Exchanging Knowledge | Extending Quality Life

Visualisation for better healthcare

In June 2010, KT-EQUAL hosted an event jointly with the Envisage Project team to discuss how data can be presented visually to research users, replacing the traditional reliance on tables and graphs.

Data visualisation — presenting complex data in forms that we understand and use easily — is now part of everyday life. An example that comes to mind readily is increasingly sophisticated computer gaming, but this is just one example. Data visualisation is pervasive not only for leisure but also in the home and at work.

The increasing use of the Nintendo Wii in clinical and care settings demonstrates that visualisation has potential for rehabilitation too. But relatively little attention has been given to how the tailored visualisation of complex data, presented to users of rehabilitation services, can help with people's treatment and promote their recovery.

Summary of the event

This event showcased a project called Envisage, which is funded through the Medical Research Council's Lifelong Health and Wellbeing programme (http://www.strath.ac.uk/bioeng). The project examines whether visualisation of complex datasets, such as biomechanical data, can assist and improve rehabilitation.

Interventions are currently being designed for a number of specific rehabilitation challenges:

- exercise compliance
- falls prevention
- joint replacement
- stroke rehabilitation

- ankle foot orthosis tuning

These interventions will then be evaluated using randomised trial methodology.

Complementary research was presented by international experts from Australia and Canada. Finally, representatives from the SMART consortium (www.thesmartconsortium.org, funded by the Engineering and Physical Sciences Research Council) gave illustrations of processes and some of the outcomes of similar work for upper limb stroke rehabilitation to that being conducted through the Envisage project.

Interpreting biomedical data

The complexity of interpreting biomedical data was illustrated by Professor Phil Rowe, University of Strathclyde. He began by making two observations: firstly, that healthcare professionals are good at interpreting movement but designers are less so; and secondly, that biomechanics data presents challenges to healthcare professionals. He explained the fundamentals of biomechanics to the audience and gave an example from human movement. Application of force to the leg upon heel strike has generates moments at the ankle, knee and hip which are countered by groups of muscles (up to 22 muscles at the hip). Visualisation is important due to the complexity of data and that can be collected while studying movement and analysing it.It is easy therefore to get swamped by tables and graphs. Hence the aim of Envisage is to make this valuable data accessible to clinical practice in a number of applications through visualisation and to learn more about what is involved and what is successful.

Interdisciplinary collaboration

Professor Alastair MacDonald, Glasgow School of Art and Design, described how his interest in this topic had started through a conversation with a biomechanical scientist. This triggered thoughts about how interdisciplinary collaboration between biomechanics and design might lead to improved design. A subsequent EQUAL grant was conducted to examine the demands of upon a cohort of 84 older people when undertaking 11 different activities of daily living (http://www.strath.ac.uk/bioeng/research/rehabilitationengineering). Movements were recorded using motion capture and the complex data sets were then translated into a 3D animated model. The model is able to show changes in physical demand upon the person as a consequence of different design as well as the impact of different medical conditions upon functionality. It was realised that this method of data presentation made it potentially accessible to whole range of stakeholders including designers, rehabilitation specialists and older people and a second project followed to explore the value of the animated model. This involved focus interviews with older people and separate groups with a sample of health professionals. Findings provided new insights and enabled dialogue and are available from the NDA (http://www.newdynamics.group.shef.ac.uk/assets/files/172.pdf). A SPARC website was held in November 2008 where the findings were presented (http://www.sparc.ac.uk/workshops/2008-11-12-inclusive-design/).

Visualisation on mobile devices

Dr Lynne Baillie, Glasgow Caledonian University, discussed how visualisations can be supported on mobile devices. She reiterated the pervasiveness and value of capturing and visualizing movement, giving examples of home monitoring for health, sport monitoring and monitoring for fun and games. Sensor technology holds promise particularly as technology is becoming increasingly sophisticated and prices are dropping. There are a number of existing health applications: people can be monitored by information transmission via a mobile phone. A second possibility is a remote monitoring model, e.g. for people with dementia, or those who are obese. In this case ambient sensors can be put in the environment, or body worn (e.g. accelerometer, pedometer, gyroscopes, magnetometer). Lynne raised three essential requirements; identifying user needs through consultation and full engagement in prototype design, realism on the part of researchers and use of language that the lay public can understand.

Accounts from Envisage researchers

Accounts of progress with the methodological and rehabilitation challenges of the Envisage project after the first few months were provided by the researchers employed to work on the various work packages within the project.

Lucy Jones & Heather Thikey, University of Strathclyde, talked about the work being conducted on visual feedback for stroke rehabilitation and recovery. Immediate and simple feedback on lower limb movement will be provided through Bluetooth sensors strapped to the body. The hypothesis, based upon existing research evidence is that early feedback improves outcomes but it was also acknowledged that the existing body of research is unclear regarding optimum forms of feedback to achieve best outcomes. She also described a similar body of work for upper limb stroke rehabilitation. Again best evidence is guiding the work and in particular the SIGN guidelines (http://www.sign.ac.uk/pdf/sign118.pdf). Both interventions are being designed to provide feedback and practice/therapy through repetitive task training with varying degrees of intensity and virtual reality (visual feedback). The lack of evidence for virtual reality was recognised but the potential is exciting. Lucy will explore upper limb feedback and Heather lower limb feedback.

