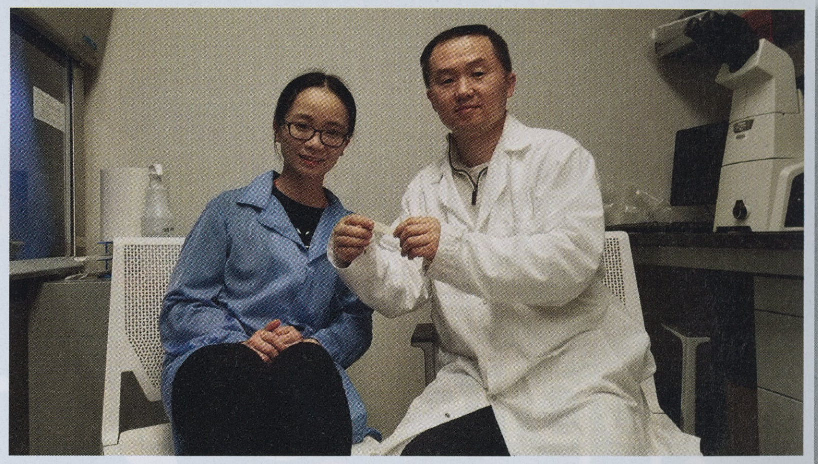
RESEARCH

Inside IISE Journals

This month we highlight two articles from *IISE Transactions*. The first article investigates how to incorporate expert domain knowledge to regulate data analytics. The paper develops a constrained Gaussian process (CGP) method where expert knowledge is incorporated into the Gaussian process (GP) in the form of constraints. The developed CGP method is applied in tissue-engineering scaffold biodegradation and yields more accurate and interpretable predictions than existing methods. The second article develops a shape deviation compensation strategy that makes additive manufacturing processes achieve higher and consistent shape accuracy under different process settings. A data-driven method is proposed to eliminate systematic errors in additive manufacturing processes by optimizing the input CAD model under different settings of process parameters. A case study conducted with an additive manufacturing system led to a 95 percent reduction in mean square errors of dimensional accuracy. These articles will appear in the May 2018 issue of *IISE Transactions* (Volume 50, No. 5).

Accommodating expert knowledge in data analytics

One problem in the practice of data analytics is that the results may not be meaningful in terms of domain knowledge due to variation of data, outliers, small samples, etc. For example, prediction of a quantity that is intrinsically positive may take a negative value; estimate of a quantity that is supposed to monotonically increase over time may not have that trend. This problem can be solved by incorporating expert knowledge to regulate data analysis.



Jian Yang (right) and his student Chuying Ma display a tissue-engineering scaffold.

This idea is investigated in the article “Constrained Gaussian Process with Application in Tissue-Engineering Scaffold Biodegradation” by Li Zeng in the Department of Industrial and Systems Engineering at Texas A&M University, Xinwei Deng in the Department of Statistics at Virginia Tech, and Jian Yang in the Department of Biomedical Engineering at The Pennsylvania State University. The interdisciplinary team developed a constrained Gaussian process (CGP) approach where three typical types of expert knowledge (bound, censoring, monotonicity) are incorporated into the Gaussian process (GP) in the form of constraints. GP is known as a flexible method for predictive modeling. The formation of expert knowledge as proper constraints on the GP modeling makes its flexibility nimble for accurate prediction with meaningful interpretation.

Applying the CGP approach to tissue-engineering scaffold biodegradation was considered in this work. The scaffold is a degradable substrate for growing cells, which is critical in developing engineered tissues, and biodegradation is an important performance aspect of the scaffold to serve its role. The case study shows that CGP can yield meaningful and more accurate predictions when GP fails, and it performs better than popular artificial neural networks. It especially has promising performance in extrapolations and interpolations with influential outliers where prediction is usually difficult. This study introduces a novel, convenient way to accommodate expert knowledge in data analytics, which has broad applicability in various applications.

