

NEWSLETTER – JUNE 2006

Content:

1. Previous Biomouth newsletters
 2. News from the University of Otago (by Jules Kieser)
 3. The Bioengineering Institute, University of Auckland (by Oliver Röhrle)
 4. The Bioengineering Institute, University of Auckland (by Nina Van Essen)
 5. Massey University, Palmerston North (by Peter Xu)
-

1. PREVIOUS BIOMOUTH NEWSLETTERS

Previous newsletters can be found under:

<http://www.bioeng.auckland.ac.nz/people/rohrle/Frames/Biomouth/BiomouthMain.htm>

2. NEWS FROM THE UNIVERSITY OF OTAGO (BY JULES KIESER)

Jules recently attended the pre-IADR satellite conference on Mastication in Brisbane from 26-27 June. While the venue was a shocker (cold, noisy and poorly catered), and the accommodation at Emmanuel College worse (cold, dirty, no TV, no internet, no coffee!), the conference itself was superb. Kemal Turker from Adelaide had drawn together members from most of the major groups in North America, Europe, Japan and Australia/New Zealand. With 32 oral and 55 poster presentations there was something for everyone.

While the emphasis was clearly neurophysiological, I did make very useful contacts with Callum Ross (University of Chicago), Susan Herring (University of Washington), Tim Miles (Adelaide) and Chris Peck (Sydney). Callum was working on lizard mastication and was particularly interested in Kylie and Christine's findings. Susan was her usual helpful self and suggested that we might model lateral pterygoid contractions for our clinical paper.

There were two Kiwi presentations – Gill Johnson and ours, and both were well received.

On the last day, almost by accident, I made contact with Per – Olaf Erickssen and Hamayun Safar of the Moto Rehab Laboratory at UMCA University Sweden. A couple of hours later, I emerged now well informed of the roles of two other masticatory joints – the atlanto-occipital and spinal joints. This laboratory had conclusively shown that you never bit without flexing your neck (something we have always known but ignored). Implications range from Bhavia and Dan's

swallowing study (we are now going to restrict the volunteer's head and neck movements and then ask them to swallow and chew – and see how pressure patterns differ to unrestrained reading to Andrew / Gill / Cath's study (where they specifically recommended two cameras and a light weight set of markers), to Andrew / Kylie / John's project (where we are going to have to think about neck movements and how these are captured).

A final useful conversation was with Jack Truman from UCLA. He stressed that feeding behaviour should be divided into appetitive behaviour (i.e. metrication to eat) and consumatory behaviour (i.e. method of eating). While each of these is studied independently, for new product development we really need to combine these and understand both issues of appetitive and consumatory behaviour surrounding our new product.

3. THE BIOENGINEERING INSTITUTE, UNIVERSITY OF AUCKLAND (BY OLIVER RÖHRLE)

Oliver Röhrle and Andrew Pullan from the Bioengineering Institute (BI) at the University of Auckland submitted a paper entitled "Three-dimensional finite element analysis of muscle forces during mastication" to the Journal of Biomechanics. This paper combines a three-dimensional anatomical model of the human mastication system, natural three-dimensional trajectories of the mandible while chewing sample foods, transversely isotropic material laws that depend on fibre orientations and motion-driven activation patterns, and the Finite Element method applied to three-dimensional finite elasticity theory. Solving for the deformations of the muscles given the location of the mandible at a sequence of time steps lead to a kinetic description of the masticatory system that allows calculating the direction and magnitude of muscle forces acting on the mandible and maxilla while chewing. Time-force relationships are presented and analysed with respect to different tasks during mastication, e.g. opening, closing, and biting. If people are interested, Oliver is more than happy to email a preprint of the paper.

At the beginning of May, Oliver visited Jules Kieser and Ionut Ichim, as well as the department of anatomy at the University of Otago. Further he (and others from the BI) met up with Merilyn Duxson and her group to discuss how we could use and include anatomical micro-structural details such as fascicle directions and tendons within modelling, in particular within three dimensional finite element models of skeletal muscles.

On May 26/27, Oliver visited the TMJ Bioengineering Conference in Broomfield, Colorado (USA). The conference was interesting in the sense that it combined researchers from different fields, such as biomechanics, tissue engineering, biology, as well as maxilla-facial surgeons and people involved in the commercial development and production of implants. Interestingly enough, one of the major issues and challenges remain the force distribution within the TMJ, even during rather simple tasks like clenching. During the conference, Oliver met and had long and very interesting conversations with Eiji Tanaka from the University of Hiroshima, Japan. He is thinking about visiting NZ on one of his next trips to Australia.

