2011 Rensselaer CATS Technology Showcase and Conference

Program

April 27, 2011

The Center for Automation Technologies and Systems (CATS)
Rensselaer Polytechnic Institute
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2011 Rensselaer CATS Technology Showcase and Conference

- Agenda -

**Buffet Breakfast** – 8:00-9:00am (Ferris Ballroom B – 1st Floor)

**Welcome!!** – 9:00-9:15am (Ferris Ballroom B – 1st Floor)
  John Wen – Director, Center for Automation Technologies and Systems, RPI

**Technical Sessions I** – 9:15-10:30am (Sage Ballrooms I/II – 2nd Floor)

I-a. **Clean Tech Energy** (Sage Ballroom II – 2nd Floor)
  - Steve Rock* – Research Scientist, Center for Automation Technologies and Systems, RPI
  - Steve Harshbarger – VP, Director Electronics & Advanced Energy Division, Sono-Tek Corporation
  - Dan Lewis – Assistant Professor, Materials Science and Engineering, RPI
  - Ruth Cox – President and Executive Director of the Fuel Cell and Hydrogen Energy Association
  - Brent Solina – President and VP Technology, MICROrganic Technologies Inc.

I-b. **Thermal Management** (Sage Ballroom I – 2nd Floor)
  - Yoav Peles* – Associate Professor, Mechanical, Aerospace and Nuclear Engineering, RPI
  - Theodorian Borca-Tasciuc* – Associate Professor, Mechanical, Aerospace and Nuclear Engineering, RPI
  - Madhusudan Iyengar – Senior Engineer, Advanced Thermal Laboratory, IBM Systems & Technology Group
  - Peter de Bock – Electronics Cooling Researcher, Aero-Thermal & Mechanical Systems, GE Global Research
  - Peter Bronecke – Program Manager, Lockheed Martin Radar Systems Advanced Programs

**Break** – 10:30-10:45am

**Technical Sessions II** – 10:45am-12:00pm (Sage Ballrooms I/II – 2nd Floor)

II-a. **Advanced Composites** (Sage Ballroom II – 2nd Floor)
  - Daniel Walczyk* – Associate Director od Manufacturing, Center for Automation Technologies and Systems, RPI
II-b. **Production Scheduling and Optimization** (Sage Ballroom I – 2nd Floor)
- Jennifer Ryan* – Associate Professor, Industrial and Systems Engineering, RPI
- Detlef Pabst – Sr. Industrial Engineer, Manufacturing Technology Group, GlobalFoundries
- Wai Kin (Victor) Chan – Assistant Professor, Industrial and Systems Engineering, RPI
- Steve Derby – President, Distributed Robotics LLC

**Buffet Lunch** – 12:00-1:00pm (Ferris Ballroom B – 1st Floor)

*Research at Rensselaer*
- Fran Berman – Vice President for Research, RPI

**Panel Discussion** – 1:00-2:00pm (Ferris Ballroom A – 1st Floor)

*Effectively Leveraging University/Industry Collaborations*
- Craig Dory* – Associate Director, Center for Automation Technologies and Systems, RPI
- Hon. Dennis Gabryszak – Chair, Task Force on University-Industry Cooperation, New York State Assembly
- Richard Frederick – Director, Emerging Ventures Ecosystem, RPI
- David Gross – Director, Manufacturing Systems Technology, GlobalFoundries
- Janet Joseph – Vice President, Technology and Strategic Planning, NYSERDA
- Jeff Lawrence – Executive VP, Technology, Center for Economic Growth
- Edward Reinfurt – Executive Director, NYSTAR

**Break** – 2:00-2:15pm

**Business Sessions II** – 2:15-3:30pm (Sage Ballrooms I/II – 2nd Floor)

III-a. **CATS Success Stories** (Sage Ballroom I – 2nd Floor)
- Ray Puffer* – Program Director, Industrial Automation, CATS, RPI
- Ray Dromms – Director of Manufacturing Engineering, Welch Allyn
- Ryan O'Donnell – CEO and Co-Founder, BullEx, Inc.
- Bruce Phipps – President, MPI Incorporated
- Anthony Hynes – President and CEO, Precision Valve & Automation, Inc.
- Chris O’Connor – Operations Program Manager, Ducommun Aerostructure
III-b. **Panel Discussion** (Sage Ballroom II – 2nd Floor)

*Business Startup and Expansion Funding*

- **Craig Dory** – Associate Director, Center for Automation Technologies and Systems, RPI
- **Suzanne Pollard** – Economic Development Specialist II, Empire State Development
- **Tom Reynolds** – Vice President, New York Business Development Center
- **Kate Baker** – Business Advisor, Small Business Development Center
- **Madi Kalibala** – Senior Project Engineer, Space Alliance Technology Outreach Program
- **Marcene Sonneborn** – SBIR Specialist, Central New York Technology Development Organization

**RPI Faculty Showcase** – 3:30-4:30pm (Ferris Ballroom A – 1st Floor)

- **John Wen** – Director, Center for Automation Technologies and Systems, RPI
- **Johnson Samuel** – Assistant Professor, Mechanical, Aerospace & Nuclear Engineering, RPI
- **Sandipan Mishra** – Assistant Professor, Mechanical, Aerospace & Nuclear Engineering, RPI
- **David Corr** – Assistant Professor, Biomedical Engineering, RPI
- **Pankaj Karande** – Assistant Professor, Chemical and Biological Engineering, RPI
- **Agung Julius** – Assistant Professor, Electrical, Computer, and Systems Engineering, RPI

**Poster Session and Exhibits** – 4:30-6:30pm (Ballroom Foyer and Ferris Ballroom A – 1st Floor)

...more than 60 posters and exhibits showcasing industrially driven research projects, CATS partner companies and affiliates...

**Plated Dinner** – 7:00-9:00pm (Ferris Ballroom B – 1st Floor)

*Congressman Paul D. Tonko – Innovative Manufacturing: The Key to America’s Competitiveness*

*Denotes Session Chair*
Congressman Paul D. Tonko

Biography

Congressman Paul D. Tonko is serving his second term in Congress representing the 21st District of New York, which includes the state’s capital city, Albany. Paul comes to Washington, DC with over two decades of administrative, legislative and policy experience having served in the New York State Assembly from 1983 to 2007, and as President and CEO of the New York State Energy Research and Development Authority (NYSERDA) from 2007-2008.

Congressman Tonko is a nationally recognized expert on energy issues. An engineer by training, Paul served as chairman of the New York State Assembly Standing Committee on Energy prior to leaving the Assembly to join NYSERDA. As Chairman, Paul fought to protect consumers, fought against utility deregulation and worked to upgrade our aging energy infrastructure. While at NYSERDA, Paul worked to advance an aggressive green agenda for businesses and residents throughout New York State.

In Congress, he is a member of the Budget Committee - where he works to promote investments that create jobs and grow the economy, protect investments in the middle class and help bring down the deficit.

Congressman Tonko is also a member of the Committee on Science, Space and Technology, which merges his energy expertise with his environmental agenda. Serving on subcommittees for Energy and Environment as well as Research and Science Education, Paul hopes to spur an environment where innovation and cutting-edge research and design spur economic development in the 21st Congressional District.

Building on his work in the New York State Assembly, where he fought for one of the nation's strongest mental health parity laws (known as "Timothy's Law"), Paul has always promoted fair and equitable health care policies that strengthen our communities and protect our most vulnerable citizens.

An advocate for a “green economy” and “green-collar jobs”, Congressman Tonko has promoted wind development in Upstate New York and successfully lobbied GE to locate their growing GE Wind
operations in Schenectady, NY. In the New York State Assembly, Paul was a lead sponsor of the Power for Jobs program, which provides low cost power to employers throughout New York State and has retained or created 300,000 jobs statewide. In 2006, Paul successfully negotiated for Beech-Nut to keep their plant in Montgomery County, and expand their operation by relocating their corporate headquarters. The new Beech-Nut headquarters is a green building and retained 356 jobs while creating 135 new positions.

Congressman Tonko also has strong ties to local government, which he sees as a crucial partner in delivering programs and services to constituents. At age 26, Paul was the youngest person in the history of Montgomery County to be elected to the county’s Board of Supervisors. He served as chairman of that body until 1981. Prior to his election to the Assembly in 1983, Paul was an engineer in the New York State Department of Transportation and also served on the staff of the Department of Public Service. Paul has been a longtime member of the Public Employees Federation (PEF) and proudly serves as the first PEF member elected to Congress.

Paul graduated from Clarkson University with a degree in mechanical and industrial engineering. He is a lifelong resident of the city of Amsterdam, New York.
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The Current State of the Fuel Cell and Hydrogen Industry: the View from Washington  
Microbial Fuel Cells

Session I-b. *Thermal Management*  
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Challenges and Opportunities in Servers and Data Center Cooling and Energy Efficiency  
Thermal Management Challenges in RF Sensors  
Thermal Management for Electronics at GE Global Research

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Composite Design for Underwater Structures  
Bio-composites Based on a Mycelium Matrix  
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From the Director

To be competitive in the global stage, companies need to push the boundary of performance and capabilities. The Center for Automation Technologies and Systems (CATS) at Rensselaer Polytechnic Institute, with over thirty affiliated faculty across multiple departments and eight staff members, provides its industrial partners with a broad range of integrated research expertise, from modeling and simulation to optimization and control, to achieve the competitive advantage. We also pride ourselves as a key portal into Rensselaer for industry that seeks partnership in problem solving, product development, process improvement, joint proposals, and training. The CATS connects companies’ needs with right faculty and staff, facilitates contract negotiation, and provides linkage to other companies and partners for teaming opportunities.

In program year 2010, in addition to numerous continuing projects, we have started several new initiatives. CATS faculty Jennifer Ryan is leading an incipient collaboration with GlobalFoundries in the area of scheduling and optimization. The CATS, jointly with our sister center, Center for Future Energy Systems (CFES), is working with Ultralife Corp. on developing advanced energy storage systems with the support of The New York State Energy Research and Development Authority (NYSERDA). The CATS has partnered with several small companies, including Ceralink, InfoSciTex, InterScience, and Barron Associates, on winning multiple SBIR and STTR awards. The CATS has also forged multi-organization teams to pursue larger DOD and DOE funding. Within Rensselaer, the CATS is teaming with the newly founded Emerging Venture Ecosystem (EVE) program and the Severino Center for Technology Entrepreneurship to provide technical assistance and mentorship to student start-up companies. As part of our continuing outreach activities, the CATS conducted another successful annual technology showcase on May 10, 2010, with 38 participating companies and over 180 in attendance. Leveraging the New York State’s annual investment of nearly $1M, the CATS has been delivering results for companies across the entire state for over two decades. In program year 2010, the CATS’ economic impact totaled $52M in revenue and 35 new and retained jobs.

Our fuel cell manufacturing program, under the leadership of CATS Program Director for Industrial Automation, Ray Puffer, in partnership with BASF Fuel Cell, PMD, and Sono-Tek, and with additional research funding from NSF, DOE, and NYSERDA, continues to be recognized as the leading research program in this field. The CATS is the only university research organization invited to the Navy-sponsored Fuel Cell Manufacturing Manhattan Project together with leading industrial players to formulate the fuel cell manufacturing roadmap to meet the Navy’s needs. Alas, with the program in outstanding shape, Ray has decided that it is time to pass the baton. Ray will retire this June after serving 24 years as the anchor of our industrial automation and manufacturing program. His dedication and leadership is exemplary to us all. We will have a celebration of Ray’s accomplishment in the afternoon of May 24 – mark your calendar for this event! We welcome the newly named CATS Associate Director of Manufacturing, Daniel Walczyk, faculty in Mechanical, Aerospace, and Nuclear Engineering (MANE), and CATS Research Scientist, Steve Rock, will together assume the leadership role in CATS industrial automation and manufacturing research programs.
We also welcome new faculty addition to Rensselaer and the CATS: Sandipan Mishra, Johnson Samuel, and Riccardo Bevilaqua, all in MANE. They significantly enhance CATS capability in mechatronics, control, micro- and nano-scale engineering, and manufacturing. Congratulations also to the CATS affiliated faculty David Corr, Jeff Ban, and Dan Lewis for winning NSF CAREER Awards.

