Breadth of Opportunities in Electrical and Systems Engineering

Arye Nehorai
Chair, The Eugene and Martha Lohman Professor of Electrical Engineering

www.ese.wustl.edu
Outline

• ESE areas and applications
• Our faculty
• Changes we made since 2006
• Flexible curricula and double degrees
• Undergraduate research projects
• Study abroad program
• Career opportunities
Areas & Applications

**Energy**
- Smart Grid, Storage
- Photovoltaic Cells
- Power Electronics
- Efficiency

**Applied Physics**
- Advanced Materials
- Integrated Photonics
- Nano-fabrication
- Devices

**Information**
- Imaging
- Signal Processing
- Information Theory
- Communications

**Systems**
- Applied Math
- Computational Math
- Optimization
- Control

**Robotics**
- Mechatronics
- Surgery

**Security & Defense**
- Radar, Sonar
- Sensors, Networks
- Information Analysis
- Environment Monitoring

**Medicine**
- Sensors
- Imaging
- Genomics
- Proteomics

**Systems Analysis**
- Biology
- Operations Research
- Management
- Finances

**Integrated Photonics**
- Advanced Materials
- Nano-fabrication
- Devices

**Robotics**
- Mechatronics
- Surgery
Degrees We Offer

**BS**
- Electrical Engineering
- Systems Science & Engineering

**Minors**
- Electrical Engineering
- Mechatronics (new)
- Robotics
- Energy Engineering (in development)
Meet the Faculty

Applied Physics

Daniel L. Rode
Jung-Tsung Shen
Barry E. Spielman
Lan Yang

Information Processing

R. Martin Arthur
Paul S. Min
Robert E. Morley
Arye Nehorai
Joseph A. O'Sullivan

Systems Science and Applied Mathematics

I. Norman Katz
Jr-Shin Li
Hiro Mukai
Ervin Y. Rodin
Heinz M. Schaettler
Tzyh-Jong Tam
Awards (2006 - 2009)

- Dr. Arye Nehorai received the 2006 Technical Achievement Award from the IEEE Signal Processing Society.
- Dr. Jr-Shin Li received the NSF CAREER Award: "Ensemble Control with Applications to Spectroscopy, Imaging, and Computation," 2007.
- Dr. Chris Byrnes is awarded the 2008 Hendrik W. Bode Lecture Prize by the IEEE.
- Dr. T. J. Tarn received the 2009 George Saridis Leadership Award in Robotics and Automation from the IEEE Robotics and Automation Society, in May 2009.
- Several faculty members have given a total of 10 keynote or plenary lectures in major conferences.
- Joshua York, ESE senior student, won First Place Award in the St. Louis Area Undergraduate Research Symposium (STLAURS) under the guidance of Dr. Nehorai, 2009.
Faculty Research and Leadership

MURI: Adaptive Waveform Design for Full Spectral Dominance

Arye Nehorai

- **Leading** multiuniversity research initiative (MURI), team from WUSTL, ASU, Harvard U, U of Maryland, Melbourne U*, Princeton U, Purdue U, UIC, and Raytheon*

- **Goal:** Adaptive optimal design waveforms for radar and communications

- **Approach:**
  - Electromagnetic modeling
  - Waveform mathematics
  - Statistical signal processing
  - Optimization

- **DoD/AFOSR funding:** $5.5m, 2005 to 2010

* Externally funded
Changes We Made (2006 – 2009)

- Improved the instruction
- Renovated our electronics lab
- Introduced new minors in Mechatronics and Energy (soon)
- Added lab to ESE 230 Intro to Electrical & Electronic Circuits
- Made EE senior design more flexible
- Expanded undergraduate research projects
- Collaborated with industry on projects
- Created a study abroad program in summer 2009
- Revitalized the IEEE student chapter
Bryan 306:

- Renovated 16 stations
- Purchased oscilloscopes, function generators, spectrum analyzers, power supplies, computers, and digital multimeters
Electronics Lab Renovation (Cont.)

