BIOMOUTH NEWSLETTER
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1. NEWS FROM THE SIR JOHN WALSH RESEARCH INSTITUTE, OTAGO UNIVERSITY (BY JULES KIESER)

This has been an extremely exciting year for us, especially in the field of postgraduate research. Nitan Raniga completed his studies on tongue pressure, only to have his shoes filled by Guy Farland, who is looking at viscosity effects on tongue pressure. Guy is familiar to most of you, having attended Maggie-Lee's dysphagia course and presenting at this year's Biomouth in Christchurch. While Nit's research is being submitted to *Dysphagia,* we were also lucky to be asked to present a general review of our work to the *Journal of Texture Studies.* The best news is that Prof Mauro Farella has joined our group, with vast experience of modeling and EMC work. Our next clinical Doctoral student is Hannah Jack, whose project will focus on lip pressures during swallowing.

Our photo shows Prof Chris Bolter, Nitan and Guy hard at work on our pressure data.

Another new student, Carolina Loch, is also now familiar to many of you – having presented at Biomouth. Carolina, who hails from Florianopolis in Brazil, is doing her PhD on the teeth of fossil and living dolphins. She is particularly focused on form and function of the masticatory complex in these fascinating animals and will be working with Prof. Ewen Fordyce and Jules.

This picture shows Carolina and Jules dissecting a dolphin head recently.

2. Mastication Robots, Biological Inspiration to Implementation (by Peter Xu and John Bronlund)

Peter Xu and John Bronlund authored a research book, Mastication Robots, Biological Inspiration to Implementation. The book was just released by Springer, Berlin Heidelberg, in August 2010. Its ISBN 978-3-540-93902-3, eISBN 978-3-540-93903-0. The book contains 10 chapters ranging from the design, motion control and experiments of various robots, and neural control of the robot, as well as knowledge based systems for human chewing behaviours. The book presents the body of the work we have done in the perspectives of mechatronics. The publisher's synopsis reads as follows:

Mastication Robotics: Biological Inspiration to Implementation is the first book in the special field of masticatory robots for applications including foods texture analysis, dental training and speech therapy. It is a collection of the efforts we have made in the field at Massey University, New Zealand. The book provides a thorough review of the human masticatory system, and presents principles, analysis, design, simulations and experiments of a number of masticatory robots developed by the authors. This book is a valuable reference for researchers, engineers and graduates in the field of robotics, mechatronics, automatic control, artificial intelligence and food sciences.

Upon the releasing of the book, we would once again like to acknowledge the contributions from many of you in this group, at various levels.
http://www.springer.com/engineering/book/978-3-540-93902-3

3. MASTICATION ROBOTICS IN JAPAN (BY PETER XU)

I was in Japan, as a JSPS Visiting Professor at Keio University, May to July 2010. I took the opportunity and visited many other universities. At TWINs, Tokyo Women's Medical University - Waseda University Joint Institution for Advanced Biomedical Sciences, I met with Prof Takanishi who pioneered the field of mastication robotics (for dental training) and toured his fascinating laboratories (robotics for medicine, rehabilitation). I even saw his robots displayed in the Future Science Museum in Tokyo. Besides my impression with newer versions of chewing robots in the lab, I also saw a few Airway Robots for doctoral training, which is amazing. On top of existing friends, I made a good number of new friends in the field. I was last in Japan, with Ristumeikan University, in Kyoto, 1994 and 1995.

