maa news

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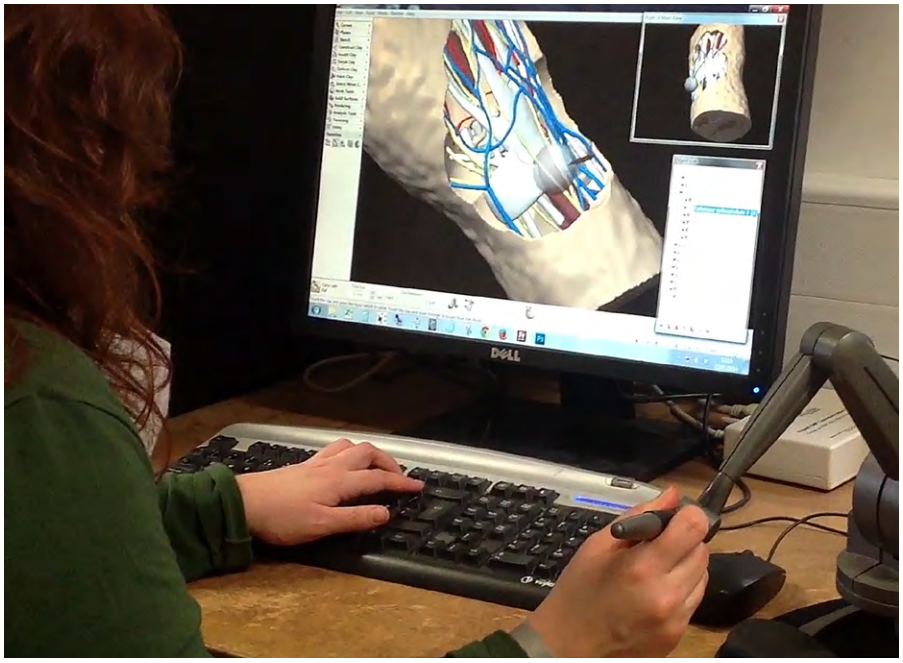
Reflections on a PhD in Medical Visualisation



Dr Caroline Erolin using the interface with the haptic feedback device

Overview

I began my part time PhD in June 2009. As a lecturer in Medical Art at the Centre for Anatomy and Human Identification (CAHID), at the University of Dundee, I was lucky enough to have the opportunity to study alongside working full-time. I had been using the 3D modelling software FreeForm (at the time produced by Sensable Technologies, now taken over by Geomagic), which is used alongside a haptic feedback device for some years to create facial reconstructions. For my PhD however, rather than reconstructing the anatomy, I was interested in using the software and hardware for virtual dissection. My thesis was entitled 'Does Virtual Haptic Dissection Improve Student Learning? A Multi-Year Comparative Study'.

While I believe that human dissection is invaluable, I also think there is a role for complimentary learning resources including three dimensional digital models. Hours dedicated to teaching anatomy in the UK and US have reduced considerably over the last few years. This combined with an increased scarcity of cadavers has resulted in many universities turning to digital resources. The past decade has seen the release of a number of computer packages aimed at enhancing anatomical education. Previous 'virtual anatomy' research has tended to focus on the replacement of cadaveric dissection, with only a few exceptions highlighting the benefits of integrating new technologies with existing teaching practice. In addition, none of the packages currently available offer 'haptic' dissection, i.e. cutting through the anatomical layers using a force-feedback interface. It was with this in mind that I decided to study the potential benefit of integrating new technologies with existing methods of teaching.