I would like to thank the NYSTAR for its guidance and support, our outstanding and dedicated faculty, staff, and students for their enthusiasm and contribution, and our industrial, educational, and outreach partners for their collaboration. We look forward to continuing this wonderful journey together!

Sincerely,

John T. Wen

Director, Center for Automation Technologies and Systems (CATS)
Professor, Department of Electrical, Computer, and Systems Engineering (ECSE), and
Department of Mechanical, Aerospace, and Nuclear Engineering (MANE)

Rensselaer Polytechnic Institute, Troy, NY
Session I-a. *Clean Tech Energy*

**Ultrasonic Coating Technology for Thin Film Solar Manufacturing, an Economical Alternative to CVD / Sputtering**

Steve Harshbarger  
*VP, Director Electronics & Advanced Energy Division, Sono-Tek Corporation*

As the thin film solar manufacturing industry grows, manufacturers are finding that manufacturing cost reductions are necessary to obtain and maintain profitability.

A huge portion of capital equipment costs in the thin film solar industry involves expensive coating machines such as CVD / Sputtering units for the deposition of active layer and buffer layer coatings. Ultrasonic wet process has proven to be a cost effective alternative to CVD / Sputtering processes for the deposition of these thin film solar chemistries. Ultrasonic wet process offers drastic reduction in capital equipment costs for R&D, pilot line and high volume production machines with greater effective chemistry usage compared to conventional CVD and sputtering machines (>95%). Performance efficiencies of the ultrasonic wet coating process have recently been improved, and are rapidly approaching to near equal of CVD / Sputtering technology in both R&D and Pilot line production, providing a possible fast track solution for thin film manufacturers in the goal to reach grid parity with their products.

Ultrasonic coating systems have been proven successful for the past 30 years in high volume manufacturing operations. The technology is well established and widely used for silicon solar manufacturing applications such as phosphoric doping, fluxing of solder bus lines and texturing of wafers. Ultrasonic technology is also used extensively in research areas for organic solar, DSC solar and TCO coatings.

**Characterization of Vaporization Rates on SOFC Interconnect Alloys**

Micah Casteel, Dan Lewis  
*Rensselaer Polytechnic Institute*

Dan Lewis  
*Assistant Professor, Materials Science and Engineering, RPI*

Ferritic stainless steels are an attractive option for interconnect applications in solid oxide fuel cells due to their low coefficient of thermal expansion (CTE) and low cost. However, a key problem with ferritic stainless steels in these applications and other high chromium materials is the vaporization of chromium species. This vaporized chromium poisons the cathode, which can impact cell performance significantly. In order to understand this problem we have incorporated a solution based ionic
conductivity method into the more traditional transpiration measurement method. Using this novel method we have determined the vaporization rates of Crofer 22 APU, E-brite, ZMG-232, Haynes 230, and 441 SS. Further work has been performed to investigate the effects of water vapor partial pressure on vaporization rate. It is hoped that this data will be useful for alloy and coating characterization and valuable in determining the utility of the ionic conductivity method.

**The Current State of the Fuel Cell and Hydrogen Industry: the View from Washington**

**Ruth Cox**  
*President and Executive Director, Fuel Cell and Hydrogen Energy Association*

Ruth Cox, President and Executive Director of the Fuel Cell and Hydrogen Energy Association will discuss the current state of the fuel cell and hydrogen industry: the view from Washington; how the industry is progressing nationally; what markets are here now and which are right around the corner; and what is in store for the future. Ruth will address the various policy issues at the Federal and State levels and what the FCHEA is currently doing to promote it.

**Microbial Fuel Cells**

**Brent Solina**  
*President and VP Technology, MICROrganic Technologies Inc.*

Microbial fuel cells share a number of similar operating principles with all types of fuel cells. They are unique, however, in performance characteristics and operational constraints. This talk will present an overview of microbial fuel cell strengths and limitations, and discuss potential applications.
Session I-b. **Thermal Management**

**Thermal Management From Device to System Level: An Overview of Research Activities**

**Yoav Peles, Theodorian Borca-Tasciuc**
Center for Automation Technologies and Systems

**Yoav Peles**
*Associate Professor, Mechanical, Aerospace and Nuclear Engineering, RPI*

High, steady and transient, multiple and distributed heat loads permeate a wide range of applications from chip-scale to systems such as radars, ships, and data servers. Thermal management solutions, which increase heat transfer rates and efficiency and decrease weight and volume, are in high demand. At Rensselaer Polytechnic Institute teams of faculty and researchers are exploring new ideas to maintain chip, device, and system temperatures below operating limits and to manage heat dissipation in distributed, large-scale and high heat flux electronic systems using microfabrication, nanotechnology, and modern systems design and control. The talk will give an overview of the CATS research and expertise in the thermal management field including solid state heat spreaders and impinging micro-jets for hot spot cooling, nanostructured thermal interface materials, high efficiency heat sinks, and system level thermal modeling and control.

**Challenges and Opportunities in Servers and Data Center Cooling and Energy Efficiency**

**Madhusudan Iyengar**
*Senior Engineer, Advanced Thermal Laboratory, IBM Systems & Technology Group*

Information Technology (IT) data centers consume a large amount of electricity in the US and world-wide. Cooling has been found to contribute about one third of this energy use. Thus, understanding and improving the thermal management and energy efficiency of data center systems is of growing importance from a societal cost and sustainability perspective. In addition to their energy consumption related challenges, the heat flux of electronic devices and the volumetric heat density of servers and the racks that house them are also rapidly increasing for many applications. Thus, research and productized technologies that enhance energy efficiency and cooling performance over several length scales of electronic devices and systems will be critical to the future success of the IT industry. This seminar will comprise of an introduction to servers and IT data centers, a discussion of relevant energy and cooling trends, a highlight of some recent product innovations in this area, and a summary describing areas for future research and development.
Thermal Management Challenges in RF Sensors

Peter Bronecke
*Program Manager, Lockheed Martin Radar Systems Advanced Programs*

Continual improvements in the performance and cost of solid state Radio Frequency (RF) power amplifiers are enabling their expanded application into Active Electronically Scanned Array (AESA) based antennas for radar, electronic warfare and communications. These applications place constraints on the amplifiers driven by its environment, desired power levels, efficiencies and reliability. Thermal management of the amplifiers is one of a number of parameters that must be controlled for reliable, high performance operation. This presentation will discuss the thermal management constraints imposed by a number of RF sensor systems in their operating environments. Thermal management techniques and their limitations for a given applications will be presented. Areas for research and development to improve a system’s thermal management performance will be identified.

Thermal Management for Electronics at GE Global Research

Peter de Bock
*Electronics Cooling Researcher, Aero-Thermal & Mechanical Systems, GE Global Research*

Abstract: Thermal Management is an crucial field of science for the advancement of wide range of electronics and industrial applications. Recent trends demanding higher capability from our electronics products in smaller packages lead to higher and higher levels of heat dissipation. Similarly trends in electrification of large systems is leading to a rapid increase in the power density of electronics we use on platforms such as aircraft. The thermal management group at GE Global Research works actively to address these challenges by providing innovative thermal management solutions for the wide range of products offered by GE. Highlights of some of these technology innovations include work on advanced heat pipes for DARPA and development of Synthetic jets for convection enhancement. Collaboration between Industry, Academia and Government is seen as the success formula for future technology development programs.
Session II-a. **Advanced Composites**

Overview of the NorthEast Composites Manufacturing Forum, and Composites Research at CATS

Daniel Walczyk  
*Associate Director of Manufacturing, Center for Automation Technologies and Systems, RPI*

There will be two parts to this presentation: a description of the NorthEast Composites Manufacturing Forum and related upcoming events, and an overview of composites research at the CATS.

NECMF is an academia-led industry organization focused on providing: higher visibility for the Northeast U.S. composites industry; tailored technical training (e.g., continuing education courses, college courses); networking opportunities; a conduit between new engineering students, trained technicians, and companies looking to hire; and opportunities to pursue R&D funding.

Rensselaer has a rich history in composites research including a well-regarded research center in the late 1980’s and early 1990’s, and more recently, well-recognized efforts in manufacturing processes and nanocomposites. Dr. Walczyk will discuss the most recent work in new manufacturing process development with Avanti Composites, a Division of Kintz Plastics, Inc. including rapid double diaphragm forming and thermal press curing. He will conclude with an overview of other composite-related research thrusts in the CATS.

Composite Design for Underwater Structures

Ronald Bucinell  
*Associate Professor, Department of Mechanical Engineering, Union College*

Off shore structures located thousands of feet below the surface of the ocean are subjected to extreme pressures, temperature, and operational requirements. Creative uses of conventional and composite materials are needed to successfully synthesize design solutions in this environment that are also compatible with existing hardware. Obtaining optional solutions requires a mixture of theoretical mechanics and finite element analysis throughout the design process. The composite design starts with the choice of appropriate constituent materials and their structural configuration. For the design to be successful the residual stress that results from the fabrication technique must be taken into account. Areas that are critical to the success of the design include the interface between materials, clearances between moving components, and holes that create free edges. Two designs are discussed that demonstrate the mixed material design process for deep offshore structures. The constraints are reviewed, material decisions discussed, the role of fabrication stresses are reviewed, and the determination of factors of safety are presented.
Bio-composites Based on a Mycelium Matrix

Gavin McIntyre
Co-Founder and Chief Scientist, Ecovative Design LLC

The use of polymer matrix composites (PMC) has grown and continues to grow steadily because of their high strength-to-weight and stiffness-to-weight ratios as compared to conventional engineering materials. Unfortunately, PMCs are notoriously unsustainable due to petroleum-based constituent materials, the wasteful and energy-intensive manufacturing processes used, and an inability to recycle at the end of life. Academic and industrial researchers have investigated encapsulating natural fibers with both petroleum-based polymers and biopolymers (cellulosic plastic) to produce more biocompatible composites with varying degrees of success, but all attempts have still fallen short of an ideal ‘bio-composite.’

Ecovative Design uses mycelium as a matrix for binding natural fibers and core filler materials together into sustainable composites. First, the core bulk material is bound together over time by mycelium growing into and around common agricultural waste (cotton burrs). Then, reinforcing layers made from natural fibers (hemp) inoculated with fungal cells are applied to the core faces, allowed to infiltrate the laminate and bind to the core material, and then heated to inactivate the growth process to make a resilient composite sandwich structure.

