes feasible.

However, theoretical results of scaling predict that raw power output and even power per unit volume will decrease with scaling. This indicates that a single large generator, taking up the same area as several small generators, would produce a noticeably larger power output.

Due to time constraints, no new generators could be fabricated within the time span of the project. An existing piezoelectric cantilever was used to verify the theoretical predictions of resonant frequency and static deflections under applied voltage. These predictions agreed quite closely with the observed results. However, no measurable electrical response could be found while exciting the beam with an electromagnetic shaker device. A similar experiment was performed using an AFM to directly excite the beam, but again the electrical response was difficult to characterize.

While the results of the experiments were not optimal, the difficulty in measuring the electrical response of the beam demonstrates the design challenges involved with energy harvesting on a small scale. Piezoelectric generators rely on resonance to generate useful quantities at power, and power output is highly sensitive to the frequency of the physical vibrations applied. While generators of this type could be useful if targeted to a specific application if the frequency of environmental vibrations is known, a more versatile approach would use a different design to reduce the frequency sensitivity. Broad-band designs, using either non-resonant or self-tuning structures, would be able to harvest energy much more efficiently in changing environments.

Design of a System to Study Human Disc Strains in Torsion and Compression Measured Noninvasively

Valerie Walters (Engineering Science and Mechanics) – Virginia Polytechnic and State Univ.
Advisors: Dawn M. Elliot and Jonathon Yoder

Many people suffer from lower back pain, which can be caused by disc degeneration. We are studying the properties of non-degenerated and degenerated human lumbar intervertebral discs. The objective of this study is to quantify strains in the disc when it is under torsional and compressive loading. This will be done by using a magnetic resonance images and texture correlation. A custom built device is being designed that will load the specimen as previously described and be compatible with the magnetic resonance imaging (MRI) machine. The plan is to incrementally load the specimen and measure the applied torque during the entire test. We expect displacement results to agree with previous studies that have been done. The strain results that we expect to obtain do not have a previous test to compare to; this is the first study that will quantify internal disc strains when the disc is in torsion. We expect the results to provide useful information about the properties of the disc. This information could also be used when studying disc failure.

Micromechanical Imaging Analysis of Bulk vs. Local Properties Concerning Mesenchymal Stem Cell Heterogeneity

Jeffrey Perreira (Mechanical Engineering) - Lehigh University
Advisor: Dr. Robert Mauck
Graduate Student: Megan Farrell

Mesenchymal stem cells (MSCs) harvested from bone marrow posses differing likelihoods of cell differentiation along with portraying a variety of phenotypes. This paper used micromechanical analysis with florescent microscopy on MSCs and cartilage to study the strength and development of the cells' extra cellular matrix (ECM). The hypothesis was that comparing the local mechanical properties to the bulk properties of MSCs and chondrocytes will explain why the MSCs are weaker. The study also uses confocal microscopy to asses cell deformation as a function of matrix production over time. The cell deformations were analyzed via a customized MATLAB program to act as a standardized analysis method. Analysis, when complete is expected to prove that the varying likelihoods of MSC differentiation can be analyzed via the micromechanical properties of the cells and give insight into the deformation chondrocytes and MSCs experience with mechanical stimulation.

Automated Gait Optimization for a Centipede-Inspired Modular Robot

Sarah Koehler (Engineering Science) – Cornell University
Advisors: Dr. Mark Yim and Dr. Daniel E. Koditschek

Manually tuning a robot's gait so that it can walk quickly and efficiently is a time-consuming and tedious task. For this project, CKBot (a modular robot system) has been configured into a centipede-inspired configuration with six legs. The project started with a few manually tuned gaits which follow an alternating tripod pattern. The purpose of this project is to automate tuning of the robot's gait such that it optimizes a factor such as specific resistance, speed, or power. Most of the effort in this project has gone into setting up the framework for such optimization trials. Each optimization trial runs the centipede back and forth and adjusts the six parameters that change the robot's gait by using the Nelder Mead optimization method. The end result after optimization is a gait with minimal specific resistance, maximum speed, or some other optimal factor.

Autonomization of a Mobile Hexapedal Robot Using a Global Positioning System Module.

Phillip Dupree (Mechanical Eng,) – Columbia University
Advisors: Daniel E. Koditschek, Galen Clark Haynes

An important step in the autonomization of robots specifically designed for mobility is autonomous navigation: the ability to navigate from a current position to a programmed point, without the manual control of a human user. The object of this summer research was the autonomization of the robot RHex, a highly mobile hexapodal robot built in the GRASP lab of the University of Pennsylvania, which was accomplished by the integration of a global positioning system (GPS) module into the robot. The GPS module gave the robot the ability to follow a “breadcrumb” path of GPS way-points. Once the GPS data was parsed, the coordinates of both the robot’s location and the path of waypoints were converted into flat-earth approximate Cartesian coordinates, and then inputted into a linear control system. Once this was accomplished, the robot had the ability to “know” its current position and navigate from it to any programmed point, providing there were no obstacles in its path.

