



RUTGERS SCHOOL OF ENGINEERING

DEPARTMENT OF INDUSTRIAL AND
SYSTEMS ENGINEERING

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Outline

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- A brief overview of Rutgers School of Engineering
- A brief overview of Industrial and Systems Engineering
- Energy Analytics
- Research Opportunities at Rutgers
- Q&A

Rutgers

- Since 1766
- Member of Big Ten Academic Alliance
- Tier 1 Research University
- Public Ivy
- Member of American Research Association (only 60 universities)
- Universities Research Association (Int'l)
- 9000 faculty members, 45000 undergrads and 20,000 graduate students
- \$700M in Research funding
- Great location – close to NYC and Philadelphia
- NY and DC corridor home to many industries



Overview of School of Engineering

- Member of the Big Ten Academic Alliance
- 3,900 undergraduates and 1,100 graduate students
- 1 in 4 students are women
- 164 faculty, 28 distinguished professors
- \$70 million external research expenditures
- Nationally recognized centers in
 - Transportation
 - Energy Storage
 - Wireless Communication
 - Materials
 - Advanced Manufacturing

Overview of School of Engineering

7 DEPARTMENTS

- Biomedical Engineering
- Chemical and Biochemical Engineering
- Civil and Environmental Engineering
- Electrical and Computer Engineering
- Industrial and Systems Engineering
- Materials Science and Engineering
- Mechanical and Aerospace Engineering

SIGNATURE STRENGTHS

- Unmanned Aerial Systems
- Advanced Manufacturing
- Biomaterials
- Energy Storage and Systems
- Signals and System Processing
- Transportation
- Infrastructure
- Cyber Security
- Coastal Resilience
- Reliability Engineering
- Glasses and Ceramics
- Regenerative Tissue
- Pharmaceutical Science
- Engineering

ISE has over 65 years of history ...

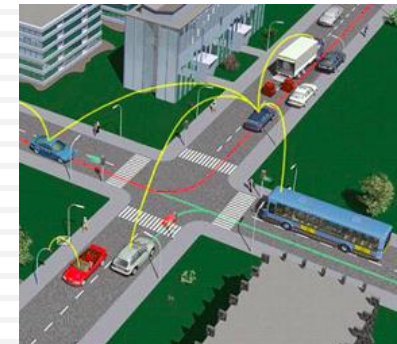
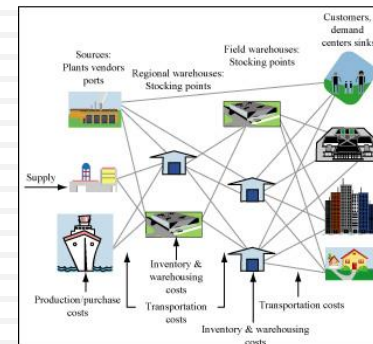
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- B.S. degrees in IE since 1947.
- M.S. degrees since 1964.
- Ph.D. program since 1992.
- Member of Big 10+ ISE programs in US since 2015.
- Degrees offered:
 - ▣ B.S. in IE
 - ▣ M.S. in ISE
 - ▣ M. Eng. in ISE
 - ▣ Ph.D.
- Interdisciplinary programs on Energy Systems and Quality and Reliability Engineering
- Core areas of strength:
 - ▣ Reliability and quality Control
 - ▣ Operations Research
 - ▣ Stochastic Modeling
 - ▣ Data Analytics and Data Mining
 - ▣ Production and manufacturing
 - ▣ Control & Automation
 - ▣ Ergonomics
- Application areas:
 - ▣ Supply chains and distribution systems
 - ▣ Energy Systems
 - ▣ Advanced Manufacturing,
 - ▣ Security,
 - ▣ Transportation Systems
 - ▣ Healthcare
 - ▣ Systems Health Monitoring & Control

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- ## Make better decisions with big data and advanced analytics
- ✓ automation
 - ✓ system design & operations
 - ✓ finance & consulting
 - ✓ marketing & sales
 - ✓ supply chain
 - ✓ big data & data science
 - ✓ risk management