Nanocomposites for High Voltage Cable Transmission and Smart Lighting

Linda S. Schadler
Professor, Materials Science and Engineering, RPI

The focus of our research is to tailor the nanofiller / polymer matrix interface in order to control macroscopic mechanical, electrical, and optical properties of nanocomposites. This talk will focus on our progress in creating nanodielectrics for high voltage cable transmission and high index of refraction / high transparency composites for smart lighting applications. By tailoring the enthalpic interactions between the matrix and filler, we have achieved well dispersed nanofillers leading to an increase in the electrical breakdown strength by up to 30% and the voltage endurance by orders of magnitude in insulating polymers. Through the use of nanoparticles with grafted polymer chains that impact both the enthalpic and entropic interfacial interactions, we have achieved highly transparent nanocomposites with an index of refraction of 1.8.
Session II-b. *Production Scheduling and Optimization*

Scheduling challenges in semiconductor manufacturing

Detlef Pabst  
*Sr. Industrial Engineer, Manufacturing Technology Group, GlobalFoundries*

Manufacturing of semiconductors defines long recurrent process flows utilizing hundreds of tools under complex constraints. The heavy capital investments for such manufacturing facilities establish the need for efficient production scheduling solutions. Additional complexities arise in the high product mix, low product volume setting of the foundry business. This presentation gives an introduction to the characteristics and challenges of these scheduling problems.

Optimal Scheduling of Multi-Cluster Tools

Victor Chan  
*Assistant Professor, Industrial and Systems Engineering, RPI*

In semiconductor manufacturing, finding an efficient way for scheduling a multi-cluster tool is critical for productivity improvement and cost reduction. This talk presents a method for scheduling multi-cluster tools equipped with single-blade robots and constant robot moving times. We introduce a closed-form expression for computing the cycle time of cluster tools. We prove that the optimal robot scheduling of two-cluster tools can be solved in polynomial time. We also demonstrate how to reduce a multi-cluster into a single-cluster tool with equivalent cycle time.

The Treadbot - High Throughput Multi-Head Robot

Steve Derby  
*President, Distributed Robotics LLC*

This presentation will cover the benefits of multihead robots for high throughput applications. The tradeoff of high speed vs. high throughput will be explored. This continuous motion transfer robot will look at the needs of dwell times for proper picking and placing.
Supplier Qualification and Selection Processes in Outsourced Supply Chains

Jennifer Ryan
Associate Professor, Industrial and Systems Engineering, RPI

The talk will present results of an on-going research project with Bell labs Ireland, Alcatel-Lucent. We consider a typical two-stage procurement process, commonly used in federal government procurement, as well as in many manufacturing supply chains. We seek to understand how the manufacturer can design this procurement process to enhance profitability by (1) designing the qualification stage to ensure that the firm only sources from qualified suppliers and (2) encouraging competition among the suppliers in the supplier selection and order allocation stage. Of particular interest are the interactions between the two stages of the sourcing process, i.e., the impact that decisions regarding supplier qualification have on the process of supplier selection and allocation.
Session III-a. **CATS Success Stories**

**Welch Allyn- Success in the Health Care Industry**

*Ray Dromms*

_Director of Manufacturing Engineering, Welch Allyn_

Founded in 1915 and headquartered in Skaneateles Falls, NY (USA), Welch Allyn is a leading global provider of medical diagnostic equipment and a complete range of digital and connected solutions. With 2,600 employees working in 26 different countries, Welch Allyn specializes in helping doctors, nurses, and other frontline practitioners across the globe provide the best patient care by developing innovative products, breakthrough technologies, and cutting-edge solutions that help them see more patients, detect more conditions, and improve more lives. RPI/CATS has through an effective Public/Private partnership helped Welch Allyn achieve innovations in healthcare.

**BullEx: From Student Project to Global Leader in Firefighter Training Equipment.**

*Ryan O’Donnell*

_CEO and Co-Founder, BullEx, Inc._

In just over six years BullEx has grown from an RPI start-up to become a leading manufacturer of fire and safety training equipment. BullEx markets, sells and manufactures over 30 fire and safety training products used by safety professionals and emergency responders in over 40 countries and has been featured in **FORTUNE** magazine and on NBC’s **The TODAY Show**. BullEx CEO and Co-founder Ryan O’Donnell discusses the company’s founding, first product launch and subsequent growth with a focus on the assistance and impact of the CATS. _Ryan and fellow Co-founder and COO, Tom Rossi were both undergrad and graduate student researchers at the CATS and engaged the CATS post start-up to assist with product launch and growth initiatives._

**New Technology for an Old Industry Sector**

*Bruce Phipps*

_President, MPI Incorporated_

MPI, a small company located in Poughkeepsie, NY, manufactures and sells capital equipment for investment casting foundries’ wax rooms to customers worldwide. For more than ten years MPI has partnered with CATS researchers on several innovative research projects, resulting in new product offerings and new market opportunities for MPI. The CATS provides to MPI: a surrogate R&D organization; credibility when seeking third party funding, such as with NYSERDA; professional project management; creative, out of the box, thinking and innovative solutions; and important connections within the robotics community. With the assistance of the CATS, MPI has transformed itself into a
modern, technologically savvy company that is a leader in this important industry sector, creating high value jobs and increased sales.

The Path to Success – Precision Valve and Automation

Anthony Hynes  
*President and CEO, Precision Valve & Automation, Inc.*

Precision Valve and Automation (PVA) literally started in Founder, Tony Hynes’ basement in 1992. Since then, PVA has grown to become a Global supplier of precision dispensing, coating and curing components and systems serving numerous industry sectors, including electronics, aerospace, pharmaceuticals, and automotive. PVA provides high value jobs to more than 150 employees at its Cohoes, NY headquarters and manufacturing facility, and offices in seven countries. Along the way Rensselaer and the CATS have provided important resources to assist in the success of the company, ranging from key engineering talent, to access to laboratory facilities, and business and technical advice.

The CATS Competitive Advantage

Chris O’Connor  
*Operations Program Manager, Ducommun Aerostructure*

Ducommun Aerostructures, New York (DASNY) has evolved dramatically over the last 30 years and CATS has been a partner for much of it. The company originated as DynaBil Industries, a small family business that manufactured sheet metal components for the Aerospace industry. As their reputation for quality work grew so too did their business with major commercial and military suppliers. In the late 90’s DynaBil teamed up with CATS for what would be the first of many projects utilizing technology and innovation to improve efficiency and capability in fabrication. The CATS group continues to provide DASNY with access to a team of cutting edge researchers connected to the latest developments in manufacturing technology, all with a mindset for applying these technologies with innovation to solve real manufacturing challenges.
RPI Faculty Showcase

Nano/Micro-Scale Manufacturing and Material Design

Johnson Samuel  
Assistant Professor, Mechanical, Aerospace & Nuclear Engineering, RPI

This talk will highlight some of the key manufacturing research areas being investigated at the newly-established Nano/Micro-scale Manufacturing and Material Design Laboratory (Nano-M3 Design Lab) at Rensselaer. The specific areas to be discussed include: 1) Designing material micro/nano-structure for engineering functionality and manufacturability; 2) Developing sustainable cutting fluids for micro-machining operations; and 3) Developing a printing-based high-throughput additive manufacturing process for sub-micron textured surfaces.

The materials and manufacturing processes to be discussed span the areas of health-care, sustainability, and defense. Specific material systems include nanocomposites (polymer and metal-based), sustainable hierarchical-composites, bone, medical implant materials, bulk metallic glasses and self-healing composites. The manufacturing processes to be discussed include mechanical micro-machining processes such as micro-milling/drilling/turning, and non-conventional manufacturing processes such as micro-electrical discharge machining and electrohydrodynamic-jet printing.

Precision Instrumentation and Control of Micro- and Nano-scale Manufacturing

Sandipan Mishra  
Assistant Professor, Mechanical, Aerospace & Nuclear Engineering, RPI

Current trends in printed electronics, biotechnology, and micro-electromechanical systems are leading to increased demand for high-resolution manufacturing capabilities. This seminar highlights the role of precision instrumentation and control theory in emerging manufacturing, such as for transitioning nano-science into nano-manufacturing. We demonstrate an example of this transition in the context of E-jet printing, an additive micro/nano-manufacturing process that uses an electric fields to induce fluid jet printing through micro-scale nozzles. To sum up, a general overview of the fundamental control systems-related challenges in scale-up and functional reliability of micro/nano-manufacturing will be put forth.
Engineering the Stem Cell Microenvironment with Automated Laser Bioprinting


David Corr
Assistant Professor, Biomedical Engineering, RPI

Our collaborative research aims to understand the impact of various environmental and developmental stimuli on stem cell behavior and fate decisions. We employ a novel gelatin-based laser direct write process (LDW) to “print” living cells to create spatially-precise cellular cultures and co-cultures. Our recent work in stem cells shows this technique can target and transfer specific cells to a substrate with spatial precision, and can do so in a manner that not only maintains high cell viability, but also preserves the stem cell’s pluripotency. When employed with substrates of different topology and stiffness, this enables us to engineer stem cell microenvironments that explore the influence of cellular microenvironmental factors on the fate decisions of stem cells and other precursor cells. Further development within the CATS seeks to introduce image-guided automation to this CAD/CAM cell printing process, to greatly increase the utility and throughput of this technique.

Design of an Immunocompetent Human Skin Tissue Model by 3D Free Form Fabrication

Gurtej Singh, Vivian Lee, John Trasatti, Guohao Dai and Pankaj Karande

Pankaj Karande
Assistant Professor, Chemical and Biological Engineering, RPI

Skin forms the first line of defense against foreign elements such as pathogens, environmental insults, and physical or chemical trauma. Apart from being a passive physical barrier, skin hosts a highly sophisticated immune surveillance network. This inherent potential of skin as an immune organ can be used for targeting vaccines and immunomodulators to the skin for a systemic immune response. Transdermal immunization offers several advantages over oral and needle-based vaccination as it can induce both cellular and humoral immunity. However, the development of effective transdermal immunotherapeutics is currently hindered by the lack of an adequate immunocompetent human skin tissue model. We have recently developed an in vitro, multi-compartmental, three-dimensional (3D), immunocompetent human skin model using a novel cell-printing technology called three-dimensional free form fabrication (3DFFF). The availability of this model is expected to positively impact the development of transdermal vaccines and immunomodulators for infectious diseases and autoimmune disorders. 3DFFF is a powerful and flexible technology that allows printing of multi-cellular, multi-layer skin tissue structures in a high-throughput manner. We present our preliminary results that indicate the feasibility of 3DFFF for designing fully viable and functional, immunocompetent skin tissue that bears morphological and phenotypical resemblance to in vivo skin. It also provides a rapid and reliable model to test the immune potential of vaccine candidates and immunomodulators.
Controller Synthesis using Computer Games

Agung Julius
Assistant Professor, Electrical, Computer, and Systems Engineering, RPI

Hybrid systems are a mathematical framework that has been widely used to model cyber-physical systems. In this talk, I will present a framework for solving some computationally hard problems, i.e. the controller synthesis for hybrid systems. These problems are concerned with finding ways to control the systems, so as to meet their goals and safety requirements.

Our approach is based on the idea of establishing the robustness of execution trajectories, such that a provably correct controller can be synthesized using finitely many valid execution trajectories. We developed a framework, with which these valid trajectories can be obtained from human played computer games that simulate the hybrid systems. I will also discuss a potential deployment in a crowdsourcing scenario. Such implementation will push the existing computation crowdsourcing technology to a new level, as it would enable the use of dynamic human inputs to solve a hard computational problem formally (i.e. with proof).
A. Fuel Cell Manufacturing

A-1. Spraying Techniques for Large Scale Manufacture of PEM-FC Electrodes

Casey J. Hoffman  
*Center for Automation Technology and Systems (CATS), Rensselaer Polytechnic Institute*

Two of the largest barriers to PEMFC commercialization are the materials costs for individual components, especially platinum catalyst, and the fact that few large-scale manufacturing capabilities currently exist. The research effort discussed in this poster focuses on large-scale manufacturing of polymer electrolyte membrane (PEM) fuel cell electrodes. More specifically, emphasis is given to the gas diffusion electrode architecture, in which the catalyst layer is applied to a gas diffusion layer (GDL) rather than on the membrane. These electrodes can be used for both low- and high-temperature PEM fuel cells.

