

# Preface

A major objective of medical research is related to the development of improved medication and implants. Due to the individual anatomy of each human being, the research direction points more and more towards a patient specific medicine. This in turn requires a better understanding of biological systems and of the performance of implants in humans. In engineering disciplines the application of virtual process design has originated many important innovations. Virtual modelling helps understand and control processes. Furthermore, virtual testing is fast and flexible. Hence, many new products can be efficiently designed and verified by numerical approaches.

In recent years these concepts were successfully applied in the field of biomedical technology. Based on the tremendous advances in medical imaging, modern CAD systems, high-performance computing and new experimental test devices, engineering can provide a refinement of implant design and lead to safer products. Computational tools and methods can be applied to predicting the performance of medical devices in virtual patients. Physical and animal testing procedures can be reduced by use of virtual prototyping of medical devices. These advancements enhance medical decision processes in many areas of clinical medicine.

In this book, scientists from different areas of medicine, engineering and natural sciences are contributing to the above research areas and ideas. The book provides a good overview of new mathematical models and computational simulations as well as new experimental tests in the field of biomedical technology.

In the first part of the book the virtual environment is used in studying biological systems at different scales and under multiphysics conditions. Modelling schemes are applied to human brain tissue, blood perfusion and metabolism in the living human, investigation on the effect of mutations on the spectrin molecules in red blood cells and numerical strategies to model transdermal drug delivery systems.

The second part is devoted to modelling and computational approaches in the field of cardiovascular medicine. The contributions start with an overview of current methods and challenges in the field of vascular haemodynamics. This is followed by new methods to accurately predict heart flow with contact between

the leaflets, estimation of a suitable zero stress state in arterial fluid structure interaction, solution strategies for stable partitioned fluid-structure interaction simulations, methods for stable large eddy simulation of turbulence in cardiovascular flow, a demonstration of the importance using non-Newtonian models in specific hemodynamic cases, a multiscale modelling of artificial textile reinforced heart valves, and new strategies to reduce the computational cost in fluid-structure interaction modelling of haemodynamics. The part closes with a method to computationally assess the rupture risk of abdominal aortic aneurysm.

A parameter study of biofilm growth based on experimental observations and numerical test as well as a multiscale modelling approach to dental enamel are contributions that face current challenges in dentistry.

The part related to orthopaedics starts with an overview of challenges in total hip arthroplasty and is followed by a concept for a personalized orthopaedic trauma surgery based on computational simulations.

The last part addresses otology and shows that an off-the-shelf pressure measurement system can be successfully used for intrachochlear sound pressure measurements. The second contribution is a user-specific method for the auditory nerve activity, leading to a better understanding of the electrode nerve interface in the case of cochlear implants.

All contributions highlight the state-of-the-art in biotechnology research and thus provide an extensive overview of this subject.

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