Bryan 316:

• Purchased state-of-the-art National Instruments NI-Elvis II teaching platform and a dual-channel USB-based oscilloscope

• This enables students to master the concepts instead of dealing with the complexity of traditional equipment operation

We spent $114k on the renovation
New Courses

We introduced:

• ESE 103 Introduction to Electrical Engineering, Fall 2009
• ESE 105 Introduction to Electrical & Systems Engineering, Fall 2007
• ESE 107 Introduction to Sustainable Energy, Fall 2008
• ESE 230 Introduction to Electrical & Electronic Circuits, Fall 2008 (new version)
• ESE 497 Undergraduate Research, Fall 2007
Department of Electrical & Systems Engineering

Flexible Curricula and Double Degrees
### BS EE Curriculum: Electives

<table>
<thead>
<tr>
<th>Course Description</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Req/General:</td>
<td></td>
</tr>
<tr>
<td>Required CS Course:</td>
<td></td>
</tr>
<tr>
<td>CSE 131 or 126</td>
<td>4 or 3</td>
</tr>
<tr>
<td>EE Breadth:</td>
<td></td>
</tr>
<tr>
<td>Chosen from engineering or sciences outside EE</td>
<td>9</td>
</tr>
<tr>
<td>Required EE Courses:</td>
<td></td>
</tr>
<tr>
<td>ESE 230, 232, 260, ESE 317, 326, 330, 351, ESE 498.</td>
<td>26</td>
</tr>
<tr>
<td>Upper-level EE Laboratories:</td>
<td></td>
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<tr>
<td>Two chosen from: ESE 331, ESE 435, 447, 448, 465, 488</td>
<td>6</td>
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<tr>
<td>Elective EE Courses:</td>
<td></td>
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<tr>
<td>Chosen from: ESE 330-399, ESE 400, 402, 405, 407, 409, 425, 430-499, ESE 503-589</td>
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<tr>
<td>Non-ESE Engineering Elective:</td>
<td>3</td>
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<tr>
<td>ESE 141 Intro. Robotics:</td>
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</tr>
<tr>
<td>Humanities and Social sciences:</td>
<td>18</td>
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<tr>
<td>Free Electives:</td>
<td>11 or 12</td>
</tr>
<tr>
<td>Total</td>
<td>120</td>
</tr>
</tbody>
</table>

Students must complete a selection of courses for which the accumulated engineering topics is 45 units. Also certain restrictions apply about the total number of credits of ESE 400 (independent study) and ESE 497 (undergraduate research.)
Double Degree: BSAS EE and BS BME
Double Degree: BS EE and BS BME

Total number of credits: 146
Department of Electrical & Systems Engineering

BSEE Pre-Med

Pre-med Sample Plan

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 112A, Gen. Chemistry 2</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 152, Gen. Chemistry 2 Lab</td>
<td>2</td>
</tr>
<tr>
<td>BIO 2960, Principles of Biology 1</td>
<td>4</td>
</tr>
<tr>
<td>BIO 2970, Principles of Biology 2</td>
<td>4</td>
</tr>
<tr>
<td>BIO 3058, Physiological Control Systems</td>
<td>2</td>
</tr>
<tr>
<td>CHEM 251, Organic Chemistry 1</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 252, Organic Chemistry 2</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 257, Organic Chemistry Lab</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>23</strong></td>
</tr>
</tbody>
</table>
# Bachelor of Science in Electrical Engineering and Computer Engineering