A pair of non-contact deposition methods for catalyst inks are being investigated (e.g., direct spray, ultrasonic spray) in order to achieve higher throughput and repeatability through increased process control capability, while maintaining or improving electrode performance. After this is completed, the most promising techniques will be chosen for further development of a complete manufacturing system concept.

A-2. Automated Ultrasonic Sealing and Welding Station

Jake Pyzza  
*Center for Automation Technology and Systems (CATS), Rensselaer Polytechnic Institute*

Ultrasonic bonding provides the potential for both reduced cycle times and more efficient energy use over traditional fuel cell MEA bonding practices. The objective of this research is to optimize the manufacturing of polybenzimidazole (PBI)-based Membrane Electrode Assemblies (MEAs) using ultrasonic bonding, and to control parameters that are critical to fuel cell stack performance. We have designed and built an automated system to demonstrate the feasibility of the ultrasonic bonding process. The system fabricates a continuous web of MEAs, whereas traditional systems create individual, unitized MEAs. Using a flexible web of support material with registration features eliminates the need for rigid frames to transport fuel cell components.

William Ziomek, Justin Gullotta  
Center for Automation Technology and Systems (CATS), Rensselaer Polytechnic Institute

An experimental fuel cell stack was designed to examine individual MEA performance and cell to cell variation. The stack and test stand are instrumented to collect temperature and voltage data at each of the cells. The stack is designed to be reconfigurable to run up to ten cells as well as include and vary the configuration of optional coolant plates. This stack is also intended to support future planned research wherein the compression of MEAs can be varied during operation, allowing for a more complete understanding of the effect of compression on cell and stack performance.


Dave Guglielmo, Todd Snelson, Dan Walczyk  
Center for Automation Technology and Systems (CATS), Rensselaer Polytechnic Institute

Ultrasonic welding has the potential to be used in the assembly of fuel cell MEAs. Currently the details of the process are not well understood. It is the goal of the modeling effort to determine the heating effect of vibration on a fuel cell MEA as a function of time and energy input. Each physical layer was modeled as a spring-mass-damper system, and the time-dependent motions of each component were determined mathematically. These motions were used to find the heat dissipated in each component. An FEA model was used to find the time-dependent temperature as a function of each heating rate. These were found to closely match experimentally determined temperatures taken with thermocouples. Further work will need to focus on adapting the modeling process to work with MEAs of varying size and composition.

A-5. Characterization of Vaporization Rates on SOFC Interconnect Alloys

Micah Casteel, Dan Lewis  
Rensselaer Polytechnic Institute

Ferritic stainless steels are an attractive option for interconnect applications in solid oxide fuel cells due to their low coefficient of thermal expansion (CTE) and low cost. However, a key problem with ferritic stainless steels in these applications and other high chromium materials is the vaporization of chromium species. This vaporized chromium poisons the cathode, which can impact cell performance significantly. In order to understand this problem we have incorporated a solution based ionic conductivity method into the more traditional transpiration measurement method. Using this novel method we have determined the vaporization rates of Crofer 22 APU, E-brite, ZMG-232, Haynes 230, and 441 SS. Further work has been performed to investigate the effects of water vapor partial pressure on vaporization rate.
It is hoped that this data will be useful for alloy and coating characterization and valuable in determining the utility of the ionic conductivity method.

A-6. An Evolution of CATS Fuel Cell Activities & Interests

Steve Rock, Ray Puffer, Dan Walczyk, Glenn Saunders, Justin Gullotta  
*Center for Automation Technology and Systems (CATS), Rensselaer Polytechnic Institute*

Fuel cell manufacturing process development and automation is a key focus area of the CATS research program. This poster illustrates the evolution of fuel cell research within CATS, presents current areas of investigation, and provides a vision of future opportunities for collaboration both with other Rensselaer researchers and with industrial partners.

A-7. Fuel Cell Stack Demonstration System

Michael Kleinigger  
*Center for Automation Technology and Systems (CATS), Rensselaer Polytechnic Institute*

The CATS has developed and built a self-contained 300W Proton Exchange Membrane (PEM) fuel cell demonstration system with a commercial fuel cell stack, control unit, adjustable load, power inverter, and data acquisition system for automatic polarization curve generation under varied operating conditions. This system has been used in various fuel cell courses as part of the NSF Integrative Graduate Education and Research Traineeship (IGERT) grant on fuel cells.
B. Composites Engineering

B-1. Consolidating and Curing of Advanced Thermoset Composite Laminates by Thermal Pressing – A Low-Cost Alternative to Autoclaving

Jaron Kuppers, Daniel Walczyk
Center for Automation Technology and Systems (CATS), Rensselaer Polytechnic Institute

The standard process for consolidating and curing advanced thermoset composite laminates is by vacuum bagging the formed workpiece over a rigid tool, subjecting it to high temperature and pressure in an autoclave for several hours, and finally debagging the workpiece after removal from the autoclave. The process is time consuming and very expensive, both for capital equipment and consumables. CATS researchers in collaboration with Kintz Plastics, Inc. (Howes Cave, NY) are developing a patent-pending process, called thermal pressing, as a direct alternative to autoclaving. The process mimics the autoclaving process by pressing a formed composite laminate between a precisely heated metal mold and an elastomer-covered mating mold made of an insulating material. When the tool set with laminate is pressed together with a precise clamping force, the uniform pressure and temperature usually provided by an autoclave is reproduced, although at 1-2 orders-of-magnitude less cost and energy consumed. Pressing time is also significantly reduced because part heat up and cool down are essentially instantaneous by comparison with autoclaving. Thermal Press Curing has been demonstrated for a complex 3-dimensional carbon/epoxy composite part.

B-2. Core Materials for Wind Turbine Blades

Nate Baker (MTLE), Dylan Blanset (MECH), Tim Janson (MECH), Allen Keegan (MECH), Evan Kenyon (MECH), Anthony Lucarelli (MECH), Ben Santagata (MECH), Nick Wengrenovich (MTLE)
The Design Lab at Rensselaer, Rensselaer Polytechnic Institute

The RPI O.T. Swanson Multidisciplinary Design Lab is working in partnership with GE Energy to research advanced materials to be used as the core of composite sandwich structures in the blades of wind turbines. The ability of being able to create lighter and stronger composite structures will allow for greater efficiency when harvesting wind energy. New core materials can help manufacturers of large wind turbine blades optimize their designs by reducing both weight and cost. Current methods for manufacturing turbine blades use balsawood or a balsawood modification as a core material around which a fiberglass “frame” is assembled. This research project will evaluate eleven engineered foam and composite cores as suitable replacements for the balsawood core and create FEA models that adequately depict the composite sandwich’s response to loading and deformation with rectangular and I-beam geometries.
B-3. Guided Wave Health Monitoring of Composite Structures

Ratneshwar (Ratan) Jha
Center for Advanced Materials Processing, Clarkson University, Potsdam, NY

Structural Health Monitoring (SHM) is a critical enabling technology for advanced, high performance composites. This research aims at development of SHM methods that do not need baseline (healthy) structural response free damage detection. The detection of delamination in composite plates using the Damage Force Indicator (DFI) and Modified Time Reversal (MTR) methods are presented. The global dynamic stiffness matrix of the healthy structure is obtained from Wavelet Spectral Finite Element (WSFE) model condensed to the degrees of freedom consistent with experimental measurements (out-of-plane displacements). The displacement vector for the damaged structure is measured using a scanning laser vibrometer. It is shown that the DFI and MTR methods gives correct identification of damage.

B-4. Using Mycelium as a Matrix for Binding Natural Fibers and Core Filler Materials in Sustainable Composites

Daniel Walczyk\textsuperscript{a}, Gavin McIntyre\textsuperscript{b}, and Jaron Kuppers\textsuperscript{a}
\textsuperscript{a}RPI Center for Automation Technologies & Systems
\textsuperscript{b}Ecovative Design, LLC

Ecovative Design, LLC, a local company that develops and manufactures biodegradeable packaging and insulation materials, has partnered with the Rensselaer CATS and Union College on a 6-month NSF SBIR Phase I project (January - June 2011) to (1) demonstrate a new type of sustainable bio-composite material consisting of core material and fibers held together with a mycelium (mushroom roots) matrix, called Mycobond, and (2) investigate how this material will be manufactured.
C. Manufacturing Design Tools

C-1. The Sustainable Design Tool

Aric Beece, Danielle Cohen, Garrett Dickerson, Victor Ho, Caitlyn Ingram, Haris Khan, Kevin Krolik, Molly Margolis, Kaprice Montecalvo, Joshua Seldin

The Design Lab at Rensselaer

A comprehensive metrics system has been developed to measure the end of life characteristics of the materials in a given product. This Sustainability Index can be used by designers to identify problem materials as well as different assembly or manufacturing processes. By altering the “joint strength” between two materials, the Sustainability Index can be improved to make it easier to deal with the materials at end of life. A spreadsheet based tool was initially developed for capturing the components in a product and the joint strengths between parts. Part of this semester’s project team is working on reducing the subjectivity of data collection using this tool through improved instructions, more / better examples, and potential changes to the workflow. The other half of the team is re-implementing the Excel tool as a web based system. Such a system will now allow engineers and designers to share sustainability information which will now permit benchmarking of new products against existing ones. Lessons learned from the use of the Excel based tool will be leveraged to increase the usability and clarity of the web based system.

C-2. STEP-NC Simulation

Dr. David Loffredo, Mr. Jochen Fritz

STEP Tools, Inc.

Professor Martin Hardwick

Department of Computer Science, RPI

Enterprises that manufacture in small quantities need processes that are flexible and accurate. The National Simulation Service is to be a web site for sharing, linking, editing and verifying additive and subtractive manufacturing processes. The service will allow a user to upload data describing a CAM process and CAD product models for the stock, fixtures and cutting tools. The service will then simulate the process to verify correctness.

The new service will be web-enabled so that multiple users can share data and reuse processes. When parts need to change, users will be able to replace the models of the stock, cutting tools, fixtures and machine tools as necessary and rerun the simulation. If parts of the program are not working then they will be replaceable and the final result will be compared with the tolerances defined for the final product before it is released to the shop floor for manufacturing.
D. Scheduling and Supply Chain

D-1. Supplier Qualification and Selection with Uncertain Quality

Jennifer K. Ryan, Walter Yund
Department of Industrial and Systems Engineering, Rensselaer Polytechnic Institute

Yue Jin
Bell Labs Ireland, Alcatel Lucent

We consider a typical two-stage procurement process, commonly used in federal government procurement, as well as in many manufacturing supply chains. We seek to understand how the manufacturer can design this procurement process to enhance profitability by (1) designing the qualification stage to ensure that the firm only sources from qualified suppliers and (2) encouraging competition among the suppliers in the supplier selection and order allocation stage. Of particular interest are the interactions between the two stages of the sourcing process, i.e., the impact that decisions regarding supplier qualification have on the process of supplier selection and allocation. In addition, we consider how the manufacturer can use the qualification stage to learn about the capabilities of the supplier, and we study how the manufacturer can determine the amount of effort to exert in the qualification stage.