ISE Score Card

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- ❑ Ranked in top 20 by USA Today/College Factual – Undergraduate Program (2017-2018).
- ❑ Ranked 17 by US News and World Report – Graduate Program (2017-2018).
- ❑ 213 undergraduate (sophomore, junior and senior) and 123 graduate students (39 PhD, and 84 M.S./M. Eng.)
- ❑ \$72K for 2017-2018.
- ❑ ~ \$2M in research expenditure annually.
- ❑ 14 honor (out of 60) in entering sophomore class for 2017 and 8 honors in 2018 (Honors college + Honors Academy).
- ❑ 13 full time faculty + PTLs.+ expecting 3 new hires in in 2019
- ❑ New M. Eng. degree in Industrial and Systems Engineering
- ❑ New M. Eng. Program in Energy Systems
- ❑ Discussing new program opportunities with companies.
- ❑ Regional IISE awards for undergrads and best paper awards for PhD students
- ❑ Strong Industry partnership: 3M, Quanta Technology, Colgate, Ford, Lockheed Martin, Siemens, ...
- ❑ Annual Industry day
- ❑ Annual Alumni reception event

Our Strategic Plan

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Reliability Engineering

Bio-engineered & artificial human body parts and materials; manufactured parts and products, infrastructure, ...

Advanced Manufacturing

Smart materials, designs and systems in bio and other applications.

ISE

Smart Systems

Cities & communities (energy, mobility/safety & security)

Why?

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☐ Focus on reliability.

We have strength here.

Expand applications to include the reliability of human body parts and bioengineered products, which is consistent with RU focus in health.

Reliability is a specialized area that ISE can take the lead with collaborating with others.

☐ Focus on advanced manufacturing.

We have strength here.

Supports our objective of integrating technology with ISE mathematical modeling and data analysis.

Consistent with the SOE focus on advanced manufacturing and opening of Weeks hall.

Focus on manufacturing products with smart materials with bioengineering applications.

Increases

☐ Focus on smart Systems

Build on strength in energy (e.g., Rutgers energy institute, CAIT and Laboratory for Energy Smart Systems)

Build on strength in transportation (CAIT) and security

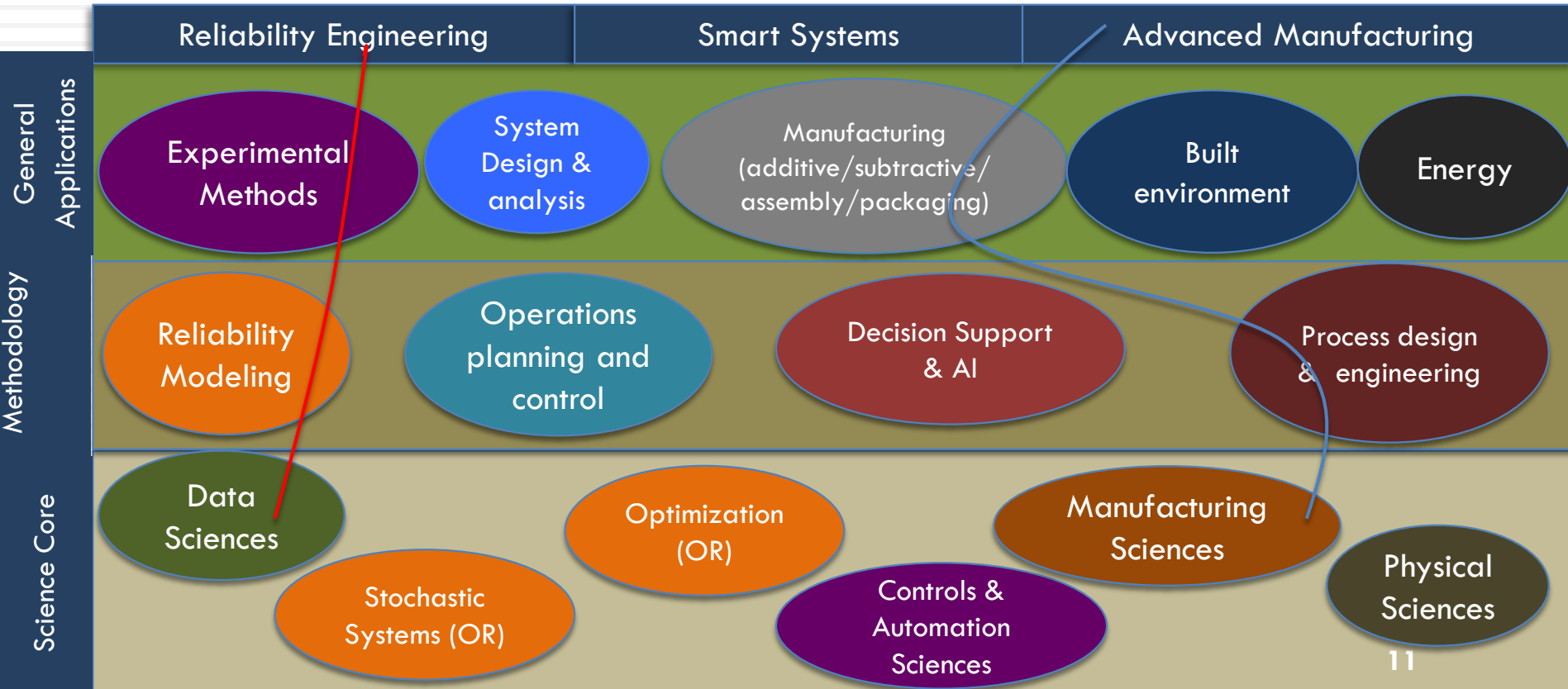
Build on M. Eng. Program on Energy Systems led by ISE

