This month we highlight two articles focusing on new approaches in quality and reliability engineering for manufacturing. The first article discusses new approaches to quality improvement in the era of big data, where the data is allowed to tell the story. The second article develops new reliability models for systems with competing failure mechanisms. These articles will appear in the May 2014 issue of IIE Transactions (Volume 46, No. 5).

**Manufacturing variation in the era of big data**

The modern era of big data offers new opportunities for manufacturing. Programs for systematically reducing manufacturing variation and improving quality are firmly established in industry.

However, the vast majority of tools were designed decades ago for use with limited amounts of data with a relatively simple structure. In contrast, massive volumes of data are available routinely in modern manufacturing operations, the result of advanced measurement, sensing and data collection technology distributed throughout the process. Typical manufacturing data now consists of a variety of spatially and temporally rich profiles obtained from thousands of quality-related process characteristics, product measurements and machine sensors.

In such an environment, researchers from Arizona State University – Ph.D graduates Amit Shinde, Anshuman Sahu and professor George Runger – along with Northwestern University professor Daniel Apley, set out to develop an easy-to-use and widely applicable knowledge discovery methodology for variation reduction designed specifically for high-dimensional data structures. They present findings in the article “Preimages for Variation Patterns from Kernel PCA and Bagging.”

Their research focuses on blind discovery of manufacturing variation sources. The goal is to learn from patterns caused by the source instead of looking for patterns based on prior models of variation sources. The challenge lies in developing methods that require identification of complex patterns using minimal user input, while performing robustly in a variety of situations, and producing results that are amenable to graphical visualization.

In this work, kernel principal component analysis (KPCA) is used to remove noise from complex, nonlinear patterns for better detection. A fundamental challenge in KPCA is to invert map this denoised data from the high-dimensional abstract feature space in which KPCA operates into its preimage in the original data space to facilitate visualization. This paper develops a new metamethod that uses the machine learning technique of bagging to improve upon the preimage estimate obtained from any KPCA algorithm when noise-free training data is unavailable. The method was applied to identifying part-to-part variation in scanned surface profile data for automotive engine gaskets.

**CONTACT:** Anshuman Sahu; anshuman.sahu@hds.com; (408) 797-8108; research scientist, Big Data Research Laboratory, Hitachi America Ltd., Research & Development Division, Santa Clara, CA.

**System reliability amid competing failure sources**

Innovation in novel and evolving technologies such as micro-electro-mechanical systems (MEMS), biomedical implant devices and other new device types continues to achieve impressive new features and capabilities.

As production rates and design complexity increase, there is a need for research focusing on new reliability models and analysis tools that can assist in the manufacture and maintenance of these evolving devices. Accordingly, this research can offer fundamentally new insights on the application of reliability analyses for technologies that have unique manufacturing challenges.

Doctoral student Koosha Rafiee and professor Qianmei (May) Feng from the University of Houston, together with professor David W. Coit from Rutgers University, are developing new probability and stochastic models to predict reliability of complex systems subject to multiple failure processes that can be applied to many current and evolving devices.

For many real-world applications, systems can fail due to random shocks or graceful degradation. Some systems may be susceptible to multiple failure processes that compete against each other. Whenever occurs first causes the system to fail. An independence assumption of these
competing failure processes often is made. But this assumption often is not valid for complex systems and may lead to underestimating the system reliability.

The authors have developed new methodologies to model system reliability when the independence assumption between competing risks of degradation processes and random shocks does not hold. Specifically in this paper, the degradation rate is considered to be accelerated according to particular random shock patterns, i.e., extreme shock model, m-shock model, run shock model and δ-shock model.

Rafiee, Feng and Coit demonstrated the new reliability models on an example MEMS device. The reliability modeling approaches resulting from this research can be transformed or extended to other developing technologies (e.g., biomedical devices, nanotechnology) where traditional reliability methods do not sufficiently address the pertinent design problems and issues.

**CONTACT:** Qianmei (May) Feng; qfeng@central.uh.edu; (713) 743-2870; Department of Industrial Engineering, University of Houston, Houston, TX 77204-4008

The most recent issue of IIE Transactions on Healthcare Systems Engineering (Volume 4, Issue 1) contains four articles covering a wide range of healthcare system problems and solution methods. The first one summarized below reviews the use of simulation to analyze propagation of influenza pandemics. The second summarizes an article that describes an information technology decision support system that uses multiattribute utility theory to help nurses prioritize patients during triage in emergency departments.

**Simulation of pandemics: What's the state of the art?**

Researchers and practitioners rely on mathematical models to study and prepare for epidemiological events such as pandemic disease outbreaks. This kind of work is especially important in light of the 2009 H1N1 swine flu epidemic and recent scares, including the 2002 to 2003 severe acute respiratory syndrome (SARS) outbreak and the increasingly dangerous strains of H5N1 "bird flu."

Over the last 20 years, agent-based and discrete-event simulation models for disease propagation have been used widely to analyze the propagation of pandemic disease as well as potential mitigation strategies. For example, what are the benefits and disadvantages of school closure, mass-immunization programs or self-isolation strategies on the spread, attack rates and costs of a pandemic?

Unfortunately, due to the lack of common guidelines, researchers have built simulation models separately and often in isolation, resulting in the repeated reinvention of the wheel.

In their article "Simulation of Influenza Propagation: Model Development, Parameter Estimation and Mitigation Strategies," doctoral student Mi Lim Lee, postdoctoral researcher Wenchi Chiu and professors Sigrún Andradóttir and David Goldsman from Georgia Tech’s Stewart School of Industrial and Systems Engineering provide a broad review of disease propagation simulation models, with emphasis on influenza pandemics. The article brings forth the information needed for researchers, practitioners and decision makers to build valid simulation models for disease propagation. In particular, the paper discusses methods for generating representative populations, how to choose appropriate influenza transmission parameters to drive the simulation, and various mitigation strategies to curb the negative effects of a pandemic.

The authors have worked on a variety of problems with colleagues at the Centers for Disease Control and Prevention, the World Health Organization and various other international health research centers. This work motivated the current paper, which the authors hope will provide a step toward the standardization of models of influenza propagation, leading to improved models and enhanced understanding of how to prevent future pandemics.