MIMOSA: Mine Interior Model Of Smoke and Action

Desirée E. Velázquez Rios, Univ. Puerto Rico
Norman I. Badler, Jinsheng Kang

The team goal for the summer is the simulation of underground coal mine fires and the study of the physiological reactions occurring during evacuations. I undertook the task of searching for new ways to modify the map creation tools used by the original *Crowds with Aleatoric, Reactive, Opportunistic, and Scheduled Action* (CAROSA) framework. I also modeled the mining equipment used to simulate a more realistic coal mine situation. First, a literature search on the web was done for software called Level Editors and Game Engines. Then, modeling the mining equipment, rigging the miner mesh model with a skeleton and animating both equipment and miner was done. These tasks used two pieces of Alias software; Maya and Motion Builder. Additionally, Maya was used to create the cell-portal mine map. Once the models and animations were created, they would be used for the simulation. With the simulation results we can validate a study made by U.S. Department of Health and compare the physiological models visualized in the simulation with the results of the study.

Pediatric Physical Activity Dynamometer

Katherine Gerasimowicz (Bioengineering) – University of Pennsylvania
Advisor: Dr. Jay N. Zemel

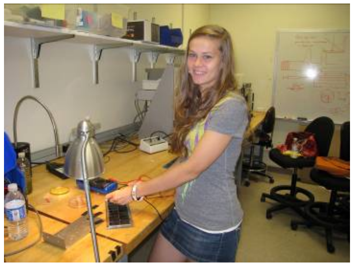
Developing strong bones early in life reduces the risk of osteoporosis in the future. Osteogenic effects have been reported in various types of physical activity in children. However, current tools used in bone development research are unable to conveniently and accurately measure the loads experienced in long bones throughout a child's regular daily physical activity. We have devised an inconspicuous system that can be embedded in a child's shoe to monitor and store force measurements during the course of a child's normal wakened activity. This in-shoe physical activity dynamometer, Foot-PAD, has been in development since the summer of 2004. The last model prior to the current research consisted of a circuit which amplified and converted electrical signals from polyvinylidene fluoride (PVDF) piezoelectric film sensors into digital force measurements. It was later discovered that, due to its characteristics, PVDF could only measure horizontal forces along the surface of the foot rather than forces directly transmitted to the foot. A new piezoelectret sensor material is available with similar charge displacement properties but with the ability to measure vertical forces. The primary accomplishment of this development phase, therefore, was the incorporation of piezoelectret sensors capable of measuring vertical forces into the system and appropriate modification of the circuit design. The fully-functional system was inserted into the heel and tested for comfort, stability, and accuracy. A comparison of its force measurements with force plate measurements confirmed that the Foot-PAD device can successfully capture forces transmitted to the load-bearing bones.

Modular Photovoltaic-Millifluidic Algal Bioreactor System

Linda McLaughlin
Community College of Philadelphia
Advisor: Prof. Jay Zemel

Abstract

Photovoltaic cells and biofuel technologies are two completely different sciences that have never been fused together. This project approaches a design using these two technologies in order to develop a prototype to convert the sun's radiation to useful power. A few models of small flat photobioreactors have been approached, constructed, and explored using the physical principle of laminar fluidity for simplicity. We propose to use *Chlorella* algae, due to its favorable properties. *Chlorella* requires carbon dioxide, water, sun light, and small amounts of minerals to reproduce. Its photosynthetic efficiency can reach 8%. Under unfavorable environmental conditions, *Chlorella* can accumulate up to 80% of fatty acids, 80% hydrocarbons, and 40% of glycerol [1]. Light shielding (dark regions) are being supplied by separated solar cells placed periodically over the PBR. The design allows variation in the spacing of the solar cell array. A solar cell over the PBR will serve as a density sensor to monitor the algae growth. Data from this sensor will provide information on algae growth as a function of the spacing geometries. The results attempt to demonstrate the feasibility of our system, regarding optimal efficiency. Specific goals are to find out how sun's radiation affects the algal growth, how photoinhibition effects can be avoided, to achieve maximum algal productivity.



Analysis of light and dark cycles on chlorella growth

Ieva Narkeviciute, Chemical Engineering, University of Massachusetts Amherst
Advisors: Jay Zemel, Jorge Santiago, David Graves, Michael Mauk

Photovoltaic cells and biodiesel produced from algae have never been combined in a cooperative system despite the fact that they both use the sun as a source of energy. The purpose of this study is to design a photobioreactor that utilizes solar cells to provide dark and light periods for algal photosynthesis that would increase their growth, if in fact these dark periods increase growth. Methods used for this study include using different spacings between solar cells placed on top of the bioreactor to achieve maximal algae growth. These measurements are done with Reynolds number analysis. A control was set up that did not have any photovoltaic cells to provide dark periods. The system without dark and light periods had a longer doubling time than the one with the dark and light periods, effectively proving that the cycles increase growth

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