RESEARCH SIGNPOST

Biomechanics Applied to Computer Assisted Surgery
2005

Editor
Yohan Payan
Laboratoire TIMC/IMAG, CNRS UMR 5525
Institut d'Ingénierie de l'Information de Santé
Pavillon Taillefer – Faculté de Médecine
38706 La Tronche, France

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Published by Research Signpost

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Research Signpost
T.C. 37/661(2), Fort P.O.,
Trivandrum-695 023, Kerala, India

Editor
Yohan Payan

Managing Editor
S.G. Pandalai

Publications Manager
A. Gayathri

ISBN: 81-308-0031-4

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INTRODUCTION

Biomechanics applied to computer-assisted surgery: an overview

This review book tries to gather results provided by research teams that have developed biomechanical models of human anatomical structures in the framework of computer-assisted surgery (CAS). The CAS community is quite recent in the context of Computer Science since the pioneer works date from the 80's. Orthopaedics was mainly the first clinical domain addressed by these pioneer CAS applications. The reason for this was probably that bones were the human body structures which were considered as the most easily includable into a CAS application: they were assumed to be rigid, i.e. with a fixed 3D geometry, they were strongly identifiable onto Computer Tomography exams, and their relative position during surgery was easily tractable by fixing *rigid bodies* onto their external surface (these rigid bodies being tracked with the use of an optical device for example).

Biomechanicians were first asked to work onto CAS applications when orthopaedic surgeons were looking for tools able to predict risks of fractures. In that case, bonny structures could no more be considered as rigid but on the contrary had to be modelled as a deformable continuum with a non-homogeneous distribution of the internal stresses. The first part of this book gathers some works proposed in this context of CAS applied to bonny structures. It covers classical orthopaedic pathologies, such as those affecting the spine (Baroud *et al.*, Skalli and Lafage, Seifert *et al.*, Contro *et al.*), the forearm (Kullmer and Richard) or the shoulder (Briot *et al.*). The bone remodelling process is also an important activity that can be studied through biomechanics in order to assist surgeons (Mellal and Botsis, Doblaré and García-Aznar).

More recently, arguing that most of the human body is made of soft tissues that can move as well as deform during surgical gestures, biomechanicians have worked even more closely with the CAS community. Indeed, sophisticated biomechanical models had to be developed to try to predict the way soft tissues are supposed to deform during surgery. By sophisticated models, we mean models that permit in most cases to take into account the geometrical (*large deformation* hypotheses) and/or the mechanical non linearities (with a non-linear constitutive behaviour of the tissues). The second part of this book aims to gather some representative works carried out in this domain, focusing onto the brain (Miga *et al.*, Ecabert and Thiran, Farag *et al.*, Bucki *et al.*), the coronaries and vessels (Ohayon *et al.*, Shkolnik *et al.*, Petrini *et al.*), the face

(Zachow *et al.*, Payan *et al.*), the uterus (Pacini *et al.*), the ligaments (Limbert and Middleton), the prostate (Cormack *et al.*) and the heart (Sermesant *et al.*). In addition, two “transversal” papers focus on methods to automatically generate patient-specific Finite Element models (Taddei *et al.*, Payan *et al.*).

Yohan PAYAN
TIMC – CNRS, France