Build on strength in automation, computational sciences, and operations research

Build on strength in reliability and data science

Applications and Science Core

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Graduate programs ...

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service, business and financial systems;
supply chain; distribution & logistics
healthcare; energy; transportation

M.S. (ISE) with options; M. Eng. (ISE); Joint degrees

Risks and uncertainty;
Optimal operation planning
Production Control;
Reliability;
Stochastic & models;
Optimization models;
Advanced Reliability;
Advanced stochastic
processes;
Linear and non-linear
systems; ...

Operations Research /
Systems Eng. Core

Data analytic;
Statistical models;
System simulation;
Large scale stochastic Monte
Carlo simulation;
Forecasting & time series;
Process modeling
(SPC/APC/MPC);
Computational methods;
Cyber security;
Industrial Information
Systems;
Statistical finance; ...

Data Analytic & computation
Core

Supply chain management;
Energy systems;
Advanced Eng. Econ.
Organizational management;
Human & Machine systems;
Maintenance modeling;
Quality Management;
Asset Management;
Financial systems;
Healthcare Systems;
Reliability Engineering;
...

Engineering & Business systems

Prerequisites: Probability models; Statistics; Linear Algebra; Optimization,...

Engineering or Science B.S. degree

ISE Alumnus work for ...

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Industry

- High-Tech industry (software, social media ...)
- Consulting companies, e.g., Accenture, IBM, Deloitte, ...)
- Financial and investment banking industry (e.g., American Express, Bank of America, Credit Suisse, JP Morgan, Goldman Sacks,...)
- Manufacturing industry (e.g., pharmaceutical, defense, Auto, electronics)
- Energy and Transportation (e.g., Siemens, Schlumberger, AECOM, DNV GL Energy)
- Healthcare (healthcare delivery and insurance companies)
- Defense industry (Lockheed Martin,...)
- Public Agencies (FAA, ...)

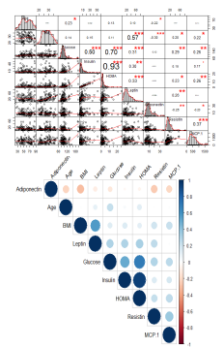
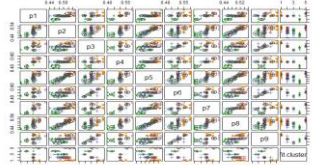
International institutions:

- University of Brescia, Italy
- University of Grenoble – France
- Chonnam National University, Korea.
- Korea Institute for Defense Analysis
- Glasgow Caledonian University in the United Kingdom
- Middle East Technical University, Ankara, Turkey
- Xian Jiaotong University, Xian, China
- Bilkent University, Turkey
- National Taiwan University
- Istanbul Sehir University
- Others

Universities and research centers

- University of Illinois – Chicago
- University of Toronto – Canada
- University of Arizona
- University of South Florida
- Lamar University
- Stevens Institute of Technology
- Siemens Corporate Research
- The Oak Ridge National Laboratory
- AT&T Research Lab
- University of Arkansas
- Cornell School of Medicine
- Colorado School of Mines
- University of Texas at El Paso (UTEP)
- Texas State University
- Texas A&M International University
- Others

Breast Cancer Diagnosis & Prediction



Testing Environments

Controlled

A child is shown building the word 'Data' using large, colorful 3D blocks. The blocks are orange, blue, green, and yellow. The child is standing next to the blocks, and a small blue bucket is on the ground.

