Michigan Tech ECE Overview

Daniel R. Fuhrmann
Professor and Chair
Department of Electrical and Computer Engineering

June 24, 2014
Michigan Tech Mission and Vision

Mission:

*We prepare students to create the future*

Vision:

*Michigan Tech will grow as a premier research university of international stature, delivering education, new knowledge, and innovation for the needs of our technological world.*

Source: MTU Strategic Plan
A PROUD HISTORY

Electrical engineers, computer engineers, and computer scientists can take a lot of credit for creating the 20th century. Michigan Tech was there every step of the way.
# ECE Faculty Profile (Fall 2013)

<table>
<thead>
<tr>
<th>Technical Area</th>
<th>Assistant Professor</th>
<th>Associate Professor</th>
<th>Professor</th>
<th>Lecturer (all ranks)</th>
<th>Instructor</th>
<th>Professor of Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power and Energy</td>
<td>2-2/3</td>
<td>2</td>
<td>1-1/3</td>
<td></td>
<td>1/3</td>
<td></td>
</tr>
<tr>
<td>Signals and Systems</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td></td>
<td>1/6</td>
<td></td>
</tr>
<tr>
<td>Electrophysics</td>
<td>1-1/3</td>
<td>3</td>
<td>2</td>
<td></td>
<td>1/3</td>
<td></td>
</tr>
<tr>
<td>Computer Engineering</td>
<td>3-2/3</td>
<td>1-1/3</td>
<td>2/3</td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>General/ Administrative</td>
<td></td>
<td></td>
<td>1 (Chair)</td>
<td>1 (Associate Chair)</td>
<td>1/2</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>TTT</th>
<th>1 on sabbatical</th>
<th>NTT</th>
<th>1 on leave - NSF</th>
<th>total</th>
<th>2 post-docs</th>
</tr>
</thead>
<tbody>
<tr>
<td>25.0</td>
<td></td>
<td></td>
<td>4.3</td>
<td></td>
<td>29.3</td>
<td></td>
</tr>
</tbody>
</table>
# Staff

<table>
<thead>
<tr>
<th>Position</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office Manager and Technical Communication Specialist</td>
<td>Lisa Rouleau</td>
</tr>
<tr>
<td>Undergraduate Advisor</td>
<td>Judy Donahue</td>
</tr>
<tr>
<td>Undergraduate Advisor (part-time)</td>
<td>Trever Hassell</td>
</tr>
<tr>
<td>Administrative Aide (Graduate Programs)</td>
<td>Brittany Buschell</td>
</tr>
<tr>
<td>Staff Assistant</td>
<td>Michele Kamppinen</td>
</tr>
<tr>
<td>Laboratory Supervisor</td>
<td>Chuck Sannes</td>
</tr>
<tr>
<td>Research Associate</td>
<td>Mark Sloat</td>
</tr>
<tr>
<td>Research Associate</td>
<td>John Kolacz (55%)</td>
</tr>
<tr>
<td>Director, Microfabrication Facility</td>
<td>unfilled</td>
</tr>
</tbody>
</table>
## Students (Fall 2013)

<table>
<thead>
<tr>
<th></th>
<th>Electrical Engineering</th>
<th>Computer Engineering</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undergraduate</td>
<td>367</td>
<td>231</td>
<td>598</td>
</tr>
<tr>
<td>MS</td>
<td>167</td>
<td>19</td>
<td>186</td>
</tr>
<tr>
<td>PhD</td>
<td>59</td>
<td>9</td>
<td>68</td>
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</table>
ACADEMIC PROGRAMS
# Bachelor of Science in Electrical Engineering

<table>
<thead>
<tr>
<th>Category</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Education</td>
<td>28</td>
</tr>
<tr>
<td>Mathematics</td>
<td>19</td>
</tr>
<tr>
<td>Basic Science</td>
<td>8</td>
</tr>
<tr>
<td>Engineering Fundamentals</td>
<td>6</td>
</tr>
<tr>
<td>Computer Science</td>
<td>3</td>
</tr>
<tr>
<td>Electrical Engineering Core</td>
<td>28</td>
</tr>
<tr>
<td>Electrical Engineering Electives</td>
<td>27</td>
</tr>
<tr>
<td>Senior Design</td>
<td>6</td>
</tr>
<tr>
<td>Free Electives</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>128</strong></td>
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</tbody>
</table>
BSEE Core Courses

