March 25, 2005

Newsletter - March 2005

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1. Progress report, John Bronlund, *(Massey University team)*

1. Jozsef-Sebastian Pap joined the Massey team as a master student in Jan 05. He is revising the robotic jaw model to ensure it is as close as possible to the human jaw actuation system. After this is done Sebastian will perform dynamic simulations and design and build its mechanical system including the motion actuation systems.
2. Jonathan Torrance joined the Massey team as a PhD student in Jan 05. He is working on the robotic kinematics and dynamics and design motion control system that will be implemented via Galil motion system. Jonathan is currently developing a literature review on the jaw kinematics and on motion and force control approaches that might be suitable for the robotic system. He is also a Massey PhD scholarship recipient.
3. The Massey team will have 3 papers published in the upcoming issue of IEEE Robotics and Automation Magazine (which is a top ranked journal in robotics field), Mechanisms and Machine Theory, and Int J of Intelligent Systems Technologies and Applications. One of these papers is co-authored by Jules Kieser at Otago. The three papers are about the initial robotic jaw models and kinematics simulations based on the preliminary work (prior to involvement in the NERF programme), though they are far from perfect, they kicked off the ball and new papers from current work will follow.
4. Dr Kylie Foster has applied for a Fast Start Marsden grant on human chewing behaviour and its relation to food preference. Co investergators include Dr Lisa Duizer (from Massey Albany) and Prof Mike Swain (from Otago)
5. Kylie Foster and John Bronlund are investigating either purchase or 3 year lease of a Carstens 3D articulograph for jaw motion tracking with enough degrees of freedom to accurately prescribe the motion required for the robotic device and for study of chewing behaviour. It is proposed that the device (if we can get it) will be based at Massey Albany probably early 2006.

6. Massey has two subcontracts (one masters and one PhD) with mastication related focuses with Crop and Food Research's "Food for energy balance" RFI PGS&T grant. Details of these will be released after some consultation with Crop and Food regarding confidentiality.

2. Bioengineering Institute, University of Auckland *(Oliver Roehrle)*

In the previous newsletter, we mentioned that the Auckland group developed/built a special brace that allows recordings of the marker locations on the brace, and hence allows to track the movement of the mandible. To do so, we use a VICON motion tracking system at the Tamaki Campus in Auckland. This time, Kylie Foster from Massey University, Albany Campus joined us and provided some special treats to chew on. The purpose of the treats was to record the movements of the mandible while chewing on food with different types of texture. Kylie expressed some concerns about the "quality" of the data (quality in the sense of having recorded a natural chewing process). For further remarks please read her contribution to the newsletter. At the moment, it is not so important to the Auckland group that the chewing process is completely natural. Currently for them, the main purpose of the data is to prescribe the displacements at the attachment points of the muscles to the bone.

To do this, I (Oliver Roehrle) wrote a MATLAB script which reads in the original data, determines the head movement, corrects the brace location by the head movement, and computes then the rotation angles and the translations leading to the current position of the mandible.

Given the rotation angles and translation, we use our software package CMISS to model the stretching of the right masseter muscle during a few chewing cycles. As far as the material properties of the masseter muscle are concerned, we used some "educated guesses" for the constitutive laws and fibre directions of the muscle. We visualized the numerical results and produced an mpeg-movie. (I am happy to email it to you. It is roughly 1MB). Although the results look already very good, we would like to have a more realistic and anatomically accurate model of the material laws. This might be one of the projects for the near future.

The chewing data is not only used by the Auckland group. More recently, Sebastian Pap, a master student supervised by John Bronlund and Kylie Foster, is using the data to estimate the maximal opening angles, velocities and accelerations during the mastication process. Further, in the scope of a senior year project, David Burgess from the University of Adelaide is using this data to rebuild MARK III (the AJJP chewing machine).

Given the fact that motion tracking systems are mainly used for gait analysis and that a few people (different groups) are planning to use this data, Kylie and I are planning to write a technical report or a paper on the experiments. For this publication, we plan to compare the data of our current experiments to the literature, identify its current weakness, and work on improvements that allow us to obtain data sets for a natural mastication process for different types of food.

I will present the goals and objectives of this project on the 12th Copper Mountain Multigrid Conference in the US. I hope to get some ideas on solvers tailored to Finite Elasticity problems. Further, I plan on talking to people involved with the maxilla-facial surgery simulation group at NEC Europe.

As far as future research plans are concerned, I plan to create a detailed model of a tooth and the gum. I also plan to visit Otago to identify/start working on some clinical applications.

3. Contributions by Kylie Foster, *(Massey University, Albany Campus)*

During January, Kylie Foster, Oliver Roehrle, and Nina measured jaw movement data using the image caption system created by the University of Auckland. Kylie made two different food products for one participant (Rob) to chew during this session. The food products were similar but not identical to those used to collect chewing data during Kylies post-doc at the University of Auvergne, France. A (crude) comparison was made between these recordings and those measured using a Carstens 2D Articulograph at the University of Auvergne.

A few concerns as to the suitability of this device for recording "natural" chewing behaviour arose during this session. They include:

1. The participant was not able to completely close his mouth due to contact with the metal brace/attachment.
2. The mouth appeared to open more than normal during the chewing of these samples. The vertical movement appeared to be very large.
3. It appeared that the device caused the participant to salivate more than normal (and he also commented that this was the case). This was possibly exaggerated by their inability to swallow easily. Increased salivation will alter the breakdown of food in the mouth and change the bolus properties. This, in turn, will change the jaw movement during the sequence as chewing is regulated by oro-sensory feedback.
4. The participant was not able to swallow easily as demonstrated by saliva coming out of the mouth during each chewing sequence and movement of the device during swallowing.
5. The device restricted natural manipulation of food in the mouth, e.g., the participant could not clean food from the teeth with the tongue.

Comparing the recordings with those obtained using an articulograph highlighted the following:

1. Vertical movement was comparable even though it appeared the participant had his mouth open a lot during the recordings.
2. Horizontal movement seems a lot smaller than normal. This is probably a result of the participant trying to keep the device fixed in place during the recording, thus restricting movement. The device appeared to move during chewing due to the action of the cheeks and tongue manipulating the food. The small horizontal movement is most obvious when comparing chewing of the elastic product; this was well outside the mean std. dev. from the recordings collected using the articulograph. The horizontal movement when chewing the plastic product was also very small however there was more variability seen with this parameter during the recordings in France.
3. Sequence duration for the plastic textured product was considerably longer during the recent recordings. This is probably a result of difficulty manipulating the food in the mouth. This isnt surprising as the plastic product is a lot more difficult to chew and requires more horizontal movement.

The comparisons were made with one of the 15 French subjects. The subject selected for comparison was one whose chewing parameters were very close to the means obtained from the 15 subjects. All of the above need to be remedied/improved if the device is to be used to collect jaw movement data during natural chewing.