Reliability modeling

Prediction

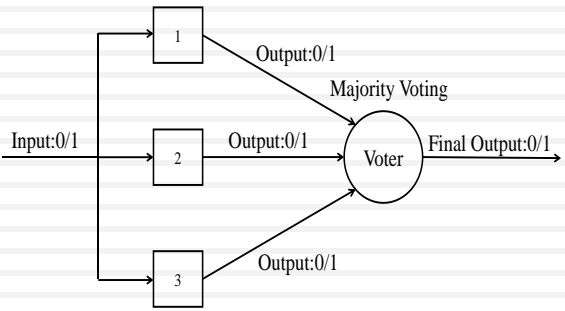
Applications

Uncertainty Complex Operating Environments

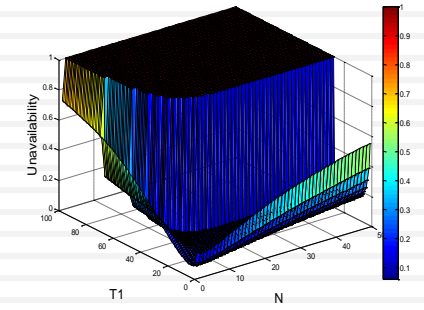
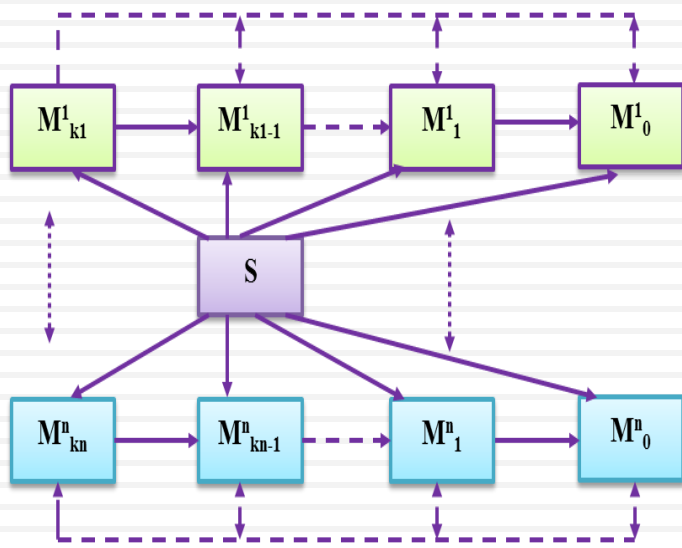
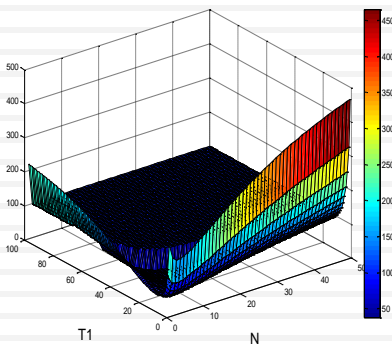
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Systems with Degradation Processes & Shocks

