Detailed Research Projects

Numerical Modeling of Bioheat Transfer and Biofluid Mechanics - John Abraham

Numerical modeling has been used to design new medical therapies and optimize existing therapies for the treatment of various medical conditions. Numerical modeling allows designers to predict medical outcomes prior to the actual procedure. The use of modeling allows the integration of techniques from three fields: mathematics, engineering, and biological sciences.

Faculty at the University of St. Thomas have been leaders in the development of the numerical techniques which enable the solution of biomedical problems such as: simulations of fluid flow in implanted stents [52,50], mitigation of urethral constriction associated with Benign Prostate Hyperplasia [4,6], treatment of malfunctioning uterine tissue through thermal ablation [1,49], and the evaluation of tissue properties required to carry out the numerical calculations [54].

The intersection between biomedical sciences, mathematics, and engineering has led to an explosion of analysis opportunities [31,3,5,55], some of which have been introduced into the undergraduate classroom with great success [2]. Faculty at the University of St. Thomas hope to expand the involvement of undergraduate students in state-of-the-art research at this three-field interface. The requisite tools and techniques have matured to enable students at the undergraduate level to make a real impact on the design and evaluation of devices and therapies which will lead to the improvement of peoples' lives.

The proposed research will focus on the modeling of heat transfer and fluid flow within living organisms. Finite element and finite volume methods will be employed to carry out the numerical solutions of coupled, nonlinear, ordinary and partial differential equations. Statistical analysis through the Design of Simulations method [31,51] will allow students to identify major contributing inputs and to quickly evaluate results over a wide variation in the values of those inputs. Special attention will be give to error estimation through residual tracking and the development of mesh-independent solutions.

It is expected that student contributions will significantly advance the ability of engineers to perform simulations for applications not limited to those discussed here. It is certain that both the region and national biomedical industries will benefit from the proposed work.