Currently, Oliver is visiting the Institute of Orthopaedic Research and Biomechanics (IROB), University of Ulm, Germany. The IROB has developed software that calculates the muscle forces or the activation patterns of the muscles given a particular movement and (ground) force measurements. Although the muscles are oversimplified by representing them as one-dimensional cables, we might yet be able to use it to considerably improve our current (mathematical) models. As mentioned above, the inputs to the IROB software are movements and forces. If we are able to gather bite force measurements through the chewing robot developed at Massey University, we could use those and the already recorded chewing trajectories as input for the IROB's software and use a simplified model of the muscles of mastication (simplified in the sense that the muscles of

mastication are represented as strings) to calculate the respective activation levels during a particular chewing cycle. This information could then be used as input into the three-dimensional finite element model of the muscles of mastication, as presented in Oliver's latest paper. A time-dependent representation of the activation patterns would present a big improvement over piecewise constant values obtained through educated guesses.

Oliver will leave the IROB again at the end of July. He will attend the World Congress on Biomechanics in Munich and returns to New Zealand on August 7. Andrew is currently on sabbatical (his GPS remote tracker seems to indicate that he is currently in Oxford, England) and will return to the New Zealand mid January. Andrew will also attend the World Congress in Munich.

Further, Oliver would like to thank John Aarts and the organisers of the annual conference of the New Zealand Institute of Dental Technicians (NZIDT) for their kind invitation to give the keynote presentation at their conference in Wellington on October 14.

Andrew Pullan got promoted to Professor! Congratulations Andrew!

4. THE BIOENGINEERING INSTITUTE, UNIVERSITY OF AUCKLAND (BY NINA VAN ESSEN)

Nina handed in her PhD thesis, "Anatomically Based Modelling of the Human Masticatory System", on June 22.

Abstract:

The human masticatory system consists of a complex arrangement of bones, teeth, muscles and joints that allow us to perform the task of breaking down food in preparation for swallowing. The process of mastication involves various types of motions, which requires that the jaw joint be able to move with six degrees of freedom. The masticatory system is prone to dysfunction, particularly in the regions of the teeth and jaw joints, with the causes of such dysfunction often unknown. If our understanding of masticatory system function could be improved then it may be possible to better predict the causes of dysfunction and also improve the treatments available.

One method for studying masticatory system function is to create anatomically based computational models of the jaw components and use these models to simulate mastication. Calculating the stresses and deformations occurring in the various components of the jaw as it is moved and loaded may provide insights into the causes of dysfunction. We present here the creation of an extensible mathematical modelling framework of the masticatory system that can be used as a foundation for the creation of a model that is capable of fully simulating masticatory system function. Three key requirements of the modelling framework are identified that ensure extensibility. These requirements cover creation of anatomical models of all the relevant components, experimental gathering of kinematical data of jaw motion, and testing of the ability of the model to calculate deformations and stresses of the bones and articular disc of the jaw joint, utilising the finite element method to solve the governing equations of mechanics.

Anatomical models of the bones, teeth, muscles and joints related to mastication have been created, as per the modelling framework requirements. Kinematical data of jaw motion has also been gathered experimentally using motion capture techniques. Two mechanical simulations using the anatomical models have been carried out. The first was a clenching simulation involving the mandible bone model only, calculating the deformation and stress of this bone when subject to muscle forces. The second involved the mandible and jaw joint model in a simulation of jaw

opening, calculating the deformation and stresses of the articular disc of the joint. The results of both these simulations indicate that the model framework is capable of fulfilling the three key requirements and, as such, is suitable as a foundation on which to carry out further research towards the overall goal of creating a computational model that can simulate masticatory system function fully.

5. MASSEY UNIVERSITY, PALMERSTON NORTH (BY PETER XU)

Dr Dong (Walter) Xie joined Massey team in April, as a Postdoctoral Fellow. He got his PhD in AI from University of Bristol early this year. He is researching in Knowledge and Data Engineering of Human Chewing Behaviours. Walter is based in Albany Massey, and works with Peter, Kylie and John. His contact is Email: D.Xie@Massey.ac.nz, Phone: 09-4140800 ext 9834.