D-2. Optimal Scheduling of Multi-Cluster Tools

Wai Kin (Victor) Chan
Department of Industrial and Systems Engineering, Rensselaer Polytechnic Institute

In semiconductor manufacturing, finding an efficient way for scheduling a multi-cluster tool is critical for productivity improvement and cost reduction. This talk presents a method for scheduling multi-cluster tools equipped with single-blade robots and constant robot moving times. We introduce a closed-form expression for computing the cycle time of cluster tools. We prove that the optimal robot scheduling of two-cluster tools can be solved in polynomial time. We also demonstrate how to reduce a multi-cluster into a single-cluster tool with equivalent cycle time.
E. Mechatronics and Robotics

E-1. Multi-probe Microassembly

John Wason*, John Wen*, Nicholas Dagalakis+

*Center for Automation Technologies and Systems, Rensselaer Polytechnic Institute, Troy, NY
+Intelligent Systems Division, National Institute of Standards and Technologies, Gaithersburg, MD

Multi-probe Microassembly is a MEMS production technology for assembling sub-millimeter parts. The assembly is accomplished through the use of multiple sharp-tip probes and visual feedback. Computer vision and control algorithms are used to grasp, position, and assemble structures and mechanisms consisting of multiple parts.

E-2. Modeling and Control of a Fast Steering Mirror with Nonlinearity

Nanhu Chen*, Benjamin Potsaid†, John T. Wen*, Scott Barry†, Alex Cable†

*Center for Automation Technologies & Systems (CATS), Troy, NY
†Thorlabs, Inc., Newton, NJ

Fast steering mirrors (FSMs) are used in many optical system applications, ranging from image tracking and scanning, to laser material processing, to jitter stabilization in optical communication. Electromagnetically actuated FSMs use electromagnets to rotate the mirror mounted on ball or flexure bearings along the perpendicular axes parallel to the mirror surface. Depending on the travel range of the mirror, nonlinear effects of the mirror due to nonlinear spring effect of the bearings and the driven magnetic force at different tilted positions will compromise the closed loop control performance of the system designed based on the linear theory. This poster presents a systematic approach to analyze and identify the nonlinear effects in the FSMs by developing a full dynamic model of a voice-coil based FSM. Two-degree-of-freedom (DOF) equations of motion are developed by using the Lagrange’s method. The expression of the magnetic force to drive the mirror, varying in different tilted position, is then derived to describe the nonlinear effect of the actuated coils. By using the experimental test results, we show that the full nonlinear model can be divided into the linear time-invariant (LTI) part and a position-dependent part, and therefore a controller designed based on the LTI model with feedback linearization applied can be an effective solution for high control performance.

E-3. The Treadbot - High Throughput Multi-Head Robot

Stephen Derby
Distributed Robotics LLC

This poster covers the benefits of multihead robots for high throughput applications. The tradeoff of high speed vs. high throughput will be explored. This continuous motion transfer robot will look at the needs of dwell times for proper picking and placing.
F. Sensing and Control

F-1. Controller Synthesis using Computer Games

A. Agung Julius, Andrew K. Winn

Department of Electrical, Computer, and Systems Engineering, Rensselaer Polytechnic Institute

Hybrid systems are a mathematical framework that has been widely used to model cyber-physical systems. In this talk, I will present a framework for solving some computationally hard problems, i.e. the controller synthesis for hybrid systems. These problems are concerned with finding ways to control the systems, so as to meet their goals and safety requirements.

Our approach is based on the idea of establishing the robustness of execution trajectories, such that a provably correct controller can be synthesized using finitely many valid execution trajectories. We developed a framework, with which these valid trajectories can be obtained from human played computer games that simulate the hybrid systems. I will also discuss a potential deployment in a crowdsourcing scenario. Such implementation will push the existing computation crowdsourcing technology to a new level, as it would enable the use of dynamic human inputs to solve a hard computational problem formally (i.e. with proof).

F-2. Dynamic Adaptive Sampling for Environmental and Smart Lighting Distributed Sensor Applications

Fangxu Dong, Arthur C. Sanderson

Department of Electrical, Computer and System Engineering, Rensselaer Polytechnic Institute

In recent years, real-time observation and monitoring have been facilitated by emerging sensor technologies. A spatially distributed network of compact and low cost sensor nodes can estimate important features of the underlying phenomena from a set of point measurements in time and space. A principal challenge posed by these networks is the selection of sampling locations and times in order to most effectively describe features and detect events of interest in the distributed observation field.

This research focuses on adaptive dynamic feature sampling of phenomena which occur as temporal and spatial distributions of variables using distributed sensor networks. A dynamic multi-scale adaptive sampling (DMSAS) algorithm is described, which can generate a variation sensitive sample distribution for exploration of the observation domain, and achieve time-efficient redeployment of monitoring resources in response to dynamic changes of the underlying phenomena. Two principal applications of this sampling approach, environmental monitoring and lighting field sampling in smart lighting system design, are presented.
F-3. Networked and Adaptive Control for Smart Lighting Systems

John Wason+, Sina Afshari+, Sandipan Mishra+, Agung Julius*, Art Sanderson*, Fernando Lizarralde# and John Wen*
+MANE/RPI, *ECSE/RPI, #Federal Univ. of Rio de Janeiro, Brazil

Energy saving and user satisfaction are two major design considerations for modern spaces. Smart Lighting Systems allows adaptation to the needs and can alter the function of a room or space, improving productivity and efficiency while supporting health and comfort. The goal of this work is to develop an integrated lighting control system, balancing light field requirement and energy utilization while taking into account usage scenarios and the presence of natural lighting. Networked and adaptive control technics for color tunable light fixtures are used to minimize a weighted combination of light field error and energy usage. For image sensor based control, e.g. using low-resolution cameras, color science provides a framework for camera calibration and estimation of the illumination spectrum considering spectral surface reflectivity. A Smart Room Testbed provides an experimental platform for the development of new concepts and capabilities in smart lighting systems. The experimental testbed allows the combination of a variety of networked sensors to detect the room usage and the natural light input, and can remotely adjust the lighting to fit the needs.

F-4. Circadian Rhythm Alignment with Intelligent Lighting Control

Jiaxiang Zhang, Agung Julius, John T. Wen
Center for Automation Technologies and Systems, Rensselaer Polytechnic Institute

Circadian rhythm is the biological process critical to the well being of all living organisms, from plants to insects and mammals. The circadian rhythms oscillate with a period of approximately 24 hours due to the 24-hour light-darkness pattern of the solar day. Circadian disruption, as experienced by night shift workers, travelers across multiple time zones, submariners or miners, can lead to lower productivity, sleep disorder, and more serious health problems. Using artificial light to regulate the circadian rhythm has long been proposed. In our work, we consider a commonly used nonlinear second order oscillator model for the circadian rhythm response with light intensity as the input and discuss how light control may be used to promote circadian entrainment. We propose a feedback-based circadian entrainment strategy by reference tracking and an open loop optimal controller by solving the minimum time control problem. Through simulation we show that the recovery of a 12-hour jet lag can be shortened from 7 days to 3 days comparing the entrainment time cost with the natural light-darkness pattern.
G. Vision and Image Processing

G-1. Characterizing Challenged Minnesota Ballots

George Nagy¹, Daniel Lopresti², Elisa H. Barney Smith³, Ziyan Wu¹
¹Rensselaer Polytechnic Institute, ²Lehigh University, ³Boise State University

Photocopies of the ballots challenged in the 2008 Minnesota elections, which constitute a public record, were scanned on a high-speed scanner and made available on a public radio website. The PDF files were downloaded, converted to TIF images, and posted on the PERFECT website. Based on a review of relevant image-processing aspects of paper-based election machinery and on additional statistics and observations on the posted sample data, robust tools were developed for determining the underlying grid of the targets on these ballots regardless of skew, clipping, and other degradations caused by highspeed copying and digitization. The accuracy and robustness of a method based on both index-marks and oval targets are demonstrated on 13,435 challenged ballot page images.

G-2. Complex Activity Recognition with Interval Temporal Bayesian Networks

Natalia Larios, Xiaoyang Wang, and Qiang Ji
Rensselaer Polytechnic Institute

As a part of the DARPA-funded VIRAT and PerSEAS projects, this research focuses on recognizing complex human activities involving interactions between humans and objects (e.g. vehicle, packages) from low-resolution surveillance and aerial videos. Complex activities typically consist of multiple primitive events happening in parallel or sequentially over a variable period of time. In order to achieve automated recognition of these complex activities, each of their composing events must be identified but, more importantly, the temporal dependencies of these events over different time intervals have to be considered. Our method consists of two parts: event detection and activity recognition. Event detection starts with tracking the people, vehicles and other objects, extracting image and kinematic features from the tracks, and detecting the events from the features. For each event, a subset of the most discriminative features is selected to reduce the input data dimensionality. A Dynamic Bayesian Network (DBN) is then constructed for each event to capture the relationships between image features and the events that constitute the activities. The event detection is achieved by evaluating the likelihood of each DBN model.

To recognize complex activities that consist of primitive events happening either in parallel or sequentially. We the Interval Temporal Bayesian Network (ITBN), a probabilistic graphical model that combines a Bayesian Network with Interval Algebra. Each ITBN is a probabilistic model of the activity events and their temporal relationships. They provide a unified model that allows representing a large variety of time-constrained relationships, while remaining fully probabilistic and expressive of uncertainty. Advanced learning methods are introduced to learn an ITBN model for each complex
activity. Recognition of an activity is performed by evaluating the likelihood of each ITBN model. We evaluate the performance of the models on real videos for six complex activities from the RPI parking lot dataset. Some of the specific activities included are: pick up, drop off, and package exchange between two persons.
H. Actuator and Sensor Design

H-1. Design and Characterization of Mach-Zehnder Interferometer Based Biosensor using a Sub-micron Silicon-on-Insulator Waveguide

Joseph Novak*, Shengling Deng*, Rena Huang*, Christopher Campbell#
*Electrical, Computer, and System Engineering Department, Rensselaer Polytechnic Institute, NY
# O’Brien & Gere, Fayetteville, NY

We explore the design, fabrication, and testing of an optical Mach-Zehnder interferometer on silicon-on-insulator (SOI) wafer for biological and chemical sensing. The waveguide consists of a sub-micron rectangular structure fabricated by e-beam lithography, restricting the waveguide to single-mode operation. Integration of input light to the SOI wafer is achieved by a design of v-groove processing and a compact taper structure. Use of sub-micron waveguides on SOI provides high confinement of input light and reduces the required surface area for Y-junction and sensing device structures for compact integration of the biosensor.

H-2. Discrete Power Synthesis for High Efficiency RF Power Amplifiers

David Clevenstine (Electrical), Dan Goodwin (Electrical), Thomas Guerra (Electrical), Hannah Thompson (Electrical)

The Design Lab at Rensselaer

In this poster, we address two fundamental issues associated with radio frequency power amplifiers. The first is the enhancement in output power capability and efficiency using integrated switchable power combiners. The second is amplifier linearization using digital predistortion. The team looking at the first problem has characterized a CMOS 2GHz power amplifier that uses discrete power synthesis to efficiently produce the RF output power. The second team presents a Digital Predistortion (DPD) Linearization model implemented in Simulink that accounts for the nonlinear behavior of the power amplifier and generates look up tables with magnitude and phase correction factors. Measurement and modeling results are presented.

H-3. Motor Design

Eric Conway (MTLE), Hengshuo Fu (ELEC), Tyler Gloski(MECH), Joseph Lyons (ELEC), Sara Lorene Makowiec (ELEC), Katie Moller (ELEC), Ibrahim Peek (ELEC), Christopher Simpson (MECH), Qianyi Zhang (ELEC)

The Design Lab at Rensselaer

The US Navy is moving to all electric ships, including electric propulsion. One of the requirements of the propulsion system is that it be very silent, both acoustically and electromagnetically. A new motor configuration, invented at RPI, is being explored. The machine has almost none of the sources of
magnetic induced vibrations and it's magnetic signature is tunable after manufacture. The poster describes this new design.