Random



Lin & Pham



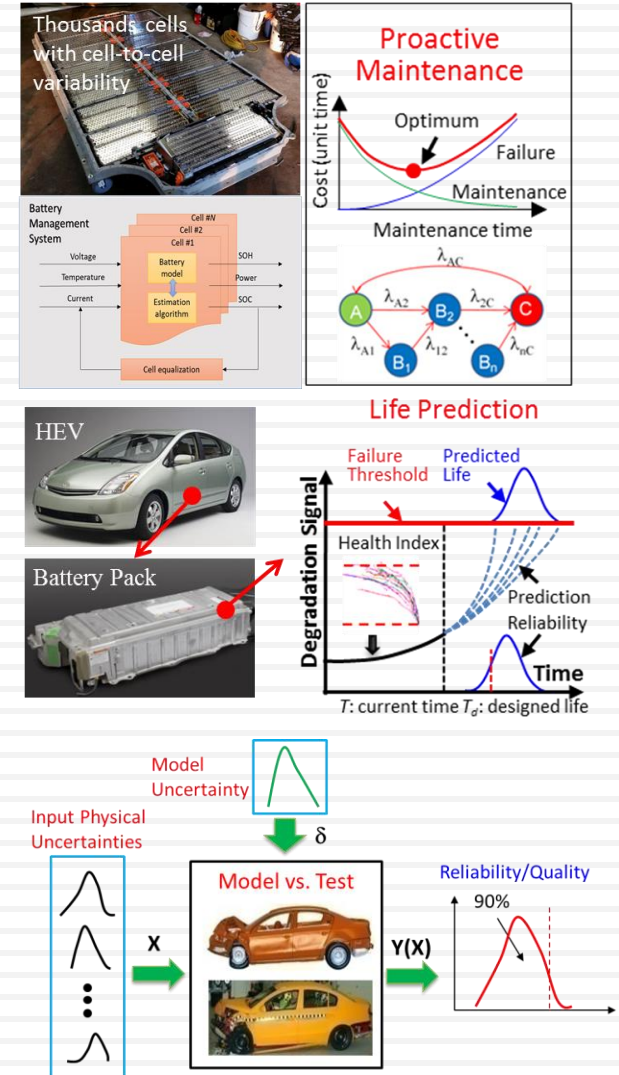
Which is large $(222)^{333}$ or $(333)^{222}$?

$$c(N, T_i) = \frac{T_i(1 - \beta^N)}{1 - \beta} + (N-1)E[T_p] + E[T_r]$$

Zhimin Xi, ISE

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- **Uncertainty Management and Proactive Maintenance of Lithium-ion Batteries in Electrified Vehicles**
 - Advancing electrified vehicles with improved safety, minimized overdesign and reduced cost of the battery system.
 - Funded by NSF
- **Online Diagnosis for Degradation of Battery Cell Capacity and Power Capability Considering Temperature and Cell-to-Cell Variability**
 - Developing innovative technologies for optimizing battery performance, improving safety, minimizing overdesign and reducing cost of the battery system
 - Received an ASME Best Paper Award
 - Funded by Ford Motor Company
- **New Theory in Model-Based Design: A Design Foundation Driven by Probability of Design Errors**
 - Effectively control design errors resulting from model errors in the design of engineering products and systems
 - Received an ASME Top 10 Best Paper Award
 - Funded by DARPA – Young Faculty Award



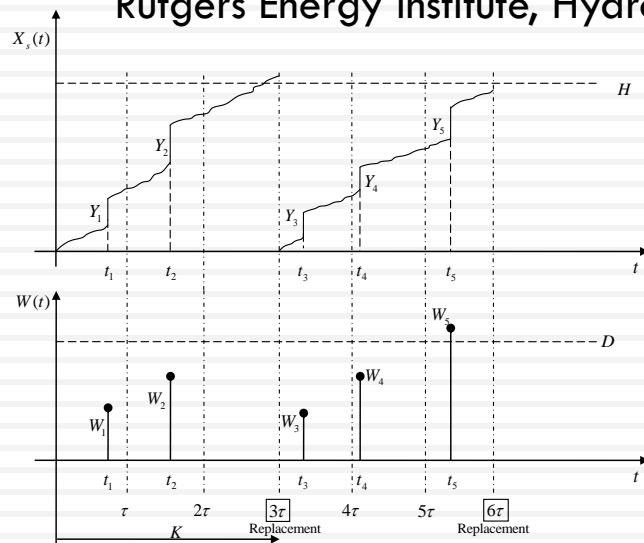
Complex Systems Optimization & Reliability Analysis

Principal Investigator: Prof. David W. Coit

Research Team: Jian Zhou, Stamatis Tsianikas, Nooshin Yousefi, Jingyu Chen, Ran Cao

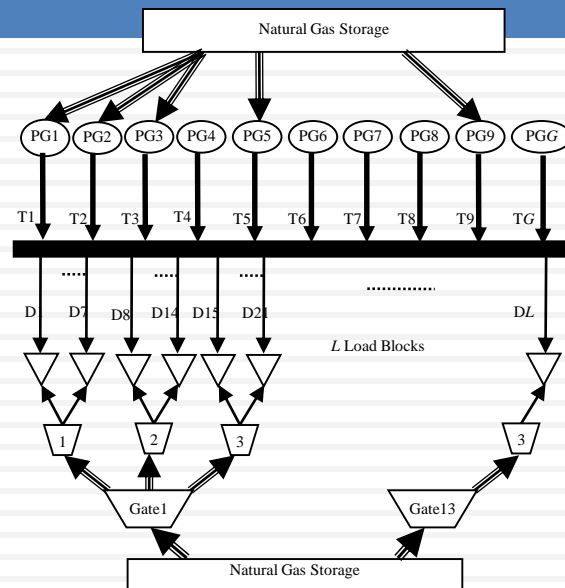
Electric Power-Grid System Expansion Models

