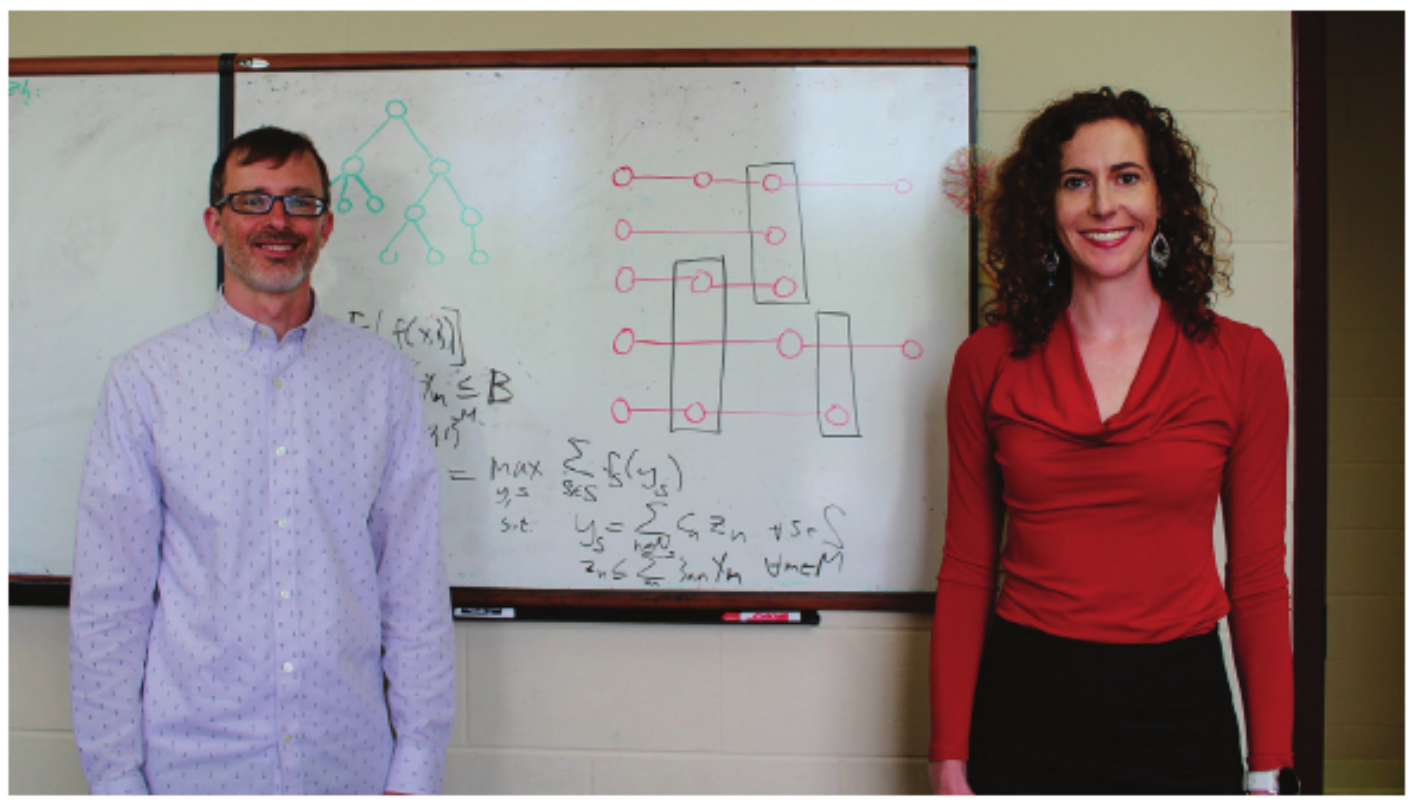
RESEARCH

Inside IISE Journals

This month we highlight two articles from *IISE Transactions*. The first studies the information and data security issues by protecting information and communication technology (ICT) infrastructure. The paper proposes an optimization framework for implementing security mitigations to cover supply chain vulnerabilities, and further formulates it as integer programming and stochastic programming models to identify security mitigations for reducing the risk of attacks.
The second summary studies quick response mechanisms to meet uncertain demand by planning reactive regional production capacities. The paper addresses the key factors, pros and cons, as well as conditions to implement speculative production or reactive production. These articles will appear in the December 2019 issue (Volume 51, No. 12).

Securing cyber-infrastructure to keep sensitive data safe

Recent cybersecurity breaches, such as those at Equifax and Capitol One, highlight the importance of information and data security. When sensitive data is not secured, the costs of the breach to the organization and to society are enormous. As a result, it is critically important to safeguard information systems and cyber infrastructure. Doing so is extremely challenging, since critical information and communication technology (ICT) infrastructure is a complex system that is vulnerable to numerous security risks, especially from sophisticated adversaries.



Professors Jim Luedtke (left) and Laura Albert of the University of Wisconsin-Madison authored a research paper on supply chain cybersecurity with doctoral students Kaiyue "Kay" Zheng and Eli Towle, now both Ph.Ds.