H-4. High-Performance System for Wireless Transmission of Power and Data through Solid Metallic Enclosures

T. J. Lawry¹, K. R. Wilt¹, G. J. Saulnier¹, J. D. Ashdown¹, H. A. Scarton¹, P. K. Das², S. Pascarelle³

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Current techniques to implement external sensors and systems on many naval vessels require hull penetrations to feed through cables for power delivery and data transmission. These solutions are expensive, often require dry-docking the vessel, and can compromise a hull's structural integrity. The work presented here utilizes ultrasound as an alternative method for transmitting power and data through solid steel barriers. Pairs of piezoelectric transducers are coaxially aligned on opposite sides of the barrier and acoustically coupled to the barrier to create acoustic-electric transmission channels through the wall. This technique eliminates the need for hull penetrations, and this system provides significant communication advantage over existing techniques. A real-time prototype was developed that has the ability to simultaneously transmit digital information at rates as high as 12.4 Mbps and as much as 50 W of power through a 63.5 mm (2.5 in.) thick steel barrier.
I. Biomedical Applications

I-1. GE Healthcare: Glass Plate Handling

Brian Bidwell, Charlie Senness, Joe Romer, Joyce Chow, Mike Ansom, Yuhuan Ling, Alex Appleman

The Design Lab at Rensselaer, Rensselaer Polytechnic Institute

This Designlab project is a collaboration between GE Healthcare and Designlab students. GE Healthcare produces digital x-ray detector panels in a clean room manufacturing facility. These panels receive many photolithography processes during their manufacture. A Nikon microscope is used to inspect these panels for any defects. Currently the panels must be manually loaded onto the microscope, which is a difficult and time-consuming task for technicians working in the cleanroom. GE aims to improve this task through automation of the panel inspection process using a robotic handling system and a custom stage to hold the glass panels on the microscope. Designlab students have been working to design and implement this system.

The design team split the task into two sub-teams. One team has focused on the stage that mounts on the Nikon microscope and the other team has designed end effector that will interface with a Genmark robot. The stage incorporates a pin actuation system and vacuum chuck for the positioning and securing of the fragile glass panels for inspection. The end effector will be made of carbon fiber and contain sensors and vacuum lines to detect and hold onto the panels as they are moved by the robot. Both components must be designed to work within the confines of a Class 10 cleanroom environment. The team has made great strides so far with the project.

The stage design was finalized, approved by GE, and construction of a prototype has been progressing. Proof of concept testing will began when all the components have been fabricated or purchased. The end effector team has been working with GE, Genmark, several RPI professors, and various vendors to design an end effector that will meet all the needs of the project. A prototype will also be produced to verify basic fit and function.

I-2. Engineering the Stem Cell Microenvironment with Automated Laser Bioprinting

A.D. Dias¹, U.S. Jonnalagadda¹,², N.R. Schiele¹, G. Saunders², J. Wen², Y. Xie⁴, D.B. Chrisey¹,³, and D.T. Corr¹

Rensselaer Polytechnic Institute, Troy, NY Biomedical Engineering ¹, Center for Automation Technology and Systems (CATS)², Material Science and Engineering ³; University at Albany – SUNY, College of Nanoscale Science & Engineering, Albany, NY⁴

Our collaborative research aims to understand the impact of various environmental and developmental stimuli on stem cell behavior and fate decisions. We employ a novel gelatin-based laser direct write process (LDW) to "print" living cells to create spatially precise cellular cultures and co-cultures. Our
recent work in stem cells shows this technique can target and transfer specific cells to a substrate with spatial precision, and can do so in a manner that not only maintains high cell viability, but also preserves the stem cell's pluripotency. When employed with substrates of different topology and stiffness, this enables us to engineer stem cell microenvironments that explore the influence of cellular microenvironmental factors on the fate decisions of stem cells and other precursor cells. Further development within the CATS seeks to introduce image-guided automation to this CAD/CAM cell printing process, to greatly increase the utility and throughput of this technique.

I-3. Adaptive Illumination Control for Reducing Photodamage in Live-Cell Microscopy

Zack Schilling+, Evan Frank+, Valentin Magidson*, John Wason+, Jadranka Lonarek*, John Wen+, Kim Boyer+, Alexey Khodjakov**+
+Rensselaer Polytechnic Institute, Troy, NY, *Wadsworth Center, NYS Department of Health, Albany, NY

Deleterious effects of high-intensity excitation light limit the number of images that can be recorded in live-cell fluorescence microscopy. Here we present a simple technique which avoids collecting unnecessary out-of-focus images by restricting image acquisition to small dynamic regions centered on objects of interest (OOI). Our approach, which we term Adaptive Illumination control for Fluorescence Microscopy (AIFM), utilizes computer tracking to predict OOI's positions at the next time point and can be implemented on standard microscopes without hardware modifications. AIFM reduces the total light exposure by limiting image acquisition to the focal planes immediately adjacent to the position of the OOI.

With traditional time-lapse imaging techniques, a fixed acquisition region leaves room for cells to move and change shape. This results in a large number of unnecessary exposures which damage cells and affect experiment outcomes. AIFM allows a biologist to select features of interest, creating a dynamic acquisition region which moves with the cell. This smaller dynamic region allows for higher resolution imaging without overexposure.

The novelty of our approach arises from the connection of a computer vision based object-tracking algorithm to the illumination source and stage controls of a live cell fluorescence microscope. Control of the illumination source based on tracking data allows for the previously unattainable goal of long duration live cell fluorescence microscopy and provides live cell fluorescent microscopy experiments with longer lasting fluorescent protein tags, healthier cells, and higher quality images.

I-4. Automated Digital Microfluidics as a Platform for Drug Discovery

Justin Gullotta, Julie M. Beaudet, Jeffrey G. Martin, Mark Buckler, Will Fergus, Jonathon S. Dordick, Robert J. Linhardt, and John Wen
Center for Automation Technologies and Systems, Center for Biotechnology and Interdisciplinary Studies
Digital microfluidics is an emerging lab-on-chip technology. We have developed a digital microfluidic system for the purpose of pharmaceutical discovery. This project involves an interdisciplinary team including biochemists, computer scientists, and engineers to develop devices that can be used for drug development, specifically the use of enzymes to create biologically significant molecules, such as heparin, for therapeutics.

I-5. Three Dimensional Kinematics of the Entire Thoracolumbar Spine as Quantified by a Novel In Vivo/In Vitro Active/Passive Robotic Simulator

Elsabee KA†; Wason JD†; Nazarian R†; Wen JT†; Carl AL†; Ledet EH†
†Rensselaer Polytechnic Institute, Troy, NY; †Albany Medical College, Albany, NY

Low back pain is among the most common ailments suffered by Americans with about 50% of the population reporting some instance each year. Degenerative disc disease, in which the integrity of the intervertebral disc becomes compromised, has been linked with low back pain. When conservative therapy fails for the treatment of symptomatic degenerative disc disease, surgery is another option. The gold standard of surgical care for degenerative disc disease is fusion, in which two adjacent vertebrae are rigidly connected limiting the relative motion. In long-term follow-up studies of fusion patients, accelerated degeneration has been identified at the levels adjacent to the operative level. These adjacent level effects have been analyzed in many in vitro studies; however, due to the current limited knowledge of the in vivo environment, the validity of these studies remains unproven. As such, it has been the purpose of this research to develop a system that evaluates the relative change in kinematics of the thoracolumbar spine after surgical intervention.

Our novel methodology used active in vivo data from normal healthy volunteers to drive a cadaveric spine passively in vitro through the same range of motion while collecting kinematic data of the entire thoracolumbar spine using a robotic simulator. Our results suggest that for a rigid fixation of a single level, if all non-operative levels have relatively equal compliances, normal bending motion will occur. This normal bending motion will transpire by each superior level moving and rotating slightly more, relative to the inferior level. The operative level, on the other hand, will show no relative movement or rotation due to the rigid fixation of the intervention. However, in a different scenario, if there is early-stage degeneration at another level (i.e. directly caudal to the operative site), there will be increased compliance at that level. When the spine bends, the operative site will have no relative movement or rotation, due to the rigid fixation, and the levels superior to the operative site will have small changes in movement and rotation. In this instance, the majority of the motion will occur at the degenerated level due to its increase in compliance. With more testing of specimens, these hypotheses may be clarified.
J. Energy Harvesting


Asantha Kempitiya\textsuperscript{a}, John Oxaal\textsuperscript{b}, Mona Hella\textsuperscript{a} and Diana-Andra Borca-Tasiuc\textsuperscript{b}

\textsuperscript{a}Department of Electrical, Computer and Systems Engineering
\textsuperscript{b}Department of Mechanical, Aerospace and Nuclear Engineering
Rensselaer Polytechnic Institute

Wireless distributed micro-sensor systems have numerous applications, from equipment diagnostic and control to real time biomedical monitoring. A major obstacle in developing autonomous micro-sensor networks is the need for local and autonomous electric power supply, since using a battery is often not a viable solution. This work investigates the modeling and optimization of novel energy harvesting circuit and micro-power generator architectures that convert ambient vibrations to electrical energy via electrostatic transduction. The micro-generator is designed to operate in a charge constrained cycle with an in-plane gap-closing configuration. Based on the optimization procedure, a novel HVCMOS integrated circuit architecture is proposed, fabricated and successfully validated by measurement results. Power levels are further enhanced by employing a tri-plate capacitor architecture whose complementary dynamic behavior doubles total harvestable mechanical energy.

J-2. Africa Initiative - Biomass Scope Study

Lauren Spinelli, Brad Walker

\textit{OT Swanson DesignLab, Rensselaer Polytechnic Institute}

In conjunction with the Kwame Nkrumah University of Science and Technology (KNUST) and in support of Rensselaer's "African Initiative", this team is continuing the work of the Spring 2010, Summer 2010, and Fall 2010 Biomass teams in an effort to tackle the issue of harvesting energy from streams of waste. This Biomass project aims to discover a feasible way to convert waste from agricultural farming into energy and usable material. The team is currently focusing on the collection of bio-oil as a viable energy supply and the utilization of solar power as a means to convert waste into energy. We, along with the O.T. Swanson Interdisciplinary Design Lab, anticipate continued advancements in future semesters and welcome the Ghanaian students as they join Rensselaer in Troy, NY this coming summer.
K. Thermal and Fluidic Systems

K-1. Vapor Compression Cycles for electronics cooling: Modeling, Controller Design and Experimental Validation

Juan Catano, Tiejun Zhang, Daniel Pollock, Fernando Lizarralde, Yoav Peles, Michael K. Jensen and John T. Wen
Rensselaer Polytechnic Institute

The ever increasing power density of high-end electronics has made vapor compression cycles (VCC) a viable and attractive alternative for electronics cooling, specially, in high-heat-flux applications, like military ships and computer servers. However, due to different boundary conditions at the evaporator (imposed heat flux) from traditional VCC (temperature difference), VCC for electronics cooling require new modeling and control algorithms to guarantee its safe operation in real applications. This poster presents the ongoing work in steady-state optimization, dynamic modeling and control of VCCs with imposed heat flux at the evaporator. The steady-state optimization is based on conflicting objectives of compressor power and evaporator wall temperature. Where both objectives cannot be maximized simultaneously and the designer has to decide which solution is the best solution for a particular application. The dynamic model is based on a lumped parameter approach for the evaporator and condenser dynamics, while the compressor, expansion valve and accumulator are modeled as static components. The model is used for controller design and a experimental validation for changes in heat load is presented.

