Dieter Bender will present his Dissertation Defense, “Diagnostic Algorithms and Data-Driven Knowledge Discovery Integrating Domain Expertise for Complex Biomedical Problems,” on Tuesday, December 14, 2021, in CEER 314 at 11:00 a.m. Please see attached Abstract.

Dieter is advised by Dr. C. Nataraj.

The defense is open to the public. If you cannot attend in person, please join via ZOOM by preregistering with your Villanova email address here:
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Diagnostic Algorithms and Data-Driven Knowledge Discovery Integrating Domain Expertise for Complex Biomedical Problems

Dieter Bender

December 14, 2021
11:00 a.m.
CEER 314 / ZOOM

ABSTRACT

With a vastly growing amount of biomedical data, uncovering new information through data-driven technologies has become an essential part of modern medicine. Motivated by the trends toward personalized and precision medicine, there has been a recent surge in the implementation of machine learning and other automated computational approaches with some showing good results. However, in the healthcare field, the data is often characterized by its complexity in terms of limited size, the rarity of events, high noise, incompleteness and heterogeneity making automated solutions in this domain difficult, and at times, impossible. While most researchers in this field concentrate on algorithms such as classical machine learning, this work proposes an interactive approach where the domain expertise (expert's knowledge) is integrated into the algorithmic loop. With its roots in reinforcement learning, preference learning, and active learning, the presented concept can generally be defined as algorithms that can interact with agents, which can be a machine or a human, and optimize their course of action through these interactions.

This dissertation deals with knowledge- and data-driven algorithms to predict, diagnose, and optimize medical intervention in order to prevent unfavorable outcomes for three important problems. First, active learning and embedded genetic algorithms are employed in the machine learning process to develop a predictive model for a rare brain injury, Periventricular Leukomalacia, with a limited data set. The performance of the resulting classical support vector machine classifier is improved in terms of generalization, accuracy, explainability, and complexity. Second, in an effort to improve cardiopulmonary resuscitation (CPR), a high dimensional mathematical model of a cardiovascular system and a data-derived chest compression model are combined in an optimization framework. The system is optimized with design variables and an objective function defined in collaboration with critical care experts. Third, in an analytical investigation, an interactive algorithm utilizing wavelet synchrosqueezed transform and machine learning is developed to discriminate between primary and secondary asphyxia-associated ventricular fibrillation during cardiopulmonary resuscitation. More broadly, this work proves that to gain implicit knowledge about a complex problem through a data-driven technique, it is necessary to intelligently integrate explicit domain knowledge of the problem into the algorithm.