To protect critical ICT infrastructure, companies, governmental organizations and other institutions must consider more than just their infrastructure; they must also consider risks stemming from supply chains. Supply chain risks include those associated with third-party vendors, maintenance, manufacturing and processing. These can be mitigated by implementing controls and security procedures, including physical measures such as replacing vulnerable hardware or requiring tamper-evident packag-

Though the risk cannot be totally eliminated, the right mix of mitigations can substantially reduce the risk. All organizations have limited security budgets and employee resources, and there is uncertainty about the effectiveness of all security tactics.

In the paper "A Budgeted Maximum Multiple Coverage Model for Cybersecurity Planning and Management," authors Kaiyue "Kay" Zheng, Ph.D. of Amazon, professors Laura Albert and

framework for implementing securit mitigations to cover supply chain vul nerabilities. This optimization frame work supports a formal supply chain ris management framework by identifying portfolio of security procedures designe for a long-term phased rollout that ca reduce risk. They propose new coverag models, which are formulated as intege programming and stochastic program ming models, to identify a portfolio c security mitigations that can reduce th

ing, and broader initiatives like training employees, regularly assessing vendors or tightening shipping requirements.

Jim Luedtke from the University of Wisconsin-Madison and Eli Towle, Ph.D. of Gurobi, propose an optimization

risk from attacks originating in suppl chains.

A detailed computational analysis pro

vides insights into policies for protecting ICT infrastructure. Their results shed light on critical components that require the most protection, in particular when there is uncertainty, and how to balance risk-reduction with cost and other criteria.

Zheng and Towle were doctoral students of Albert and Luedtke when they worked on this paper.

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Upfront investment for reactive production: Is it beneficial or detrimental?

Timbuk2, a San Francisco-based bag manufacturer, produces make-to-stock (speculative) units overseas, mainly in Vietnam and Indonesia, and make-to-order (reactive) units regionally in the United States, but the required materials must be sourced well ahead of time from overseas.

Xiaomi, an electronics company based in China, speculatively produces batches of phones in China for the Indian market, then uses local Indian capacity for reactive production runs. In preparation for this, several complex components must be secured ahead of time. Quick response mechanisms to meet uncertain demand necessitate many manufacturing companies to plan for reactive regional production capacity that takes advantage of updated demand information, in addition to speculative production. However, significant investments in material prepa-

sistant professor at Shanghai Jiao Tong University; Masha Shunko, an assistant professor at University of Washington; Nagesh Gavirneni, a professor at Cornell University; Yan Shu, a software engineer at Google; and Kan Wu, an assistant professor at Nanyang Technological University. In their paper "Reactive Production with Preprocessing Restriction in Supply Chains with Forecast Updates," they investigate a supply chain with two-mode production consisting of speculative production and reactive production restricted by preprocessing.

They demonstrate that it is not always beneficial to prepare for reactive production, and they provide guidelines and identify key drivers and associated contracts for manufacturing companies to best leverage the reactive production option. The benefit of the two-mode production can be substantial (as large as 104%) when compared to the traditional purely speculative production when manufacturing companies face a huge inventory shortage cost.

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This month we highlight two articles from *IISE Transactions on Healthcare Systems Engineering* (Volume 9, No. 3). The first article is on using smartwatch machine learning methods to predict the onset of PTSD symptoms. The second article addresses the use of motion data to diagnose and treat the effects of chronic ankle instability.

Using wearable technology and machine learning to solve veterans' mental health crisis from PTSD

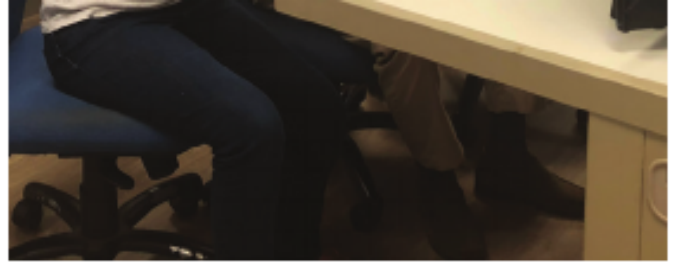
Post-traumatic stress disorder (PTSD) is a mental disorder that has been associated with high rates of suicide and profound decreases in quality of life. PTSD is particularly prevalent in the combat veteran population, due to the high frequency of traumatic events in combat. The large numbers of veterans suffering from PTSD creates a challenge for healthcare systems because the available treatments require in-session therapy and prescribed medications. These treatments are effective but they are not accessible to all veterans and leave extended periods where veterans must rely on self-management of their symptoms.

Professors Farzan Sasangohar and Tony McDonald of Texas A&M University are seeking to address this problem through the use of a smartwatch-based mobile health (mHealth) technology called First Watch Device (FWD). In "Continuous

ration must be made well in advance. When are investments in upfront preparation for reactive production opportunities beneficial to the supply chain? What is the optimal balance between speculative and reactive productions?