K-2. Thermoelectric transport modeling and device design for solid-state cooling

Eduardo E. Castillo, Yanliang Zhang, Theodorian Borca-Tasciuc
Department of Mechanical, Aerospace, and Nuclear Engineering
Rensselaer Polytechnic Institute, Troy NY 12180

Recent advances in nanomaterials for thermoelectric devices enable new solid state cooling, heating, power generation, and thermal management systems. Device applications employing nano and micro structures encounter challenges due to the parasitic effects imposed by the contacts and heat loses across the electrodes and substrates; effects usually neglected at macroscale. This work presents an analysis of thermoelectric systems developed using analytical modeling and discusses examples across multiscales, from nanowire heat pumps, to microscale heat spreaders, and compact refrigeration units. Optimized designs that employ solid-state thermoelectrics can lead to unparalleled capabilities for power dissipation from hot spots and competitive coefficients of performance. A comprehensive strategy for thermoelectric transport characterization of thermoelectric transport properties and the electrical and thermal contacts is also presented; the strategy was validated on mm-scale samples (Rev. Sci. Instrum. 81, 044902, 2010).
K-3. Thermal-Fluid Instability Analysis and Optimizing Control in Two-Phase Pump Cooling Systems

TieJun (TJ) Zhang, Fernando Lizarralde, Daniel T. Pollock, John T. Wen, Yoav Peles, Michael K. Jensen
MANE & ECSE Depts, Rensselaer Polytechnic Institute, USA

Two-loop cooling systems, consisting of a single-phase pumped loop and a vapor compression refrigeration cycle, have great potential for ultra high-power electronics cooling. Boiling heat transfer is utilized in the pumped liquid loop to reduce thermal energy transport resistance. Various dynamic flow boiling instabilities have been observed in these two-phase cooling systems and identified as critical obstacles for cooling performance enhancement. This poster presents a family of dynamic instability analysis and active thermal-fluid control strategies to exploit heat removal capability and energy efficiency. An adaptive extremum seeking control approach is developed to estimate the heat transfer coefficient (HTC) based on the device wall temperature measurement, and then the control system adjusts the flow rate to achieve the maximum HTC. A novel non-identical parallel-channel heat sink design is proposed to increase the total heat transfer surface area while maintaining the system controllability. With a model-based predictive pump flow controller, the unevenly distributed vapor/liquid flow among parallel channels can be successfully regulated so that a balanced two-phase flow is attained. An experimental two-loop cooling system prototype is introduced.

K-4. Active Flow Control Applications

Professor Miki Amitay
Mechanical, Aerospace and Nuclear Engineering, Rensselaer Polytechnic Institute

Active flow control holds tremendous promise for expanding the performance of current air vehicles and enabling revolutionary concepts for advanced vehicle designs. A novel flow control technique that involves modification of the aerodynamic performance of the vehicle via embedded miniature synthetic (zero-net-mass-flux) jet actuators has been demonstrated. The effect of this technique has been demonstrated on various aerodynamic bodies. Recent experiments show that, for some cases, flow control can replace conventional control surfaces for vehicle maneuverability. This mechanical simplicity makes the application of active flow control particularly attractive for the development of future fixed- and rotating-wing mini, micro UAVs, as well as wind turbines.
L. Nanoscale Engineering

L-1. Creep behavior of Graphene platelet-epoxy nanocomposites

Ardavan Zandiatashbar, Nikhil Koratkar, and Catalin R. Picu
Rensselaer Polytechnic Institute, Troy, New York 12180

Carbon-based epoxy nanocomposites attracted attentions due to their interesting mechanical properties and potential applications. Examples of applications include structural components subjected to vibrations such as those in the aerospace industry, and adhesives used in civil engineering and other fields. The mechanical properties of these composites are central in all these applications. In this study, the time-dependent mechanical properties and more specifically the creep behavior are investigated at the macro and nano-scale by means of classical macroscopic testing and nanoindentation. Significant creep rate reduction is observed both at the macro and nanoscale in epoxy filled with 0.1wt% graphene. The creep response in composites filled with more graphene (but below 0.5wt%) was similar to that in pure epoxy.

L-2. High Thermal Conductivity Ag/Epoxy Composites Based on Self-Constructed Nanostructured Metallic Networks

Kamyar Pashayi ¹, Hafez Raeisi Fard ¹, Fengyuan Lai ², Joel Plawsky ³, Theodorian Borca-Tasciuc ¹
¹ Department of Mechanical, Aeronautical and Nuclear Engineering
² Department of Materials Science and Engineering
³ Department of Chemical and Biological Engineering
Rensselaer Polytechnic Institute, Troy, NY 12180

We demonstrate increases in thermal conductivity by more than two orders of magnitude for epoxy nanocomposites filled with 30 vol% of 20 nm diameter silver nanoparticles. However, this effect is not observed in microcomposites processed under similar conditions and filled with 30 vol% of 1.8-4.2 μm diameter silver microparticles. Here, the thermal conductivity remains low (~0.6 W/mK) indicating the presence of new heat transfer pathways in the nanocomposite. The predictions of Maxwell-Garnett and Maxwell-Eucken models agree well with the measured thermal conductivities of nanoparticle and microparticle composites respectively. Electron microscopy studies prove the formation of the self-constructed conductive silver networks in the nanocomposite but not in the microcomposite where the microparticles are incapable of sintering to form the conductive paths at the processing temperature.

L-3. Nano/micro-Scale Manufacturing and Material Design

Johnson Samuel, Nikhil Koratkar, Sandipan Mishra
Mechanical, Aerospace and Nuclear Engineering Department
This poster highlights some of the key manufacturing research areas being investigated at the newly-established Nano/Micro-scale Manufacturing and Material Design Laboratory (Nano-M3 Design Lab) at Rensselaer. The specific areas that are highlighted include: 1) Designing material micro/nano-structure for engineering functionality and manufacturability; 2) Developing sustainable cutting fluids for micro-machining operations; and 3) Developing a printing-based high-throughput additive manufacturing process for sub-micron textured surfaces. The materials and manufacturing processes being investigated span the areas of health-care, sustainability, and defense. Specific material systems include nanocomposites (polymer and metal-based), sustainable hierarchical-composites, bone, medical implant materials, bulk metallic glasses and self-healing composites. The manufacturing processes being investigated include mechanical micro-machining processes such as micro-milling/drilling/turning, and non-conventional manufacturing processes such as micro-electrical discharge machining and electrohydrodynamic-jet printing.

L-4. High-Precision Control of Nano-/Micro-scale Manufacturing Systems

Xuemei Gao, Sandipan Mishra
Mechanical, Aerospace, and Nuclear Engineering, Rensselaer Polytechnic Institute.

This poster highlights our research efforts in the general area of instrumentation and control of micro- and nano-scale manufacturing processes. In particular, we present the role of instrumentation and control for a specific sub-micron scale additive process — Electrohydrodynamic Jet (E-jet) printing.

Our current research in this area includes (1) the development of automated tuning algorithms for “plug and play” controllers, (2) integrated process and motion control for E-jet printing, and (3) a physics-based control-oriented modeling paradigm and control strategy to realize high-speed high-fidelity E-jet printing process.
M. Modeling, Simulation, Computation

M-1. Understanding Cracking and Defect Formation during AlN Crystal Growth

Antoinette Maniatty (RPI), Payman Karvanirabori (RPI), Kristen Lee (RPI), Matthew Miller (Cornell), and Robert Bondokov (Crystal IS)

Aluminum Nitride (AlN) single crystals possess some excellent properties including a very large band gap, high thermal conductivity, and low electrical resistivity, making AlN well-suited for applications in high power and high frequency electronic and photonic devices, such as ultraviolet (UV) light emitting diodes. The growth process of AlN at high temperature leads to thermal stress induced cracks and defects leading to low yield and high manufacturing cost. In order to predict stresses and dislocation density, the growth furnace is modeled in ABAQUS and the acquired temperature field history is mapped onto a 3D crystal model which has been implemented into the parallel finite element framework for high fidelity simulations of the crystal during cooldown. The results, including the mechanical response of the crystal, are being analyzed to correlate the thermal stresses to the probability of cracking in AlN crystal. A dislocation based crystal plasticity model is being developed to implement into the model for a more accurate calculation of the stress field and for prediction of dislocation defect density.

M-2. The Computational Center for Nanotechnology Innovations (CCNI): A powerful partner for cutting-edge research and industrial competitive advantage.

James Myers\textsuperscript{1}, Jackie Stampalia\textsuperscript{1}, Michael Henesey\textsuperscript{2}

\textsuperscript{1}Computational Center for Nanotechnology Innovations, Rensselaer Polytechnic Institute
\textsuperscript{2}International Business Machines

The Computational Center for Nanotechnology Innovations (CCNI) was launched in 2007 with the deployment of the world’s 7th largest computer through the combined efforts of Rensselaer, New York State, and IBM. With the stated mission to support the development and deployment of innovative nanotechnologies across a wide array of industries, CCNI has quickly become a vital resource for a very broad range of Rensselaer researchers and their New York State colleagues and a powerful competitive advantage for New York State industry in nanotechnology and beyond. With flexible use and partnership models, and the ability to provide a combination of computational resources, training, and computational and cyberinfrastructure research and development as required, CCNI can be a highly effective partner in the development and application of new modeling techniques as well as an efficient provider of increased capacity for the production use of existing high-performance computing applications and services.
N. Education and Outreach

N-1. FIRST Robotics: filling the STEM pipeline

Paul Schoch
Center for Initiatives in Pre-College Education, Rensselaer Polytechnic Institute

FRC Team 1493
Albany High School

The FIRST Robotics Competition, FRC, has proved to be effective in motivating students to pursue degrees in Science, Technology, Engineering and Math. High school students and teachers team up with mentors from industry and academia to build robots and compete in regional competitions. Rensselaer, (with support from National Grid, BAE Systems, CATS and NYSTAR,) works closely with Albany High School FRC Team 1493. The Rensselaer Technology Park provided space for a full size practice field used the 7 area teams this season. Each year a robot is designed, built, tested and shipped during a 6 week build period. Competitions are held in over 49 regional events followed by a championship competition at the end of the season. During the off season FRC teams reach out to younger students by doing demos of their robots to middle school students, to girl and boy scout troops, at school open houses, town fairs, and as part of summer enrichment programs. Over 52,000 high school students participated in the FRC this year.

N-2. Interactive Technologies and LEGO Robotics in STEM Teaching and Learning

Josephine C. Seddon, Paul Schoch, Jordan Vener, Michele Murray
Center for Initiatives in Pre-College Education (CIPCE), Rensselaer Polytechnic Institute

Rensselaer’s Center for Initiatives in Pre-College Education (CIPCE) continues to develop STEM-based teaching and learning resources featuring LEGO Robotics and other interactive technologies. Programs are created for and implemented with K-12 teachers and students as well as college level Mathematics Education students who will be entering the K-12 educational system as teachers. Activities are designed for use in MST classrooms to teach and motivate the application of NYS standards-based mathematics and science concepts. Additionally, CIPCE’s afterschool and summer Robotics Engineering Academies for students are supported by a team of undergraduate students at Rensselaer Polytechnic Institute who serve as mentors to hundreds of K-12 students each year. CIPCE hosts FIRST LEGO League tournaments and qualifiers to further encourage pre-college students to consider STEM-based study and careers by engaging them in hands-on inquiry-based activities in an exciting environment.
N-3. Mobile Studio Environments to Enhance STEM Education

Ken Connor, Mohamed Chouikha, Dianna Newman Bill Brubaker, Deborah Walters, Yacob Astatke, Judy O’Rourke

Rensselaer Polytechnic Institute, Howard University, Rose-Hulman, University at Albany, Morgan State University, St. Rose

STEM education with significant engineering content at all levels from kindergarten through grad school generally requires expensive, complex equipment and thus is typically built around elaborate facilities with well-trained staff support. Mobile Studio Pedagogy (using the Mobile Studio Desktop software and the I/O board) makes it possible for students to carry their enthusiasm for engineering and science from the classroom to any place they have a computer. It gives them access any time and any place to a full electronics laboratory for the price of a textbook. Students have a portable lab in which tinkering is again possible; requiring only a spark of interest - not a big budget. With a good start provided by interested and dedicated teachers, student accomplishments are only limited by their imagination.