- Determination of optimal power-grid expansion plans considering minimization of CO₂ emissions
- Determination of power grid expansion models given extreme weather events and climate change
- Multiple-objective stochastic power-grid expansion models
- Integration of societal health care costs
- Research funded by Bloustein School CEEEP, DOE, Rutgers Energy Institute, Hydro-One



System Reliability Modeling & Optimization

- Prediction of aircraft carrier recovery system reliability given uncertain and changing stress profiles
- Models to combine and optimize manufacturing variability and product life (MEMs, etc.)
- Determination of optimal system reliability designs considering uncertainty and risk-aversion
- Research funded by NSF, U.S. Navy, U.S. Army



James Luxhoj

Probabilistic Modeling of UAS Safety Risk



Key Insight/Innovation

- Modeling of the *complex interactions* of hazards related to the UAS, Operations, Airmen and the Environment is important.
- The approach uses the methodology of Bayesian Belief Network (BBNs) and its extension of Object-Oriented Bayesian Networks (OOBNs) for the analytics.
- The most prominent risk factors can be identified and mitigations assessed.

Scientific Impact

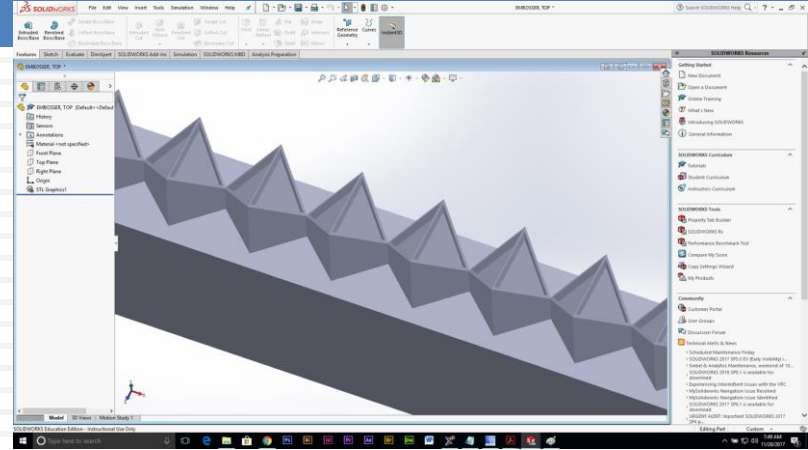
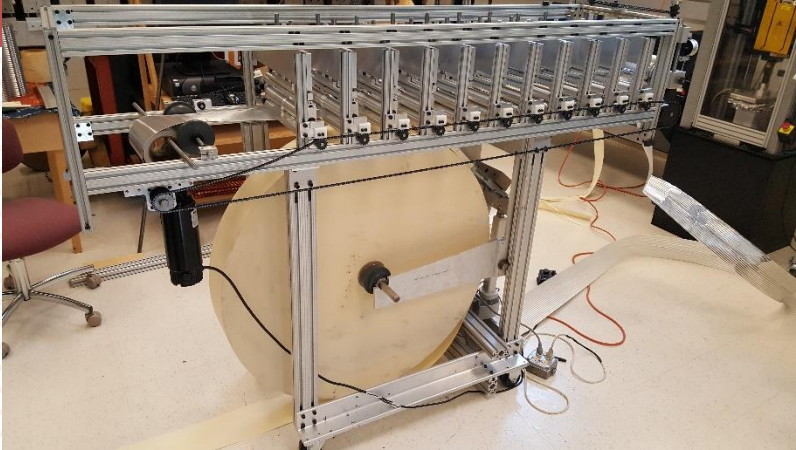
- Advances the probabilistic modeling for the *integration* of socio-technical risk factors and complements traditional fault and event trees.
- BBNs are especially appropriate for dealing with disparate data sources.
- For domains with sparse data sets, as in small UAS applications, BBNs offer an alternative modeling tool for eliciting expert judgment.

