EUROMECH Colloquium 595

"Biomechanics and computer assisted surgery meets medical reality"

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There have been recent major developments in biomechanics and computer assisted surgery. Several researchers are working on approaches to improve and optimize medical treatments. Personalized medical treatment is the objective of such research. However, the key issue of patient-specific treatment is the final validation in relation to the medical reality. In order to improve treatments, scientists want to develop patient-specific in-silico simulations that mimic the medical reality with the highest possible accuracy. The key issues scientists have to address is how to represent the medical reality in simplified form, model the anatomy and the geometries of the considered structures in interaction, and thereby develop the numerical and physical models and behaviour laws. Comparison with medical reality requires researchers to understand the limitations of clinical measurements and clinical trials, having reduced sensitivity and accuracy with increased uncertainties.

The aim of EUROMECH Colloquium 595 was to allow the exchange of ideas, approaches and methodologies in recent developments, dealing with fluid and solids. There were 38 participants and 36 presentations, including four key-note lectures by:
- Karol Miller, University of Western Australia;
- Irène Vignon-Clementel, INRIA Paris & Sorbonne Université UPMC;
- Abdul Barakat, Ecole Polytechnique;
- Hervé Delingette, INRIA Sophia Antipolis.

The presentations and the discussions addressed four key issues:
- **From experimental tests to constitutive models**

Presentations highlighted the differences between constitutive models which seek to represent every contribution of every scale of soft tissue, and the experimental ability to measure an effective sensitivity to every parameter. Despite the considerable progress of destructive and non-destructive mechanical characterization it seems, to the participants understanding, more pragmatic to differentiate the first order parameters, whose influence can be identified, from second order parameters, whose influence might not be identified, and to simplify as much as possible the constitutive models to be applied in a high-dispersion medical context.
- **From medical images to numerical simulations**

The key to patient-specific simulation, and patient-specific treatment, lies in the ability to obtain a numerical model directly from medical imaging. The medical images, obtain in a clinical environment and not in a research environment, are of low resolution. The main difficulty stems is in the ability to obtain an accurate geometric and mechanical model from such low resolution medical images. Participants presented several methods to identify the geometry of the anatomical feature under investigation. In each case resolution was the key problem. Several papers introduced manufactured physical models and particularly silico models, observed using medical imaging equipment. Silico models seem to offer the best numerical accuracy for patient-specific simulation.
- **From model to numerical simulations**

Constitutive models and numerical simulations must be gathered and used to simulate patient-specific cases. This leads to simulation with a very large number of parameters, coming from both constitutive and geometric models. The resolution of the numerical models, the number of degrees of freedom of finite element meshes and numerical algorithms to solve nonlinear problems are important factors. The sensitivity to that large number of parameters and the accuracy of the final results have also been questioned.
- **Real-time & planning surgery simulations**

In a surgery-planning context, numerical simulations should be real-rime to fulfil the expectation of surgeons. In such a context, the huge number of parameters, or degrees of freedom, of a problem is an

issue. Real-time simulation requires minimisation of the number of parameters. However, the requirements of accurate simulation, being compared to medical reality, require high fidelity. The balance between reducing the resolution of models to reach real-time simulations and increasing the accuracy of models to reach bio-fidelity has been addressed during the colloquium. Physical models manufactured in silico which mimic physiological or physio-pathological cases, seems to be a direction of development to estimate the balance between speed-up and resolution in real-time simulation.

EUROMECH Colloquium 595 provided a very good opportunity for the community of researchers in biomechanics to link with those working in applications and medical reality, share experience and discuss applications and problems. Several participants in the colloquium said how much they enjoyed the exchange and wished to meet again in 2 years. Colloquium 595 is also leading to a book series "Biomechanics and Computer – Assisted Surgery Meets Medical Reality", being published by Springer in 2017 with selected contributions.