EE 1110  Essential Mathematics for Electrical Engineering
EE 2111  Electrical Circuits I
EE 2112  Electrical Circuits II (+ lab)
EE 2174  Digital Logic (+ lab)
EE 3120  Introduction to Energy Systems
EE 3131  Electronics (+ lab)
EE 3140  Electromagnetics
EE 3160  Linear Systems and Control
EE 3171  Microprocessors (+ lab)
EE 3180  Probability and Signal Analysis
EE 3250  Communication Systems
EE 3162  Control Systems
# Bachelor of Science in Computer Engineering

<table>
<thead>
<tr>
<th>Category</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Education</td>
<td>28</td>
</tr>
<tr>
<td>Mathematics</td>
<td>15</td>
</tr>
<tr>
<td>Basic Science</td>
<td>8</td>
</tr>
<tr>
<td>Engineering Fundamentals</td>
<td>6</td>
</tr>
<tr>
<td>Computer Science Core</td>
<td>26</td>
</tr>
<tr>
<td>Electrical Engineering Core</td>
<td>26</td>
</tr>
<tr>
<td>Cpe Electives (EE, CS, Math)</td>
<td>9</td>
</tr>
<tr>
<td>Senior Design</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>128</strong></td>
</tr>
</tbody>
</table>
BSCpE Core Courses

CS 1121  Introduction to Computer Science I
CS 1122  Introduction to Computer Science II
CS 1141  C/C++ Programming
CS 2311  Discrete Structures
CS 2321  Data Structures
CS 3331  Concurrent Programming*
CS 3421  Computer Organization
CS 4321  Intro to Algorithms
CS 4461  Computer Networks

EE 1110  Essential Math for EE
EE 2111  Electric Circuits I
EE 2112  Electric Circuits II (+lab)
EE 2174  Digital Logic (+lab)
EE 3131  Electronics
EE 3160  Linear Systems and Control*
EE 3173  Hardware/Software Integration (+lab)
EE 4431  Computer Architecture (+lab)

*choose one
Outstanding Teaching Laboratories
Senior Design Projects

2011-2014 sponsors:

- Nexteer Automotive
- International Transmission Corporation
- BAE Systems
- 3M Corporation
- ArcelorMittal
- East Jordan Iron Works
- Harris Corporation
- U. S. Department of Energy
- Cinetic Automotive
- Union Pacific
- American Transmission Company
- Ford
- Chrysler
- DTE Energy
- American Time Corporation
- ZA Technologies
- Eaton
Enterprises

Wireless Communication Enterprise

Blue Marble Security

Automotive Computing Enterprise/Hybrid Electric Vehicle Enterprise
Undergraduate Enrollment

S/F ratio 20.4
Master of Science in EE/CpE

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>ECE 5000-level courses</td>
<td>18</td>
</tr>
<tr>
<td>Electives</td>
<td>12</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>30</strong></td>
</tr>
</tbody>
</table>

Plan A: thesis (9 credits typical)

Plan B: project (6 credits typical)

Plan D: coursework only
Online Energy Education in ECE

<table>
<thead>
<tr>
<th>Courses</th>
<th>Certificate</th>
<th>Adv Cert</th>
<th>MSEE</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 3010 – Circuit Analysis</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EE 3120 – Energy Conversion, Renewables</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EE 4221 – Power Systems I</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>EE 4222 – Power Systems II</td>
<td>✔</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>EE 4227 – Power Electronics</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>EE 5200 – Advanced Analysis of Pwr Syst</td>
<td>✔</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>EE 5220 – Transient Simulation (EMTP)</td>
<td>✔</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>EE 5221 – Advanced Machines &amp; Drives</td>
<td>✔</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>EE 4223/5223 – Power System Protection</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>EE 5230 – System Operation</td>
<td>✔</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>EE 5240 – Computer Methods</td>
<td>✔</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>EE 4225/5250 – Distribution Systems</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>EE 5260 – Wind Power &amp; Grid Integration</td>
<td>✔</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>EE 6210 – Power System Stability</td>
<td>✔</td>
<td></td>
<td>✔</td>
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## PhD in EE/CpE