## Double Degree: BSAS EE and BS CoE

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Semester 1</strong></td>
<td><strong>Semester 2</strong></td>
<td><strong>Semester 1</strong></td>
<td><strong>Semester 2</strong></td>
</tr>
<tr>
<td><strong>MATH 132</strong> Calculus II (3 credits)</td>
<td><strong>MATH 233</strong> Calculus III (4 credits)</td>
<td><strong>MATH 217</strong> Differential Equations (4 credits)</td>
<td><strong>ESE 317</strong> Engineering Mathematics (4 credits)</td>
</tr>
<tr>
<td><strong>PHYS 117A</strong> General Physics I (4 credits)</td>
<td><strong>PHYS 118A</strong> General Physics II (4 credits)</td>
<td><strong>ESE 230</strong> Intro to Electrical Engineering (3 credits)</td>
<td><strong>ESE 326</strong> Prob and Stats for Engineers (3 credits)</td>
</tr>
<tr>
<td><strong>CSE 131</strong> Intro. Computer Science I (4 credits)</td>
<td><strong>CSE 132</strong> Intro. Computer Science II (4 credits)</td>
<td><strong>ESE 232</strong> Electronic Circuits (3 credits)</td>
<td><strong>EE Elective with engineering units</strong> (3 credits)</td>
</tr>
<tr>
<td><strong>ESE 240</strong> Logic and Discrete Mathematics (3 credits)</td>
<td><strong>CHEM 111A</strong> General Chemistry I (3 credits)</td>
<td><strong>ESE 260</strong> Intro to Digital Logic (3 credits)</td>
<td><strong>EE Elective with engineering units</strong> (3 credits)</td>
</tr>
<tr>
<td><strong>CSE 361</strong> Intro to Systems Software (3 credits)</td>
<td><strong>ESE 361</strong> Intro to Systems Software (3 credits)</td>
<td><strong>CSE 462</strong> Computer System Design (3 credits)</td>
<td><strong>CSE 465</strong> Digital Systems Laboratory (3 credits)</td>
</tr>
<tr>
<td><strong>Elective</strong> Humanities or Soc. Sciences</td>
<td><strong>Elective</strong> Humanities or Soc. Sciences</td>
<td><strong>Elective</strong> Humanities or Soc. Sciences</td>
<td><strong>Elective</strong> Humanities or Soc. Sciences</td>
</tr>
<tr>
<td><strong>ESE Elective</strong></td>
<td><strong>ESE Elective</strong></td>
<td><strong>ESE Elective</strong></td>
<td><strong>Elective</strong> FREE</td>
</tr>
</tbody>
</table>

### Required Courses
- MATH 132 Calculus II (3 credits)
- MATH 233 Calculus III (4 credits)
- MATH 217 Differential Equations (4 credits)
- ESE 230 Intro to Electrical Engineering (3 credits)
- PHYS 117A General Physics I (4 credits)
- PHYS 118A General Physics II (4 credits)
- CSE 131 Intro. Computer Science I (4 credits)
- CSE 132 Intro. Computer Science II (4 credits)
- CHEM 111A General Chemistry I (3 credits)
- CHEM 241 General Chemistry Lab (2 credits)
- CSE 240 Logic and Discrete Mathematics (3 credits)
- ESE 260 Intro to Digital Logic (3 credits)
- CSE 241 Algorithms and Data Structures (3 credits)
- CSE 361 Intro to Systems Software (3 credits)
- EP 310 Technical Writing (3 credits)
- Select one course in Humanities or Social Sciences

### Electives
- ESE Elective
- CoE Course
- H & SS Elective

### Prerequisites and Corequisites
- **Prerequisite**
- **Corequisite**
Students must complete a selection of courses for which the accumulated engineering topics is 45 units. Also certain restrictions apply about the total number of credits of ESE 400 (independent study) and ESE 497 (undergraduate research.)
BS SSE Pre-med

Washington University in St. Louis

Department of Electrical & Systems Engineering

Bachelor of Science in Systems Science and Engineering (Pre-Med Sample Plan)

Year 1
Semester 1: MATH 132 Calculus II (3 credits)
Semester 2: MATH 233 Calculus III (4 credits)

Year 2
Semester 1: MATH 217 Differential Equations (4 credits)
Semester 2: ESE 317 Engineering Mathematics (4 credits)

Year 3
Semester 1: ESE 441 Control Systems (3 credits)
Semester 2: CS Elective CSE 241 (3 credits)