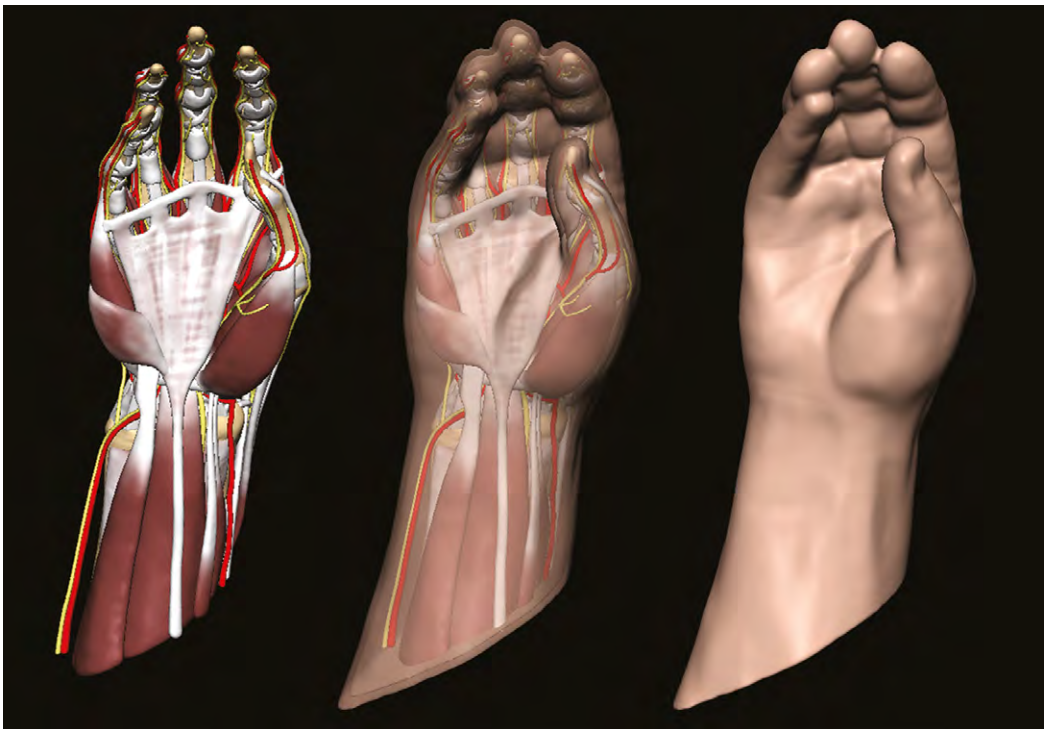
The first stage was to create a three-dimensional digital model of the hand and wrist that could be virtually 'dissected' using a haptic interface. The model was created using a mixture of Computerised Tomography (CT) and photographic data from the Visible Human Project (VHP) Female [9]. The 3D visualization software Amira was used to automatically separate out the hard tissues and skin from the CT data as well as manually segment the soft tissues from the photographic slices. Each structure was created as a separate file to allow for individual manipulation within the 3D modelling software FreeForm. Once segmentation was complete the individual structures were saved and exported as STL files. Once imported into FreeForm each structure required varying degrees of remodelling where detail had been lost during the segmentation process. This involved smoothing out jagged edges as well as remodelling missing and partial elements. The nerves, veins and arteries were difficult to observe and segment on the cross-sectional images and were modelled freehand.

The interface for interaction with the model was an adaptation of the FreeForm system used to create it. The software allows alterations to be made to the desktop layout so that all unnecessary tools and windows can be hidden, leaving only those required for interaction with the model. Interaction with the model was possible through either a keyboard and mouse or haptic interface. Use of a haptic interface not only adds the sense of touch, but also alters the way in which the user interacts with and views the model. For example, cutting through the layers of the model produces a 'window of view' similar to that produced during traditional cadaveric dissection.

The model was used as a teaching and revision aid both prior to and following cadaveric dissection. A haptic enabled version of the model, allowing for real-time dissection, was compared with a non-haptic version using a keyboard and mouse. Both versions were tested on students of gross anatomy and compared with respect to test results and student experience. The study ran over five successive years and was divided into three discreet phases. Phase one took place over four years (2011-2014) and compared the results of postgraduate MSc students across control, non-haptic and haptic groups. Each group was from a different year to maximise participant numbers. Two years of control data was gathered due to my being on maternity leave. Phase two took place over one year (2014) and compared undergraduate BSc students across control and haptic groups. Phase three took place over one year (2015) and compared undergraduate BSc students across control, non-haptic and a haptic groups. Multiple phases were undertaken in order to increase participant numbers as each group was quite small (n=7-20) on its own.