<table>
<thead>
<tr>
<th>Coursework</th>
<th>30</th>
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<tbody>
<tr>
<td>Research</td>
<td>30</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>60</strong></td>
</tr>
</tbody>
</table>

- Written qualifying exam (breadth at UG level)
- Oral qualifying exam (depth at graduate level)
- Dissertation proposal
- Dissertation
- Dissertation defense
PhD Enrollment and Graduation

**PHD ENROLLMENT**

**PHD GRADUATES**
RESEARCH
## Research Programs – Key Metrics

<table>
<thead>
<tr>
<th></th>
<th>FY08</th>
<th>FY09</th>
<th>FY10</th>
<th>FY11</th>
<th>FY12</th>
<th>FY13</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Research Expenditures</strong></td>
<td>2.74M</td>
<td>2.21M</td>
<td>2.77M</td>
<td>2.45M</td>
<td>2.04M</td>
<td>1.60M</td>
</tr>
<tr>
<td><strong>Journal Publications</strong></td>
<td>22</td>
<td>19</td>
<td>27</td>
<td>26</td>
<td>43</td>
<td>65</td>
</tr>
</tbody>
</table>
Michael C. Roggemann
Professor

✦ **Optical Information Processing**
  – multisensor information fusion
  – plenoptic cameras and image reconstruction
  – high-speed optical communication

✦ **Atmospheric Turbulence**
  – measurement and monitoring systems
  – laser beam projection and imaging through turbulence

✦ **Adaptive Optics**
  – MEMS systems for adaptive optics
  – beam control and steering

**Educational Interests**: Educating US citizen MS and Ph.D. students for jobs in the aerospace industry in the areas described above, and related areas.

**Research Funding**: ongoing project in sensor fusion with AFRL; recently awarded a MURI (Multi-University Research Initiative) grant with the University of Dayton and four other universities in “Wave Optics of Deep Atmospheric Turbulence”
Zhi (Gerry) Tian  
Professor

✧ Cognitive Radio Networks  
  – wideband spectrum sensing  
  – joint dynamic resource allocation and waveform adaptation

✧ Wireless Sensor Networks  
  – sparse event detection in large scale networks  
  – decentralized information processing and optimization

✧ Compressed Sensing and Sparse Signal Recovery

Daniel R. Fuhrmann
Professor and Chair

Radar Signal Processing

✓ Multiple-Input Multiple-Output (MIMO) Radar
✓ Adaptive Sensing and Target Tracking
✓ Target Models for Multistatic Radar
✓ Synchronization of Multiple Transmitters
✓ Hybrid MIMO Phased-Array Radar
✓ Radar System Simulation
✓ Continuous Phase Modulation
Research Activity: PERC
Power and Energy Research Center

Alternative Energy

Power Systems

PERC

Power Electronics
✧ **Power Electronics**
  - Energy Conversion
  - Non-linear and optimal control methods.
  - Thermal control

✧ **Micro Grids**
  - Decentralized control based on game theory.
  - Renewable energy integration

✧ **Hybrid and Electric Vehicles.**
  - Electric propulsion drive train
  - Grid Integration

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*Wayne Weaver*

Associate Professor

*Michigan Tech*
Power Grid Cybersecurity

Control Center Framework

Substation Automation

Research Focus:
- Cyber-physical Dependency Modeling
- Anomaly Detection
- Hypothesized Impact Evaluation
- Data Validation against Cyber-Tampering
- Mitigation Strategies

Utilization of Geographic Information System (GIS) for Cyber-Related Assessment

Chee-Wooi Ten
Assistant Professor

Michigan Tech
Create the Future
Research Activity: MuSTI
Multiscale Technologies Institute

Home department: Mechanical Engineering & Engineering Mechanics
Microfabrication Facility managed by ECE

- Carbon nanotubes
- Single-electron transistors
- Nano-magneto-photonic rotation sensor
- MEMS chemical vapor sensor
- Protein-based toxin nanosensor
- Electric propulsion
Elena Semouchkina
Associate Professor
Adjunct Professor, Pennsylvania State University

