On behalf of Slovak University of Technology in Bratislava, Faculty of Mechanical Engineering, Slovak Society for Mechanics and Central European Association for Computational Mechanics, we are pleased to announce that

Prof. Thomas J.R. Hughes

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has been selected to receive the **Medal of STU**. On this occasion, Prof. Hughes gives a lecture titled **Patient Specific Computer Modeling and the Predictive Paradigm in Cardiovascular Medicine**

on

October, 3rd, 2016; at 10,00 a.m.
STU in Bratislava, Vazovova 5, 812 43 Bratislava
3rd floor, Conference room

Prof. Ing. Robert Redhammer, PhD.
Rector of STU

doc. Ing. Branislav Hučko, PhD.
Dean of Sjf STU

Patient Specific Computer Modeling and the Predictive Paradigm in Cardiovascular Medicine

Abstract:

Engineering has played an increasing role in medicine in my lifetime. That will undoubtedly continue, but I believe it is also about to take on a new and fundamentally different role that will have profound consequences in the future.

Cardiovascular disease (CVD) is the leading cause of death of both men and women in the United States and the entire industrialized world and is the most costly component of total health care spending. Consequently, the understanding and treatment of CVD are subjects of the greatest national and international importance.

The historical and current paradigm in cardiovascular medicine is diagnosis. Physicians use various tests to determine a medical condition and then plan a treatment or intervention based upon experience. There is no attempt to predict an outcome although there may be some statistical data to indicate the success rate of a procedure. Success may be defined in various ways depending on the nature of the treatment. It may be the ability to regain certain bodily functions, or simply to survive. However, statistics alone are not reliable predictors of success for individual patients. There is simply too much variability from case to case, especially for diseased patients. The current situation is far from satisfactory.

It is interesting to compare medical practice with engineering. Both are problem-solving disciplines. However, in engineering there is an attempt to accurately predict the performance of a product or procedure. The entire design process is based upon predicted outcomes. Very often a number of criteria must be satisfied simultaneously. Sophisticated computer and analysis technologies are employed.

However, the pace has become so rapid that for the newer, high-resolution technologies there is little statistical basis for treatment planning. To correct this situation it appears inevitable that, in the future, the practice of medicine will have to resemble the practice of modern engineering more closely.

An example is illustrative. Until about 20 years ago research in the computer simulation of arterial blood flow utilized very simple, idealized models and the relevance to medical practice was very limited. Then, a new era in vascular research began [1] in which realistic, patient-specific models were employed, not only to simulate and evaluate pre-operative, diseased configurations, but also to analyze post-operative outcomes. This has evolved into the concept of “predictive, or computational, medicine” in which patient-specific computer modeling and analysis are performed to diagnose disease, evaluate the efficacy of various possible treatments, and to plan and design the optimal intervention based upon predictions of outcomes. It is clear that with current technology and sufficient effort, the immediate consequences of an intervention can be predicted. For example, the effectiveness of a bypass graft configuration can be assessed with reference to the redistribution of blood flow. However, of even greater importance are the implications of the intervention after time has elapsed – a month, three months, six, a year, two, etc.

Patient-specific modeling and analysis technologies for the human cardiovascular system are under development at a number of research laboratories throughout the world. The ultimate goal is to provide cardiologists and cardiovascular surgeons with improved technologies to prevent, diagnose and treat cardiovascular disease. These technologies will enable clinicians to craft cardiovascular therapies that are optimized for the cardiovascular system of each individual, and to evaluate interventions for efficacy and possible side effects before they are performed. They will also provide design methodologies enabling biomedical engineers and physicians to devise new therapies, while decreasing costs and increasing safety associated with the introduction and clinical testing of new therapies. Indeed, the noninvasive nature of computational medicine technologies may be one of the most effective ways to control spiraling health care costs without sacrificing the quality of care. Closer collaboration between physicians and engineers will facilitate development and introduction of these technologies.

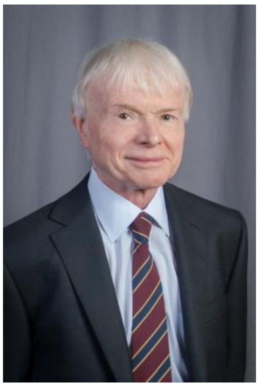
The first computational medicine technology for the diagnosis of coronary artery disease was given FDA approval in November of 2014. http://www.heartflow.com

The concept of predictive medicine has a long history. As early as the time of Hippocrates (*ca*. 460 BC – *ca.* 370 BC) the Kos physicians wanted to reassure their patients by predicting the outcomes of their treatments, but their medical knowledge and technology were too primitive to support their ambition. Now, almost two and a half millennia later, it appears that the time may be right.

The development, clinical implementation and promulgation of the predictive paradigm may well represent a milestone in the history of engineering and medicine, and one that may have significant benefit for the health and welfare of humanity.

References:

[1] C. A. Taylor, T. J. R. Hughes, and C. K. Zarins, "Finite Element Modeling of Blood Flow in Arteries," Computer Methods in Applied Mechanics and Engineering, vol. 158, pp. 155-196, 1998.



Thomas J.R. Hughes

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Professor of Aerospace Engineering and Engineering Mechanics

Thomas J.R. Hughes holds B.E. and M.E. degrees in Mechanical Engineering from Pratt Institute and an M.S. in Mathematics and Ph.D. in Engineering Science from the University of California at Berkeley. He taught at Berkeley, Caltech and Stanford before joining the University of Texas at Austin in 2002.

He is an elected member of the US National Academy of Sciences, the US National Academy of Engineering, the American Academy of Arts and Sciences, the Academy of Medicine, Engineering and Science of Texas, and he is a Foreign Member of the Royal Society of London, the Austrian Academy of Sciences, and the Istituto Lombardo Accademia di Scienze e Lettere. Dr. Hughes has received honorary doctorates from Northwestern University and the universities of Louvain, Pavia, Padua, Trondheim, and A Coruña.

Dr. Hughes is one of the most widely cited authors in Engineering Science. He has received the Huber Prize and Von Karman Medal from ASCE, the Timoshenko, Worcester Reed Warner, and Melville Medals from ASME, the Von Neumann Medal from USACM, the Gauss-Newton Medal from IACM, the Computational Mechanics Award of the Japan Society of Mechanical Engineers, the Grand Prize from the Japanese Society of Computational Engineering and Sciences, the Computational Mechanics Award of the Japanese Association for Computational Mechanics, the Humboldt Research Award for Senior Scientists from the Alexander von Humboldt Foundation, the AMCA Award for an International Scientific Career from the Argentinian Association for Computational Mechanics, and the Wilhem Exner Medal from the Austrian Association für SME (Öesterreichischer Gewerbeverein, OGV). He has received ASCE's highest honor, election to Distinguished Member.

The Special Achievement Award for Young Investigators in Applied Mechanics is an award given annually by the Applied Mechanics Division of ASME. In 2008 this award was renamed the Thomas J.R. Hughes Young Investigator Award. In 2012 the Computational Fluid Mechanics Award of the United States Association for Computational Mechanics was renamed the Thomas J.R. Hughes Medal.