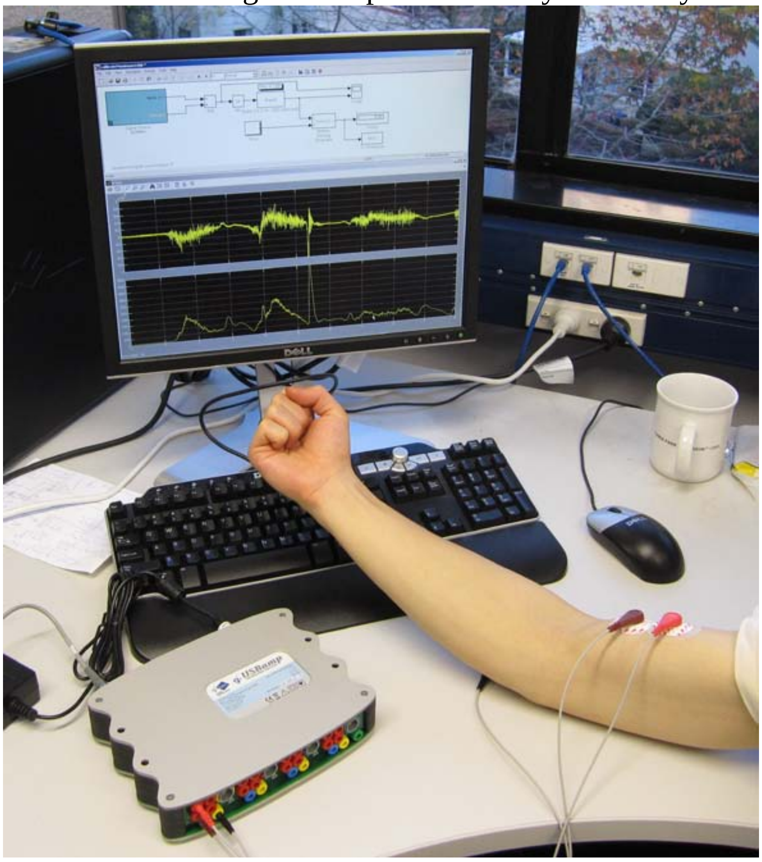
4. UPDATES FROM THE UNIVERSITY OF STUTTGART, GERMANY (BY OLIVER RÖHRLE)

Since taking up my new faculty position at the University of Stuttgart, I have focused on projects other than dental applications (most of the projects I initiated were on modelling skeletal muscle mechanics on different scale). However, more recently, I have started to resurrect a previous Biomouth Research Group project. As a continuation of our on generating functional tooth surfaces based on natural chewing trajectories work (jointly with Harry Saini, Andrew Pullan and Neil Waddell), I plan to investigate dynamic biting forces using the Finite Element method. For this purpose, I managed to hire a research assistant (part time) and a 4^{th} year bachelor student. The research assistant, Harry Saini who has already worked as a 4^{th} year student and as a research assistant at the Auckland Bioengineering Institute on generating functional surfaces, is currently working one day a week on this project. However, he might choose this project as his master thesis topic as part of the COMMAS (Computational Mechanics of Materials and Structures) program at the University of Stuttgart, Germany. As we just have started this project, there are no results yet, but I hope to report soon on progress and first results.

Despite being in Germany, I continue to co-supervise Yikun Wang, a PhD student at the Auckland Bioengineering Institute. He is working on modelling the movement of the tongue during the oral stage of the swallowing process. Recently, Yikun has successfully finished his first year report. He is currently working on two subprojects and has made great progress since starting his PhD. In the first subproject, he aims to use his computational tongue model to predict an envelope of movement of the tongue in order to determine optimal sensor locations/markers for tracking the tongue's surface using the Articulograph 500. First results do already exist. The next step will focus on developing an experimental protocol for testing and validating his computational findings. This is work in progress and joint work with Kylie Foster. His second subproject focuses on drafting up a publication describing his geometric tongue model as well as the tongue's constitutive behaviour (the publication is a joint effort with Jules Kieser, Martyn Nash, and Andrew Pullan). The paper aims to demonstrate how his computational model is capable of analysing different movement patterns of the tongue due to the activity of different muscle fibre groups within the tongue. The goal is to prove or disprove existing hypotheses (often derived from biomechanical principals and observations) which muscle fibre groups (and activation levels) contribute to specific movements.