Hypothesis

Students who use the haptic version will attain higher test results than both the control group and those using the non-haptic version. Secondly, those using the non-haptic version



A three-dimensional digital model of the hand and wrist that could be virtually 'dissected' using a haptic interface.

will attain higher test results than the control group.

Results and Discussion

An anatomy test consisting of eight questions was given to each group at the end of the study period. The first three sets of questions were anatomy 'spot test' i.e. identification questions, while the fourth group were multiple choice. Statistical analysis was performed using the Mann-Whitney U test in SPSS.

The data gathered indicated that overall, those with access to the non-haptic version of the model performed equal or better than those with access to the haptic version. This is likely due to cognitive load being adversely affected by the addition of the haptic device. Some students reported that the haptic device was not intuitive to use and took some time to get used to, if at all. Cognitive load is defined as the load that performing a task imposes on the learner's cognitive system. Cognitive Load Theory suggests that the learning process takes up a large portion of working memory and that if too much information is presented simultaneously the working memory may be overloaded, impeding learning [10]. No student used either version of the model for more than five hours, with over 40% using it for less than one hour. It is possible that with increased exposure to the haptic device students may find it easier and thus beneficial to use. The findings of this study however indicate that when used for a short period of time only (~5 hours) the haptic device may impede rather than enhance learning.

Reflections

I completed my PhD in May 2016 and graduated in the November. It was a long journey during which many changes took place. I met my husband and had our beautiful daughter Maya along the way, taking 11 months of maternity leave around the middle of my PhD. Luckily I had already done most of the labour intensive work of segmenting and creating the model and when I returned I was able to focus on the slightly less arduous task of testing and data collection.

No PhD goes exactly as planned and mine was no exception. My original research design ran over three successive years; with one year dedicated to the testing and data collection for each group (control, non-haptic and haptic). However, it was apparent early on that the student numbers would be very low. I was initially only working with MSc students as these were the only ones with access to the Thiel embalmed cadavers that CAHID was transitioning to using. I had wanted to avoid using students who used differently embalmed cadavers so as to minimise cofounding factors. However by 2014 all levels of students at CAHID were dissecting Thiel embalmed cadavers. As such it was possible to recruit undergraduates to the study. The first group of undergraduates (phase two) was split into two, a control and haptic group. However, by the time I had the results from phase one it became clear that it was actually the non-haptic group that appeared to be performing best. In order to clarify this a third phase, again consisting of undergraduate students was recruited, this time consisting of three groups; control, haptic and non-haptic.

Through doing a PhD I have developed a large number of new skills that I am now able to apply to both my teaching as well as continued research and scholarship. My 3D digital modelling skills have improved as have my research and analytical skills. I have even learned how to undertake statistical analysis, something that I had been putting off for years!

