24 July 2007

NEWSLETTER – JULY 2007

Content:

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1. THE BIOMOUTH RESEARCH GROUP WEBSITE (BY OLIVER RÖHRLE)

The new webpage for the Biomouth Research Group has moved now to www.biomouth.org. Oliver reserved the domain name and Gareth de Walters, the system administrator at the Bioengineering Institute, has kindly helped us to set up a framework of the webpage using MODx as a content management system. This should make it easy for us to modify content on the website itself. (It is very similar to other Plone systems).

The technical things aside, we need some content and structure for the website. We need plenty of links, nice pictures, movies, introductions of ourselves, etc. A good idea might also be to give a brief overview of the subgroups/universities actively involved in the Biomouth Research project as well as a list of their current and former members.

For everyone, please try out the link and email me content as well as new ideas for the structural organisation of the webpage. Thanks.

3. PETER XU, MASSEY UNIVERSITY, ALBANY

Each year Massey receives a number of visiting European students. This year will see again three French students majored in engineering for their three-month internship between July and September. They will work for a newly launched project 'neuronal oscillator modelling, simulation, and experimental control of mastication CPG'

And a new postdoctoral fellow from China will join Massey team for dynamics control of chewing machines in August."

4. HAPPENINGS AT THE BIOENGINEERING INSTITUTE, THE UNIVERSITY OF AUCKLAND

The paper "*Three-dimensional finite element modelling of muscle forces during mastication*" by Oliver Röhrle and Andrew Pullan has now been accepted by the Journal of Biomechanics. The Journal suggests that you cite it as: Röhrle, O., Pullan, A.J., Three-dimensional finite element modelling of muscle forces during mastication, Journal of Biomechanics (2007), doi:10.1016/j.jbiomech.2007.05.011.

Oliver, Andrew, and John Davidson (a PhD student at the Bioengineering Institute) have developed a new electromechanically coupled framework to model skeletal muscles more realistically. This framework bridges the scales between a three-dimensional mechanical model on the whole muscle level and electrophysiological activity of a single muscle fibre through a new multiscale constitutive law that incorporates on the muscle level homogenized cellular parameters of the cellular model. With this new model, it is possible to describe within a single muscle, for example, different muscle types, fibre distributions, and activation patterns. A manuscript titled "*Bridging Scales: A three-dimensional Electromechanical Finite Element Model of Skeletal Muscle*" was submitted to SISC (SIAM Journal on Scientific Computing). This paper describes the proposed framework and provides some mathematical validation.

The idea of different activation patterns within a muscle has also led to some joint work with Jules Kieser from Otago University. We would like to analyse the effects of different muscle activation patterns with respect to the functionality of the lateral pterygoid.

This study uses an anatomical realistic three-dimensional model of Oliver's head. Oliver has used MRI scans of his head to construct a three-dimensional model of the skull, the mandible, the masseter muscles, the lateral and medial pterygoid muscles, and the temporalis muscles. This model also allows us to improve the analysis of the previously recorded chewing trajectories, in particular in the regions of the condoyle, TMJ, and the gleniod fossa.

Together with Kylie Foster and Ionut Ichim, Oliver has carried out some more chewing and biting experiments at the Sports and Science Biomechanics Lab at the Tamaki Campus of the University of Auckland using a VICON optical motion tracking system and at Massey University using the 3D Articulograph recently installed in Kylie Foster's lab. While some data has already been analysed, no attempt has yet been made to compare these two measuring techniques.

Oliver will be presenting his new computational framework for skeletal muscles at the World Congress on Bioengineering (9^{th}-11^{th} July 2007) in Bangkok, Thailand and at the annual meeting of the GAMM (German Society of Applied Mathematics and Mechanics) which will this year be embedded within the 6^{th} International Congress on Industrial and Applied Mathematics (ICIAM) in Zurich, Switzerland. The talk at the GAMM will be a 40 minute keynote lecture within the section "Muscle and Bone". After the conference in Zurich, Oliver will be "vacationing" in Germany for about three weeks, before returning (via Denver) to NZ in mid August.

5. UPDATE FROM THE SCHOOL OF DENTISTRY BIOMOUTH GROUP (PROF JULES KIESER, PROF MIKE SWAIN, IONUT ICHIM, NEIL WADDELL, RICHARD COOK, VINCENT BENANI AND EXCHANGE STUDENTS MARKUS PERCHTALER AND GREGOR SZWEDKA)

As part of the on-going research into human mandibular movement and mastication members of the group recently published a paper, "Functional significance of strain distribution in the mandible under masticatory load: Numerical predictions" in Archives of Oral Biology (Ichim, Kieser & Swain, 2007). The findings of this study has implications for the provision of fixed

restorations, especially bridges on the natural teeth and implants. The current trend in restorative dentistry is to place more and more rigid ceramic structures as bridges. When one looks at the movement and stress distribution in the mandible (see figure 1; fig 6 extracted from the publication), this has implications for the long-term success of the supporting bony structures, implants and the abutments and bridges placed on these teeth or implants.