Research Focus:
- Electromagnetics
- Microwave and photonic devices
- Materials
- Metamaterials

- Computational electromagnetic analysis
- Computer-aided design of microwave and photonic devices
- Electromagnetic metamaterials and their applications
- Materials integration for device prototyping
- Materials and device characterization at microwaves

Dielectric resonators form cloaking shell surrounding metal cylinder

The incident wave front is reconstructed after it passes metal object, i.e. the shell makes the object invisible

Invisibility Cloaks for the Infrared and Microwaves Designed from Dielectric Resonators
Chris Middlebrook
Associate Professor

Highlighted Areas of Research:
- Integrated Optics
- Micro-projection

Micro-projection Goal: Reduce laser speckle to allow bright laser sources to be used in micro-projectors

Integrated Optics Goal: Overcome the copper transmission line communication limitation using integrated optical waveguides

Onsite Fabrication Test and Evaluation Modeling
Massively parallel programming solutions:

- structure the algorithm so that concurrency can be exploited
- dependences need to be identified and managed
- implement the algorithm in a suitable programming environment
- execute and tune the performance of the code on a parallel system like GPUs

Hardware Solutions:

- hardware gives flexible means to exploit parallelism efficiently (both at macro and micro levels)
- allows reduction in data dependencies
- enables employing specialized memory
- allows for flexible data path to optimize computation for an application

Saeid Nooshabadi
Professor
Design Automation Group

The design automation group develops efficient computer-aided (CAD) algorithms for modeling, simulation and optimization of large-scale VLSI systems. Our current research projects include:

- Parallel circuit simulation on emerging graphics multi/many-core computing platforms
- Analysis and optimization of large-scale power delivery networks (PDNs)
- 3D integrated circuit (3D-IC) thermal analysis and optimization
- Statistical circuit modeling and simulation, statistical static timing analysis (SSTA)

Chao Hua
Asst. Professor
Alliance for Computing, Information, and Automation

An effort to bring together Electrical and Computer Engineering (ECE), Computer Science (CS), and School of Technology (SoT) closer together.

A new proposed “superstructure” to encourage collaboration and cooperation among the 3 units. **Ratified March 2014.**

- 3-person executive committee (ECE, CS, SoT) with rotating chair
- Common website
- Standing curriculum committee
- New research center, possible reorganization of existing centers
- “Federal” structure, units retain autonomy
Joint Efforts with ME-EM

Wayne Weaver
Associate Professor, Electrical and Computer Engineering
Dave House Associate Professor of Electrical Engineering

*Microgrids, power electronics, optimal control of power systems*

Lucía Gauchía
Assistant Professor, Electrical and Computer Engineering
Assistant Professor, Mechanical Engineering-Engineering Mechanics
Richard and Elizabeth Henes Asst. Professor of Energy Storage Systems

*Energy storage systems, state estimation for batteries and supercapacitors*

Bo Chen
Associate Professor, Mechanical Engineering-Engineering Mechanics
Associate Professor, Electrical and Computer Engineering
Dave House Associate Professor of Mechanical and Electrical Engineering

*Embedded systems, control, mechatronics*
Tim Schulz has stepped down as Dean of the College of Engineering and has joined the Center for Computer Systems Research. He is an expert in statistical image processing and digital photography. He will spend the 2014-2015 academic year on sabbatical at Duke University.
Electric and Hybrid Electric Vehicles

In 2012 the Automotive Computing Enterprise (ECE) merged with the Hybrid Electric Vehicle Enterprise (ME-EM), creating new opportunities for undergraduates and graduate students to develop skills in this important and emerging field.

2012 all-electric Ford Focus, gift to ECE from Ford Motor Company
Photo by DF
Industrial Control Systems

Industrial control is among the most highly sought-after skill sets by corporate recruiters at Career Fair, across a wide range of industry sectors.

Discussions regarding expanding our course offerings and laboratory capabilities are underway.

March 7: received a $255k gift from Nucor Steel for a named undergraduate Industrial Control Systems Laboratory.

Photos from infosecurity-magazine.com
QUESTIONS?