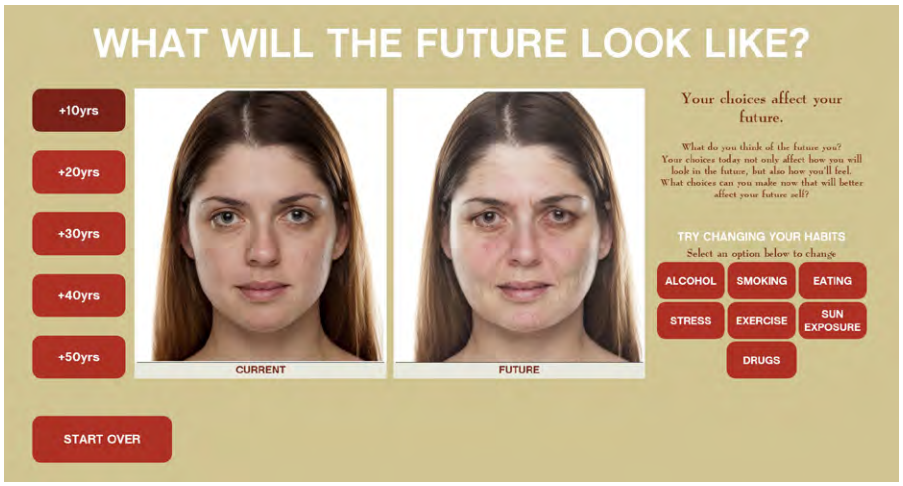
Finally, I created a website 'theinteractivehand.com' to host the models and make them available for anyone to use.

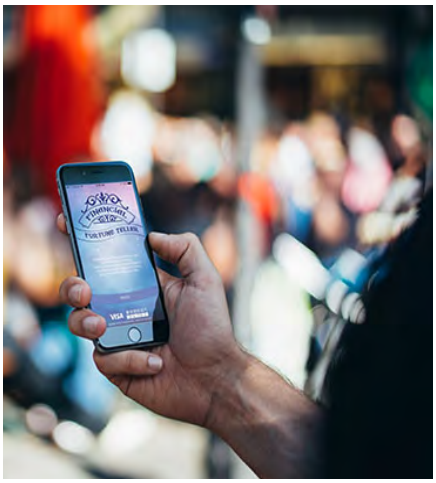
Dr Caroline Erolin, MAA Member

New Arrival

Many congratulations to Philip Ferguson Jones and his lovely wife Catherine who celebrated the the arrival of their new baby boy; Isaac Albert Thompson Jones born 7th November 2016.

Facing the Future / Future Face





'Aging Game' for COSI and 'Financial Fortune Teller' apps developed by Auriole's company Change My Face.

It's been an interesting couple of years for Change My Face, my company which makes age progression software illustrating the effects of lifestyle. 2016 saw us make an exciting Aging Game for COSI, the Science Museum in Ohio. The game allows people of all ages to take a snapshot and visualise themselves aged 10 years with the individual effects of smoking, diet, alcohol, drugs, exercise and stress for example all the while being able to go back in and make adjustments to their image by changing their lifestyle. COSI said, "If guests have half as much fun with it as we did it will be a huge hit - it's not only fun, but I think it really helps get the specific content points across." I think this interactive exhibit would work especially well in schools; it is entertaining and conducive to starting conversations about health and lifestyle choices.

I read recently that 150,000 people die prematurely each year in the UK from the big 5 diseases, cancer, heart disease, liver disease, lung disease and stroke – and most of these deaths are completely avoidable, so 'preventive medicine' seems to be the new big thing, in Asia at least. We have an existing client in Singapore who received funding to create an app to encourage employees of large companies to lead a healthier lifestyle and to get regular screening. In addition we've been asked by a team of Doctors at the University of Tokyo to create a 'Future You' app to encourage the general public of Japan to adjust their lifestyles in order to prevent major disease. The brief is to create ageing effects but also extend this to illustrate symptoms of diseases which manifest themselves internally on the organs and externally on the skin.

On the other end of the spectrum we made an app called Financial Fortune Teller for Visa in Singapore, which combines a financial calculator with an ageing predictor. The idea is to calculate how much you're saving for your pension, then visualise how you'll look at retirement depending on how much you've saved. As I tested it, the face staring back at me looked rather stressed and wrinkled which made me feel gloomy about the size of my pension fund. Another app for Toyota, shows the effects of city living surrounded by toxic fumes.