5. DEVELOPMENT OF A NEUROMUSCULAR INTERFACE: A CASE STUDY WITH THE JAW (BY JAMES PAU)

The focus of my work is on the development of an interface between a human and a robotic device/exoskeleton that is being used to assist in physical rehabilitation. Current methodologies are based on force or torque detection and these methods are more difficult to implement with reduced muscle function. An alternative solution is to obtain the control signal directly from the muscle via the electromyography (EMG) signal. The EMG signal is a measure of the superimposed electrical activity caused by the firing of numerous motor neurons within the muscle tissue and it gives an indication of muscle activation levels.
The signal is highly susceptible to noise from crosstalk from neighboring muscles and external electrical sources, and requires signal processing algorithms to obtain the desired information. However, the signal can be detected without muscle movements and can also be produced before muscle contraction begins. This is significant when dealing with human-machine interfacing as it helps to reduce system delay and improve real time capabilities.



Currently, a neuromuscular interface is being developed to assist in movement of the elbow joint, which can be approximated as a simple hinge joint. The interface consists of a biosignal amplifier which amplifies and records the EMG data and a PC which filters and processes the data to produce an estimation of the forearm angle. The prediction of the angle is based on a physiological model, which incorporates the geometric and muscular properties of the elbow joint to determine an overall joint torque that is subject specific. Kinematics are then used to determine angular displacement, velocity and acceleration.

From the simplified case of the elbow joint, work will progress onto developing a neuromuscular interface for the jaw. This will assist in the rehabilitation of jaw motion disorders that may be a result of stroke, temporomandibular joint disorders or muscular pathologies. The jaw will pose more of a challenge than the elbow joint, due to its multiple degrees of freedom and mechanical redundancy. A physiological model will need to be developed that retains as much functionality of the jaw as possible while signal processing techniques will also need to be improved to cope with the reduced amplitude and increased noise from the smaller and tightly compacted mandibular muscles.

James is supervised by Dr Shane Xi (Mechanical Engineering) and Prof. Andrew Pullan from the University of Auckland.

6. CARDIOVASCULAR AND MUSCLE ACTIVITY DURING CHEWING IN WHIPLASH-ASSOCIATED DISSORDERS (BY PER-OLOF ERIKSSON)

The following paper has recently been pulished:
Kalezic N, Noborisaka Y, Nakata M, Crenshaw AG, Karlsson S, Lyskov E, Eriksson P-O. 2010. Cardiovascular and muscle activity during chewing in whiplash-associated disorders (WAD). *Archives of Oral Biology,* 55:447-453.

Abstract:
Objective: The present study aimed to elucidate possible physiological mechanisms behind impaired endurance during chewing as previously reported in WAD. We tested the hypothesis of a stronger autonomic reaction in WAD than in healthy subjects in response to dynamic loading of the jaw–neck motor system.
Design: Cardiovascular reactivity, muscle fatigue indicies of EMG, and perceptions of fatigue, exhaustion and pain were assessed during standardised chewing. Twenty-one WAD subjects and a gender/age matched control group participated. Baseline recordings were followed by two sessions of alternating unilateral chewing of a bolus of gum with each session followed by a rest period.
Results: More than half of the WAD subjects terminated the test prematurely due to exhaustion and pain. In line with our hypothesis the chewing evoked an increased autonomic response inWADexhibited as a higher increase in heart rate as compared to controls. Furthermore, we saw consistently higher values of arterial blood pressure for WAD than for controls across all stages of the experiment. Masseter EMG did not indicate muscle fatigue nor were there group differences in amplitude and mean power frequency. Pain in the WAD group increased during the first session and remained increased, whereas no pain was reported for the controls.
Conclusion: More intense response to chewing in WAD might indicate pronounced vulnerability to dynamic loading of the jaw–neckmotor systemwith increased autonomic reactivityto the test. Premature termination and autonomic involvement without EMG signs of muscle fatigue may indicate central mechanisms behind insufficient endurance during chewing.