With the Mobile Studio, teachers are also free to reconfigure their courses, especially those with significant lab/experimental content, in quite new ways. Many instrumentation-based course offerings can now be held in normal classrooms rather than in specially outfitted facilities. It is no longer necessary to tie students and instructors to the usual lectures, recitations and labs, especially since it is possible to give hardware-based homework. When combined with online lectures and paper and pencil homework, we are now free to organize courses in ways we would never have imagined in the past.

The Mobile Studio Project is now being utilized to enhance STEM education around the world. The Mobile Studio learning platform began development at three schools, where it has been used to teach Electrical Engineering courses for both majors and non-majors. This activity has recently been expanded to additional schools with some notable early success that demonstrates how this approach can be transferred elsewhere, eventually improving programs at the original partner schools. Content development continues at several schools with new partners being added, including some in Africa. In addition to application in Electrical Engineering education and outreach, Mobile Studio materials are being developed by and for students in Adolescent Education and Computer Science at a small liberal arts college. Activities at all involved schools have added significantly to the value of Mobile Studio pedagogy.

N-4. Veggie Logistics

Darren Grove, Jon Watts

Capital District Community Gardens

Veggie Mobile, as a subsidiary of the Capital District Community Gardens, is a project designed to regularly deliver fresh produce to low income seniors and people in need. Through the use of the Veggie Mobile truck, it is possible to bring the grocery store to the customers directly. This program has not only improved the overall health of seniors, but also gives them a chance to be a part of a regular social
event. As with many nonprofit organizations, Veggie Mobile's major source of funding is through grants, which requires submitting data and reports related to sales and inventory history. The current system that Veggie Mobile uses to track this information is very labor intensive and incomplete. The RPI Capstone Design team will implement a streamlined system from point-of-sale on the truck to reporting and planning at the office.
Exhibitors

BullEx Digital Safety

BullEx was formed by engineers with experience in occupational safety and the fire service. Tired of gathering dozens of extinguishers before training sessions, trying to light a dangerous fuel mixture with a flare, “tasting” dry-chemical all day, complaints of dry-chemical coating cars and clothes, and cleaning up parking lots, our founders knew there had to be a better way to conduct this important fire safety training.

BullEx worked with hundreds of safety officials and fire service leaders to develop patented technology which enables our simulators to actually sense where the trainee aims and sweeps. Coupling this capability with a sophisticated on-board flame control system, BullEx was able to develop the world’s most advanced fire extinguisher training systems.

From the founding of BullEx, we have focused on developing new innovative technologies for fire, safety and emergency response training. BullEx technologies range from fire extinguisher training to comprehensive, large-scale simulation environments. With thousands of customers worldwide, BullEx is the new, global leader in fire training technology.

Center for Advanced Ceramic Technology (CACT) at Alfred University

The Center for Advanced Ceramic Technology (CACT) at Alfred University is unlike any research center of its kind. At the CACT, we specialize in applied and technical research that solves real-world problems and converts to practicable, scalable and marketable products and solutions. We can help you develop next-generation products or create new ones. Even better, when you conduct research with us, we help you interpret the results. In addition, we can put you in touch with other organizations to help you achieve your goals. At Alfred University’s CACT, you get everything you need to advance your company’s research and boost your bottom line.

Center for Automation Technologies and Systems, Rensselaer Polytechnic Institute

The Rensselaer Center for Automation Technologies and Systems (CATS) at Rensselaer Polytechnic Institute is a NYSTAR-designated Center for Advanced Technology that focuses its research on all aspects of automation and control in manufacturing and operations across its active thrust areas: energy-related systems and manufacturing, thermal management, active flow control, nanomanufacturing and biotechnology/biomanufacturing; and, its core application areas: manufacturing automation, precision motion and assembly, sensing and monitoring, and modeling and design. Automation is a key enabling technology for manufacturers in all industries to compete in the new economy.
Rensselaer CATS partners with companies, both small and large, throughout New York State to develop system-level solutions for high-impact, industrially driven projects – expanding and extending the traditional university-industry research model by conducting research programs that are motivated by industry needs and market opportunities rather than academic curiosity alone. The CATS has an outstanding track record helping its partner companies deliver economic impact to the New York State economy, and also collaborates with the federal government and other universities to further leverage the Center’s research, and New York’s technology investment.

Center for Economic Growth (CEG)

Since 1987, the Center for Economic Growth (CEG) has been committed to fostering visionary economic growth throughout the 11-county Capital Region, as well as a significant portion of the Tech Valley corridor.

As a private, not-for-profit organization we work with a diverse group of members and partners to advance the ability of the region and its assets to succeed in the global marketplace. With a focused and strategic approach we work to:

- **GROW** local companies by offering tactical business development strategies and services;
- **ATTRACT** opportunities for technology investment and expansion throughout Tech Valley and
- **PREPARE** communities to achieve their desired economic growth while enhancing the region’s excellent quality of life

Center for Future Energy Systems (CFES), Rensselaer Polytechnic Institute

The Center for Future Energy Systems (CFES) CFES is the Energy - Center for Advanced Technology (Energy CAT) in New York State and is funded by NYSTAR (New York State Office of Science, Technology and Innovation) and industrial partners. CFES conducts fundamental and applied research to accelerate the development of energy efficient and renewable energy technologies. Working with other academic and government institutions, and with many industry partners, we focus on the development and application of new energy materials, devices and systems. Project areas include low cost, high efficiency photovoltaic solar cells, wind turbine blade performance enhancement, advanced lighting sources, fuel cell testing and characterization, smart buildings, energy storage technologies, renewable energy grid integration, microgrid, and smart grid. CFES brings the academic research, knowledge, and technology of Rensselaer Polytechnic Institute (RPI) together with partners Cornell and Brookhaven National Laboratory to promote collaborative efforts with industry. We look forward to working with you.
Center for Initiatives in Pre-College Education (CIPCE), Rensselaer Polytechnic Institute

The Center for Initiatives in Pre-College Education (CIPCE) is an official pre-college outreach arm of Rensselaer Polytechnic Institute. As such, it is committed to working with K-12 students and teachers on inquiry-based, pedagogical approaches to teaching, and introducing teachers to some of the more compelling interactive technologies that have proven to be effective classroom tools. We offer many programs for both teachers and students, and support educational technologies both for in-school and afterschool initiatives.

FIRST Robotics Competition (FRC)

The FIRST Robotics Competition, FRC, has proved to be effective in motivating students to pursue degrees in Science, Technology, Engineering and Math. High school students and teachers team up with mentors from industry and academia to build robots and compete in regional competitions. Rensselaer, (with support from National Grid, BAE Systems, CATS and NYSTAR,) works closely with Albany High School FRC Team 1493. The Rensselaer Technology Park provided space for a full size practice field used the 7 area teams this season. Each year a robot is designed, built, tested and shipped during a 6 week build period. Competitions are held in over 49 regional events followed by a championship competition at the end of the season. During the off season FRC teams reach out to younger students by doing demos of their robots to middle school students, to girl and boy scout troops, at school open houses, town fairs, and as part of summer enrichment programs. Over 52,000 high school students participated in the FRC this year.

MPI, Inc.

MPI is the worldwide leader in wax-room equipment and has been involved in the investment casting industry since 1972...longer than any of our competitors. As the acknowledged leader in wax-room innovations, MPI has developed and introduced more systems and products than all of our competition combined.

Our mission is simple – to be the most technically advanced supplier of wax-room equipment in the casting industry and to provide customers with throughput solutions that yield the highest return on their equipment investment.

Precision Valve & Automations, Inc.

For over 15 years, PVA has supplied the world with innovative fluid dispensing solutions that remain at the forefront of motion and application technology. PVA’s customer driven solutions are utilized worldwide in industries ranging from solar, semiconductor packaging, printed circuit board assembly, medical device manufacturing, and consumer electronics. Throughout the changing global
manufacturing landscape, PVA remains committed to providing our customers with exceptional products and industry-leading global support that far exceeds expectations.

**Smart Lighting Research Center (ERC), Rensselaer Polytechnic Institute**

Imagine a world where efficient, digital lighting makes us healthier and more productive, produces significant energy savings, and even provides wireless, optical access to the internet. The Smart Lighting Engineering Research Center will develop new technologies and applications that will change the way society uses lighting. Engineered Smart Lighting Systems will optically sense the environment to provide energy efficient, comfortable illumination when and where it is needed. Beyond illumination, Smart Lighting Systems will simultaneously provide high-speed data access and scan for biological and biochemical hazards.

**Sono-Tek Corporation**

Sono-Tek Corporation is a world leader in ultrasonic nozzle systems for applying precise, thin film coatings. Major industries utilizing our ultrasonic atomization systems include electronics - printed circuit board fluxing, medical nanocoatings such as implantable device coatings onto stents, catheters, balloons and pacemakers, fuel cell PEMs, thin film solar cells, phosphoric doping, anti reflection coatings, CIGs, float glass coatings, pan release coatings for commercial baking, spray drying, carbon nanotube suspensions, and any other spray application requiring uniform deposition with minimal overspray.
New York State Economic Impact

CATS Economic Impact 2006-2010

CATS Impact on Small Companies
2010 Industrial Clients/Partners

- Advanced Acoustic Concepts, Hauppauge, NY
- Analog Devices Inc. (ADI), Norwood, MA
- Barron Associates, Charlottesville, VA
- BASF Fuel Cell, GmbH, Somerset, NJ
- Boeing, Seattle, WA
- Brown Coach, Amsterdam, NY
- Ceralink, Troy, NY
- Construction Robotics, Jamesville, NY
- Crystal-IS, Green Island, NY
- Dock-n-Lock, Great Barrington, MA
- Ducommun Aerostructures, Coxsackie, NY
- Ener-G-Rotors, Rotterdam, NY
- General Electric, Niskayuna, NY
- GlobalFoundries, Malta, NY
- IBM, Armonk, NY
- Infoscitex, Waltham, MA
- InterScience, Troy, NY
- Kintz Plastics, Howes Cave, NY
- Kitware, Clifton Park, NY
- Knolls Atomic Power Laboratory (KAPL), Niskayuna, NY
- Lockheed Martin, Syracuse, NY
- MechX Engineering, Scotia, NY
- MPI, Poughkeepsie, NY
- Northrop Grumman, Bethpage, NY
- NYISO, Rensselaer, NY
- O’Brien & Gere, Syracuse, NY
- Paper Battery Company, Troy, NY
- Progress Machine and Design (PMD), Victor, NY
- Sentient Corp., Idaho Falls, ID
- Simmetrix, Clifton Park, NY
- Somstech, Valhalia, NY
- Thorlabs, Newton, NJ
- Ultralife, Newark, NY
- X-Ray Optical Systems, East Greenbush, NY
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- Associate Director of Manufacturing: Dan Walczyk
- Program Director for Industrial Automation: Ray Puffer
- Research Scientist: Steve Rock
- Senior Research Engineer: Glenn Saunders
- Research Engineer: Justin Gullotta
- Research Technician: Kenneth Myer
- Business Analyst: Heidi Merrill
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