I still age missing persons, a legacy of my background as a forensic artist and also assist law enforcement in the US with age regression imaging which assists detectives to track paedophiles online, which I heard resulted in the arrest of over 100 suspected paedophiles last year alone. I became a STEM Ambassador last year and enjoy chatting to kids in schools in my area to let them know that art and science can be combined in a career as a medical or forensic artist and am looking forward to partnering up this year with the University of Bath to advance the ageing technology to realtime.

About a year ago, I collaborated with the British artist Gillian Wearing on an exciting project which involved commissioning me to create two age progressions of her aged 70. My images form part of a huge wall of aged portraits of Gillian in different guises. You can see the exhibition at the National Portrait Gallery in London until May 29th.

For more information about the exhibition please go to:

https://www.theguardian.com/artanddesign/2017/mar/08/gillian-wearing-facing-future-digitally-ages-new-artwork?CMP=share_btn_tw

Auriole Prince, MAA Member

68th Annual Conference – 21st April, 2017

Charles Darwin House, 12 Roger Street, London, WC1N 2JU

The Association's 68th Annual Conference will take place at Charles Darwin House conference centre located in the Bloomsbury area of central London just minutes away from London's major transport links.

With a good mix of homegrown talent and guest speakers, delegates will enjoy a full and varied academic and social programme.

The day will culminate with the Chairman's Reception and presentation of certificates. Delegates may also choose to attend the informal Annual Dinner which will take place at Sicilian restaurant 'Luci e Limoni' just minutes' walk from the conference centre.

Booking form available here:
http://www.maa.org.uk/index.php/2017-conference

We look forward to seeing you.
Conference team

D'Arcy Thompson's Zoology Museum in 3D

An example of the internal and external surfaces of the nautilus shell

During 2016 I was lucky enough to lead on an exciting project involving the digitisation of specimens from the University of Dundee's Zoology Museum. The Zoology Museum houses many fascinating specimens from around the world. Most of them were collected by the celebrated Sir D'Arcy Wentworth Thompson, the first Professor of Biology at Dundee. 2017 is the centenary of D'Arcy Thompson's influential book On Growth and Form and a number of events will be taking place around the country to celebrate.

I became involved in the project after visiting the museum with the MSc Medical Art students. The Centre for Anatomy and Human Identification (CAHID) where I work had recently purchased two new structured light scanners (Artec Eva and Artec Space Spider) and I was keen to put them to the test. I had also recently been trained to use the Universities new micro CT scanner (a Nikon XT H 225ST). The project seemed the perfect opportunity to hone my 3D scanning and modelling skills.

I worked on the project throughout 2016 whenever the opportunity arose between teaching and completing my PhD. Smaller specimens were scanned with the micro CT scanner, while larger specimens (from around 20cm) were captured using hand-held structured light scanners. An advantage of the micro CT scans was that they captured both internal as well as external surfaces, enabling them to be segmented, as in the example of the nautilus shell. The disadvantage however is that no colour information is captured. This had to be added manually at the post processing stage, therefore. Good quality images were taken of all the specimens which were used to texture the micro CT models using the 'Spotlight' and 'Polypaint' features of ZBrush. ZBrush was also used to 'tidy' all of the scans, both micro CT and surface. This involved deleting any artefacts and repairing and missing data etc. In contrast to the micro CT scans, the surface scans did capture colour texture which was exported with the scan to ZBrush.

The resulting 3D models are hosted online via Sketchfab and are available for viewing and downloading worldwide under a creative commons licence. Sketchfab is a website used to display and share 3D models online. They support cultural heritage institutions by providing free accounts and over 200 cultural institutions have joined Sketchfab so far. Once hosted on Sketchfab models can easily be embedded on websites and social media.

Finally, a webpage was created to showcase the models. The landing page features thumbnails of all available scans. When these are clicked on the user is taken to a page containing the 3D model and information about the specimen. The site went live in January 2017 and can be viewed at: https://www.dundee.ac.uk/museum/collections/zoology/zoology3d/

Dr Caroline Erolin, MAA Member

MAA News

MAA News is published twice a year by the Medical Artists' Association.

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