Year 4
Semester 1: CHEM 252 Organic Chemistry II (3 credits)
Semester 2: SSE Elective with engineering units (3 credits)
Undergraduate Research Projects
ESE Laboratories

State of the art facilities:
(a), (b) Renovated electronics laboratory
(c) Robotics laboratory
(d) Micro/nano photonics laboratory
Acoustic Source Localization
Joshua York, Patricio S. La Rosa, and Arye Nehorai

**Goal:** Build an experimental setup for estimating the acoustic-source position using a microphone array

**Applications:** Teleconferencing, assisted navigation

Diagram of experimental setup and graphical user interface (GUI)

First Place Award, St. Louis Area Undergraduate Research Symposium, April 2009
Generating Light Sources on a Silicon Chip
Kim Venta and Lan Yang

**Goal:** Achieve ultra-high-quality micro-lasers on a silicon chip.

**Applications:** Communications and biomedicine

Illustration of microresonators with toroidal shape
Goal: Create a parallel processing algorithm to speed up MPEG-4 decoding with the Tilera 64 core processor

Applications: Communications and multimedia

MPEG flow chart and its implementation on the Tilera 64 processor

Inter-processor communication
Designing a Codebook-Excited Linear Predictor (CELP) Speech Codec

Justin Lawler and Robert Morley

**Goal:** Build a Codebook-Excited Linear Predictor digital speech codec

**Application:** Cellular phones

Electronic circuit board used and encoder flow diagram
Goal: Develop a method to allow robots in the medical field to adjust to the patient's breathing.
Pulse-echo Methods for Determination of Broadband Ultrasonic Attenuation to Image Temperature in Tissue

Chris Reale and R. Martin Arthur

Goal: Maximize the echo signal bandwidth of a programmable pulser/receiver designed at WUSTL to improve ultrasonic thermometry

Experimental setup
Automated Music Generation for Sight Reading

Kevin McKee and Boaz Porat

**Goal:** Develop a computer program that automatically generates music

**Application:** Musical education

Kevin Mckee, EE Class of 2008, presenting his project at the Spring UGR Symposium 2008.

Graphical user Interface (GUI) illustrating an example of a generated music by the software
## Undergraduate Research Opportunities

<table>
<thead>
<tr>
<th>Advisor</th>
<th>Currently Available Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>R. Martin Arthur</td>
<td>Temperature Imaging Using Change in Backscattered Ultrasound Energy</td>
</tr>
<tr>
<td></td>
<td>Body-surface and Inverse Electrocardiography for Assessing Risk of VT and Electrical</td>
</tr>
<tr>
<td></td>
<td>Consequences of Diabetes</td>
</tr>
<tr>
<td>Jr-Shin Li</td>
<td>Feedback Control of Climate Dynamics</td>
</tr>
<tr>
<td></td>
<td>Development of Control and Optimization Methods for NMR and MRI Systems</td>
</tr>
<tr>
<td>Paul Min</td>
<td>Indoor location of wireless devices</td>
</tr>
<tr>
<td>Arye Nehorai</td>
<td>Robotic Microphone Array for Locating Acoustic Sources</td>
</tr>
<tr>
<td></td>
<td>MIMO Radar Using Acoustic Vector Sensors</td>
</tr>
<tr>
<td></td>
<td>Microphone Amplifier for Photo-acoustic Infrared Gas Detector (with Brasch Manufacturing)</td>
</tr>
<tr>
<td></td>
<td>Classification of Smells Using New &quot;Electronic Nose&quot; Sensors</td>
</tr>
<tr>
<td></td>
<td>Modeling 3D Distortion of a Fluorescence Microscope and CCD Imaging: Theory to Practice</td>
</tr>
<tr>
<td></td>
<td>Design Assistive Technology for People with Cognitive Disabilities</td>
</tr>
<tr>
<td></td>
<td>Automated Music Generation for Sight Reading</td>
</tr>
</tbody>
</table>
## Undergraduate Research Opportunities (Cont.)