Li Zeng (left) and Xinwei Deng worked to incorporate expert knowledge into data analytics.

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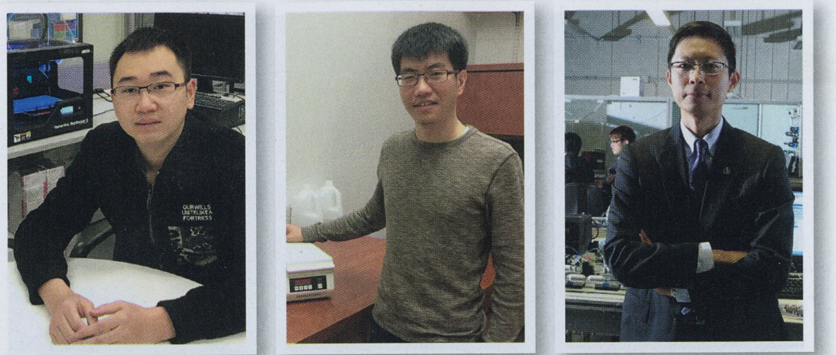

Longwei Cheng (from left), Andi Wang and professor Fugee Tsung devised a strategy to improve shape accuracy in 3-D printing.

Can shape accuracy be enhanced in 3-D printing under various process settings?

Additive manufacturing, or 3-D printing, is a promising technique for advanced manufacturing as it enables directly fabricating products with complex shapes. The shape accuracy control remains one of the major barriers to the wider application of 3-D printing in manufacturing industries.

One approach to increase the shape fidelity of a fabricated product is to eliminate the systematic error of the fabrication system by modifying the input shape defined by the CAD input file. The Quality and Data Analytics Lab from The Hong Kong University of Science and Technology started research on shape fidelity improvement through such compensation method in 2014. During their study, the research group (Ph.D. student Longwei Cheng, Andi Wang and professor Fugee Tsung) identified that the shape deviation may depend not only on the input shape but also on the setting of process parameters, such as the infill percentage of the fused filament fabrication technology. The process parameters may have a nonlinear, complex impact on the shape deviation. Since users of 3-D printers may configure these parameters to make products with desired physical properties, the compensation plan should be modified accordingly to achieve greater shape accuracy.

In the paper “A Prediction and Compensation Scheme for In-Plane Shape Deviation of Additive Manufacturing with Information on Process Parameters,” these authors present a data-driven method to optimize the input CAD model under different settings of process parameters. First, a predictive procedure is developed for the in-plane shape deviation of a product based on both process parameters and the two-dimensional input shape. Through this predictive procedure, a shape deviation compensation strategy is then proposed. This compensation strategy will make the additive manufacturing processes achieve higher and consistent shape accuracy under different process settings.

Based on the proposed strategy, practitioners may apply the proposed compensation strategy on their additive manufacturing facilities with the help of existing sensing systems. According to the study, the shape compensation method was applied successfully on a Maker-Bot Replicator 2 3-D printer with the QVI OGP measurement system: The mean squared difference between the measured shape of fabricated product and the original desired shape has been decreased by more than 95 percent for all five circular designs with different radius and settings of infill percentage.

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We feature two papers below from Volume 8, No. 1 of *IISE Transactions on Healthcare Systems Engineering*. In the first, a team of researchers tackled a critical problem, long recognized in breast cancer screening programs: overdiagnosis. A mathematical model was developed to estimate the lifetime overdiagnosis and cancer mortality risks associated with current cancer screening policies. For the second paper, a medical professional, Dr. Arne May from University Medical Center Hamburg-Eppendorf, Germany, examined the impact of the research. In his summary below, May wrote that the work's impact could be tremendous because it could help clinicians differentiate between migraines and other headaches that could be dangerous.

Breast cancer: Screen or not to screen?

Mammography is known to be the gold standard in early detection of breast cancer and can significantly reduce breast cancer mortality risk. Recently, however, there have been