Potential Applications

- The approach is being studied by the FAA, NASA and NAVAIR for risk modeling of UAS integration into the National Airspace System.

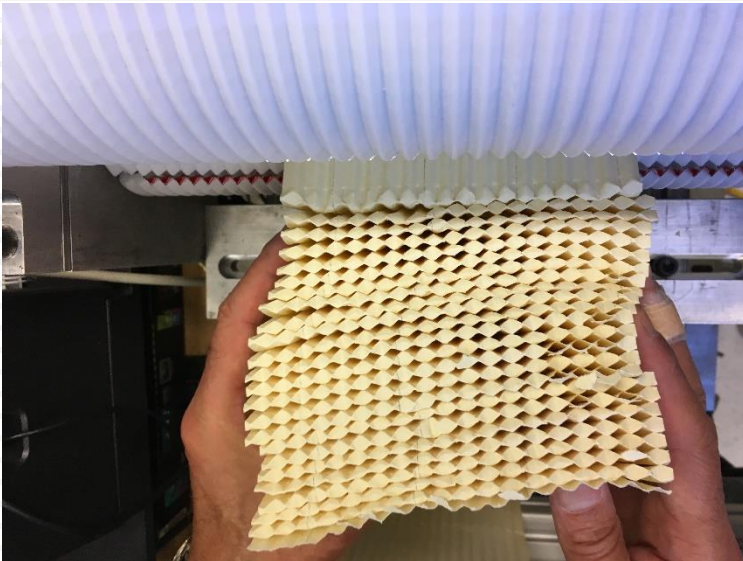
Sheet Folding Theory and Applications in Innovative Filter Designs (E. Elsayed)

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1. Roll of Filter Paper

2. Design of Geometric Shapes for the Filter



4. Filter Production



3. Paper is Fed between Dies

RUTGERS School of Engineering

Join the Rutgers Electrical and Computer Engineering Family! Become a Fully Funded PhD Student in Fall 2019!

There are several fully funded PhD and MS leading to PhD position openings
for Fall 2019 in the research areas of:

Bioelectrical Engineering

Subareas:

- biomedical devices
- biomaterials
- brain imaging
- computational methods for biological systems

Communications and Networking

Subareas:

- wireless communications
- information theory
- next-generation internet architectures
- physical-layer security

Computer Systems

Subareas:

- parallel and distributed computing
- cloud computing
- cybersecurity
- embedded systems
- human-computer interaction systems

Information Processing

Subareas:

- signal processing
- image processing
- machine learning
- computer vision
- robotics

Micro- and Nano-Electronics

Subareas:

- semiconductor materials
- nanophotonics
- analog and digital integrated circuit design

These positions include generous annual stipends ranging from \$25k to \$29k, full tuition remission, and generous health benefits. Positions are renewable for the duration of the studies, subject to student's performance and availability of funds.

To apply for these positions, visit: <http://www.ece.rutgers.edu/graduate-admissions>

All applications received by January 31, 2019 will receive full consideration for funding.

Why Rutgers ECE?

- Rutgers University, located in Central New Jersey and just an hour drive from New York City and Philadelphia City, is one of the oldest institutions of higher education in the US, founded before the founding of the USA.
- Rutgers, being a Big Ten university, has institutions such as University of Michigan, University of Illinois, University of Wisconsin, Purdue University, and University of Maryland as its peers.
- In 2018, US News & World Report ranked Rutgers as #17 in the US and #1 in the Northeast US for the "Best Public University," Times Higher Education ranked Rutgers as #13 in the US for "Graduate Employability Among Public Universities," and the Center for World University Rankings placed Rutgers at #28 among *all* universities in the US and #13 among public universities in the US.
- Rutgers ECE itself is ranked as #36 in the US News & World report ranking of Electrical Engineering departments in the US and #31 for Computer Engineering.
- Rutgers ECE has a world-renowned faculty that has received numerous national and international awards for its research contributions and is also home to the world renowned WINLAB center.
- Rutgers ECE takes pride in its mentoring, training, and social programs for the graduate students, which include internship opportunities, travel grants, public speaking opportunities, workshops for professional development, and holiday gatherings.
- Graduates of the Rutgers ECE PhD program regularly find rewarding and enriching employment opportunities in academia, government and industrial research labs, technology companies, financial companies, etc.