<table>
<thead>
<tr>
<th>Advisor</th>
<th>Currently Available Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Youngin Oh</td>
<td>Real Time BPSK Modulation and Demodulation of Voice Signals Through the AD/DA Channels</td>
</tr>
<tr>
<td>William Pickard</td>
<td>Independent Learning Group on Sustainable Energy</td>
</tr>
<tr>
<td>Barry Spielman</td>
<td>Electromagnetic Analysis of Metamaterials</td>
</tr>
<tr>
<td>Lan Yang</td>
<td>A Novel Photonic Tool for Sensing</td>
</tr>
<tr>
<td></td>
<td>Novel Photonic Structure to Enhance Solar Energy Conversion for Electricity and Hydrogen Production</td>
</tr>
</tbody>
</table>
Study Abroad Program
Introduction to Multimodal Imaging

• We created a study abroad program in summer 2009
• Six ESE undergraduate students participated
• **Topic:** Introduction to multimodal imaging
• **Host:** University of Tübingen MEG-Center, and the Max Planck Institute for Biological Cybernetics, Germany
Program

• **Period:** May 11, 2009 – May 15, 2009

• One unit of credit, with the option to continue working on an independent study or undergraduate research course

• Lectures, projects, lab visits, and social programs

• Final report

• Acknowledgment: We are grateful to the donor for his generous support that made this program possible
Jeffrey Feiereisen (BSEE 2010) uses magnetoencephalography (MEG) device and Jennifer Sisto (BSSS 2010) tests a transcranial magnetic stimulation device (TMS).

Exploring Tubingen downtown.
From left to right: Jennifer Sisto, Zeynep Esin, Michael Steinbock, Ian Beil, Patricio S. La Rosa, Jessica Stigile, and Jeffrey Feiereisen
Career Opportunities
Our graduates are highly sought after and have exciting positions in:

- Academia
- Aerospace
- Computers & communications
- Data storage
- Defense
- Electronics
- Energy and power
- Finances
- Medical imaging
- Physical layer communications
- Semi-conductors & solid-state electronics
Examples of Companies Employing ESE Graduates:

- **Energy:** Exxon
- **Defense:** Northrop Grumman, Raytheon, Boeing
- **SemiGov Lab:** APL, Lincoln Lab, JPL
- **Finance:** Bank of America, Citi Group, NISA Investment Advisors
- **Auto:** Honda of America
- **Consulting:** Accenture, Corporate Executive Board, Deloitte Consulting, CRB Consulting Engineering
- **Food:** Anheuser-Busch, Nestlé (USA & Canada)
- **Health Care:** Cerner, Proctor & Gamble, Computerized Medical Systems
- **Communications:** GeoEye
- **Engineering:** Burns & McDonnell, Jacobs Engineering
- **Government:** U.S. Patent & Trademark Office
Successful Alumni Leaders

• Several are founders or CEO's of companies
• CTO of Johns Hopkins Applied Physics Lab
• CTO of MIT Lincoln Lab is now Director of Defense Research and Engineering of US Department of Defense (DOD)
• Three are Deans of Engineering
• Two are faculty members at each of: UIUC, Georgia Tech, and Carnegie Mellon University. One faculty member at Harvard
Additional Information

• ESE department web site:
  http://www.ese.wustl.edu

• ESE undergraduate program:
  http://www.ese.wustl.edu/Academics/UndergradPrograms.asp

• ESE undergraduate research:
  http://www.ese.wustl.edu/Research/UndergradResearch.asp

• Alumni news:
  http://ese.seas.wustl.edu/About/Alumninews.asp
Summary

- Unique structure: EE and Systems
- Broad, in depth, and flexible curricula allowing:
  - Double degrees with BME, CE, CHEME
  - Double major with CS, Finance
  - Pre-Medicine program
- Grows in technologies and applications
- Graduates are highly sought after
- Department has strong reputation and alumni
Thanks!