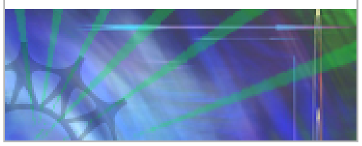

Award Abstract #1728338

Collaborative Research: Personalized Modeling, Monitoring and Control for Advancing Ventricular Assist Device Therapy in End-stage Heart Failure

NSF Org:	CMMI Div Of Civil, Mechanical, & Manufact Inn
Initial Amendment Date:	August 4, 2017
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Investigator(s):	Dongping Du dongping.du@ttu.edu (Principal Investigator)
Sponsor:	Texas Tech University 349 Administration Bldg Lubbock, TX 79409-1035 (806)742-3884
NSF Program(s):	Special Initiatives, Dynamics, Control and System D
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ABSTRACT

Annually, about 5.7 million adults in U.S. have heart failure, and the associated cost of health care services to treat heart failure is approximately $30.7 billion. An estimated 150,000 new patients are diagnosed with end-stage heart failure annually. Left Ventricular Assist Device (known as "pacemaker") implantation, as the destination therapy, becomes an important treatment option for end-stage heart failure. However, the implantation has unacceptably high mortality rate. For instance, the 1-year mortality rate is as high as 69%. The risk of implantation varies among patients, and the outcome highly depends on preoperative treatment design and postoperative care. Current therapies are guideline-based and greatly rely on the stage of the disease inferred from patients' symptoms.

Individual factors associated to disease etiology and prognosis are often neglected. This project develops a personalized preoperative-assessment and postoperative-control system for: (1) efficient risk evaluation of individual patient; (2) personalized modeling and estimation of a patient's heart function; (3) robust and adaptive control of implanted Left Ventricular Assist Devices. The outcomes from this work can lead to technologies that can revolutionize the end-stage heart failure therapy and benefit the overall population of heart failure patients, which will ultimately advance the health and life quality of the whole society. Broader impact on education includes new curriculum modules, science outreach activities, and active recruitment and involvement of underrepresented groups.

This project will bring statistical inference, personalized cardiac modeling, and adaptive control theory into a unified framework for efficient modeling and analysis of heart condition, as well as a practical infrastructure for effective monitoring and control of LVAD. It will leverage modeling, monitoring, control, and optimization methodologies in personalized diagnosis and therapeutic design of LVAD implantation. In particular, this project will: (1) integrate the probabilistic risk analysis with elastic net regularization to predict implantation risk and survival time; (2) develop a spectral approximation-based surrogate model to efficiently quantify parametric uncertainties and accurately estimate model parameters for personalized cardiac modeling; (3) adaptively tune the LVAD controller through a quadratic optimization procedure to maintain the cardiac output and pressure perfusion within acceptable physiological ranges concerning different physiological activities. The accomplishment of this project will give rise to a new paradigm of personalized risk stratification, treatment planning, and postoperative care for end-stage heart failure patients, as opposed to traditional guideline-based solutions. The methodologies are transformative to various fields that involve risk assessment, image segmentation, computational modeling, and adaptive control. These applications include neural systems, advanced manufacturing and civil infrastructure.

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