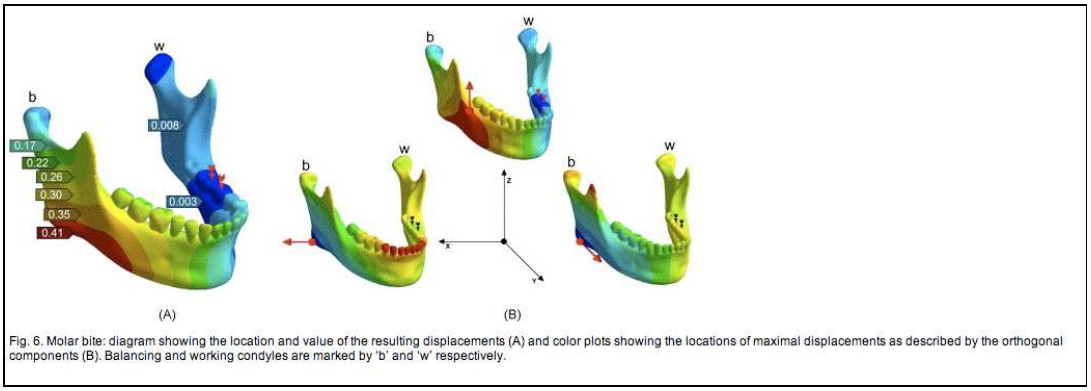

Figure 1. Extract of figure 6 from Ichim, Kieser and Swain, 2007.

The next stage of the study has been to construct an in vitro model of a mandible using materials that have the same mechanical properties as the natural mandible. Once validated, this will enable the group to look at a range of restorative options with the ultimate aim of design optimisation. The project has been carried out by Markus Perchtaler, an exchange student from the University of Applied Science, Osnabrueck, Germany, who has been with us for the last six months as part of his Diplom, Engineering in Dental Technology (figure 2, 3 & 4).

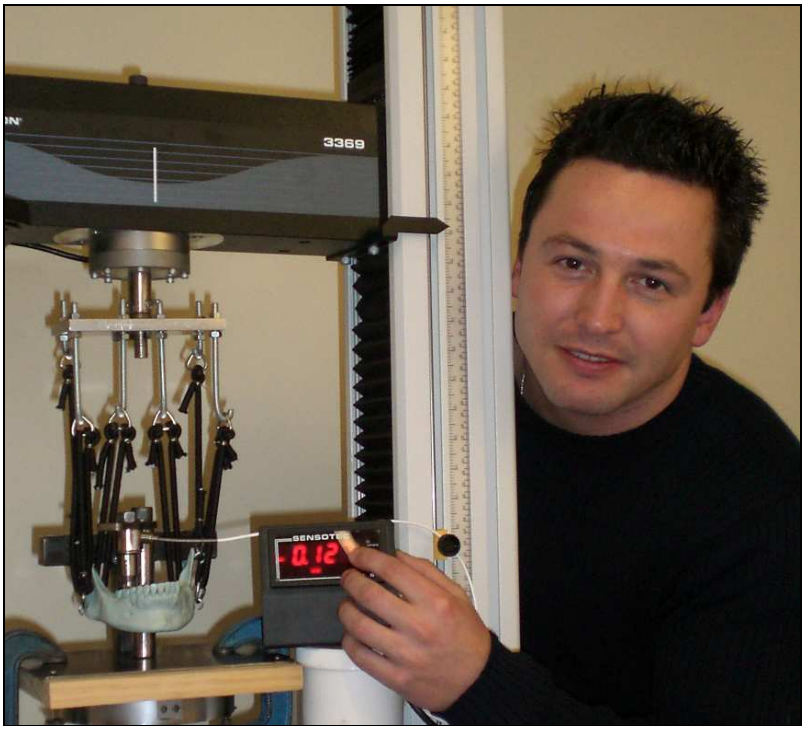

Figure 2. Markus Perchtaler alongside the mandible test rig. The image shows an adjustable position load cell (can be swung in an arch to any tooth position) placed over the first molar. Elastic muscles attached to the muscle attachment points and pull hooks attached to the universal testing machine load cell enable the recording of the bite force on the teeth and amount of muscle force required to achieve this.

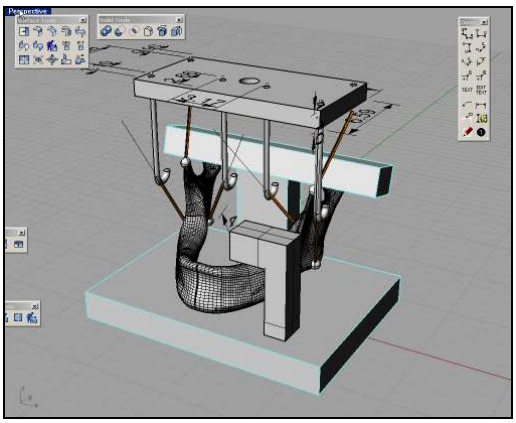

Figure 3. Preliminary drawing of mandible system.

Figure 4. Mandible in loaded from the Masseter, Temporalis and Medial Pterygoid muscle groups. Strain gauges attached to the buccal and lingual of the mandible below the first molar position on both the working and balancing side. Load cell is positioned to record the bite force at the central incisor position.

Phase two of the project is to place two implants into the edentulous side of the mandible and restore these with various bridge systems while placing strain gauges on various areas to gather data for incorporation into the existing FEA model.

References

Ichim, I., J. A. Kieser, et al. (2007). "Functional significance of strain distribution in the human mandible under masticatory load: numerical predictions." Arch Oral Biol **52**(5): 465-73.