Nagesh Gavirneni

These issues are examined by Meimei Zheng, an as-



Meimei Zheng (left) and Kan Wu discuss optimal production decisions for manufacturing companies that need to prepare material in advance for reactive production during an online meeting with Nagesh Gavirneni.

Monitoring and Detection of Post-Traumatic Stress Disorder (PTSD) Triggers Among Veterans: A Supervised Machine Learning Approach," co-authored with post-doctoral researcher Arjun Rao, Ph.D., and master's student Ashish Jatav, the authors describe the research that developed a key component of this technology: a machine learning algorithm that detects PTSD symptom onset from heart rate data.

Farzan Sasangohar works with veterans taking the First Watch Device on a test ride. The machine learning algorithm can help detect PTSD symptoms from heart rate data.

In their approach, the authors used a dataset collected from smartwatches worn by veterans during various week-long bicycling events. The smartwatches monitored the veterans' heart rates and allowed them to record the onset of symptoms with a tap on the watch face. The authors applied a structured process to refine the dataset and test and evaluate algorithms. The analysis suggested that support vector machines (SVM) and random forests could detect symptom onset significantly better than random classifiers.

The results of this research are now being used to implement and test real-time interventions for veterans afflicted with PTSD.

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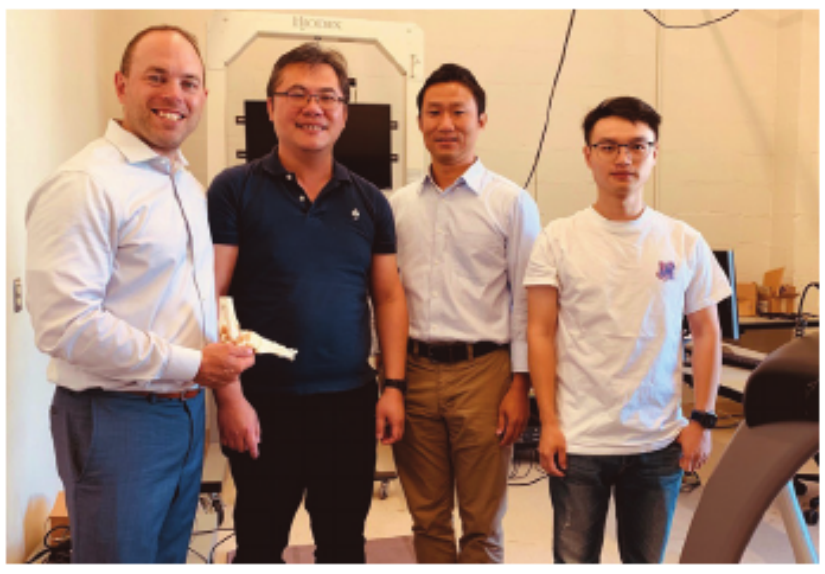

From left, professors in physical therapy at Northeastern University Eric Folmar and Sheng-Che Yen joined Chun-An Chou, an assistant professor of mechanical and industrial engineering, and Ph.D. student Shaodi Qian in a research projec using sensor data to diagnose chronic ankle instability.

as well as objectively monitor patient progress.

Recently, the advance of biosensor devices – such as the seven-camera 3D-motion capture system used in our study – opens a door for clinical practitioners to be able to mimic a patient's actual motion behaviors during different tasks, such as running. Though the information should be clear, it is difficult to differentiate between patients with and without CAI despite differences in the populations as the computer-generated curves look very similar. It remains a challenge to help patients with such data in clinical practice.

In "Self-Expressive Subspace Learning to Recognize Motion Dynamics for Chronic Ankle Instability," Chun-An Chou, Ph.D., and Ph.D. student Shaodi Qian collaborated with professors in physical therapy at Northeastern University, Sheng-Che Yen, Ph.D., and Eric Folmar, Ph.D. They developed a new

the Northeastern Seed/Proof-of-con cept grant program for which Chou the principal investigator.

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Teresa Wu is an industrial engineering pr fessor in Arizona State University's Scho of Computing, Informatics and Decisio Systems Engineering. She is editor-in-chi of IISE Transactions on Healthcare Sys tems Engineering.

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Rediscovering chronic ankle instability: Gait data has map for diagnosis, treatment

Every day, 25,000 people sprain an ankle in the U.S. More than 1 million people visit emergency rooms each year because of ankle injuries. Up to 70% of individuals do not fully recover from single ankle sprains and eventually develop chronic ankle instability (CAI).

The traditional diagnosis and assessment of CAI have long relied on self-report questionnaires, which are subjectively biased. In clinical practice, it remains challenging for physical therapists to provide diagnosis and treatment data-driven analytics tool to effectively distinguish unstable motion patterns of ankle-injured patients from normal controls. They recruited a number of subjects to acquire motion data during running in a well-controlled environment. They not only showed high prediction accuracy but also observed the interrelationship between hip and ankle joints in running patterns.

This work is really inspiring for both industrial engineers and physical therapists. This collaborative work has developed a method that helps to provide more objective measures, along with self-report measures, to support clinical management of individuals with CAI.

This research project is supported by