Felix Dartey, Glasgow School of Art and Design, described the work in progress on Exercise compliance The main question to be addressed is how adherence with exercise can be encouraged and how might visualisation methods encourage adherence. The researchers realise that they have to take into account age related challenges such as visual problems and others common to the overall population such as colour blindness. The planned trial will compare traditional methods of teaching exercise through a CD with feedback through visualisation. The primary outcome will be extent of activity through an activity diary.

Stephen Uzor, Glasgow Caledonian University, presented the work on Falls prevention This topic was selected due to the severe consequences of falls and the ability to treat risk factors for falls such as balance and mobility programmes. The intention is to combine traditional paper based exercises with technology to provide visual feedback for users to access in their own homes. Use of wireless sensors for motion capture will enable data to be saved for professionals to use. Pilot studies are being conducted and a trial will follow to compare the visualisation tool with standard treatment. The primary outcome will be walking velocity.

Dr Lynne Baillie, Glasgow Caledonian University, outlined a project planned to use mobile technology in the patients home to provide visualisation of exercise and activity to post operative knee replacement patients. The researcher on this project was still to be appointed.

Dr Bruce Carse, University of Strathclyde, gave an account of work on Ankle foot orthosis tuning. Existing evidence confirms that this can be a beneficial intervention as part of a multi disciplinary approach towards care. The key functions of the orthosis are to prevent the toe from catching on ground but even more importantly to guide and control the force through the foot as the foot contacts the floor. Tuning to obtain the necessary accurate fitting and positioning of the AFO involves two key aspects; heel wedge angle and shank inclination angle. The research hypothesis is that visualisation of gait parameters will assist tuning requirements. A trial is being planned that involves comparison of two groups; the first will obtain an orthoses that has been tuned using standard methods and the second will be given orthoses where data visualisation has been used for the tuning process. Production of the visualisation will involve translating gait analysis into computer motion analysis. Tuning is a speedy process so there are questions about how the visualisation will be used by those undertaking the task so as not to delay things and as well as the comparative effectiveness of the tuned orthosis.

The final presentation from the Envisage team was given by Dr David Loudon, Glasgow School of Art and Design, on qualitative evaluations of visualisations. He is conducting work to review the possible benefits and potential difficulties of using visualised data. This is particularly important as all the previously described workstrands have different requirements, producing varying demands upon users. This work will provide an overview. Each data collection method has challenges; for example when using wearable motion sensors there can be missing data and distorted visualisation due to inaccurate sensor placement. Errors will be intermittent as systems will respond to bad as well as good data which will need to be eradicated as far as possible. Different forms of visualisation are also required to meet the needs of the range of stakeholders such as end users, health care professionals and industry.

Gait analysis and rehabilitation

Professor Richard Baker, University of Salford (but very recently from University of Melbourne, Australia), then spoke in depth about gait analysis and rehabilitation. Gait analysis is already used for clinical decisions and can be very effective. However in common with the aims of the Envisage team, Richard is concerned with improving ways of visualising data. He illustrated the difference between observational analysis and video gait analysis and how the complexity of each can lead to language and access barriers for clinical practice. He reiterated the points made by Phil Rowe that measurement instruments now exist that are efficient, reliable and more accurate than clinical examination. Also costs are falling so price will soon no longer present a barrier. Improved visualisation tools are required but these need features such as better rendering and improved comparative data provided in a visual format. Research challenges include how to retain key data in the visual (including what aspects to visualise), how to scale the data to take account of different sized people, how to superimpose different joints and how to represent variability. Richard agreed with other presenters that biomechanical understanding on the part of clinicians is poor. He made a case for re-educating the audience; people must want to receive the data. A further point was that the application has a far wider applicability beyond rehabilitation; for example in the teaching of biomechanics.

Sleep management

Dr Shima Okada, Department of Robotics, Ritsumeikan University, Japan, gave an account of the work that she is engaged in, using visualisation technology for sleep management. Monitoring of sleep is difficult and long term. Existing research confirms that it requires a lot of sensors and an actigraph to accurately measure the activity of an individual during the night, Another method is to use videosomnography which necessitates the examination of movements from video data which is very demanding and time consuming. The research being conducted by Shima involves the automatic detection of body movement during sleep through pixel differentiation which avoids use of sensors and markers. Sleep is divided into three stages with twitch, localized and gross body movements revealing when the subject is in the different stages (gross movements precede waking). In the work being conducted by Shima, moving images of the subject are transformed into still images using gray scale. Varying levels of gray scale in the images reveal increased and decreased activity. A fascinating video was provided illustrate this. A variety of different applications for this technology are being developed to investigate various sleep disorders.

The SMART consortium

Finally, the work on visualisation conducted by the SMART consortium was then described. Professor Gail Mountain, University of Sheffield and Consortium Director, gave an introduction to the Consortium's portfolio. Projects have included SMART1 to examine how in-home upper limb stroke rehabilitation can be facilitated in people who have sustained a stroke. The SMART1 prototype involves use of wireless sensors and a decision support interface provided through a computer. The current project (SMART2) is exploring how technology can be used to encourage self management by people with long term health conditions.

Jack Parker, Sheffield Hallam University and PhD student then described the work he has been engaged in to examine the adequacy and impact of the feedback mechanisms available to users of the SMART1 system. The results of sustained in-home use confirmed that individual users prefer different forms of feedback and that there is an increased expectation that visualised data is as sophisticated as that provided through gaming technology.

The User Centred Design researcher for the SMART2 project, Silvia Torsi, Sheffield Hallam University illustrated how user engagement and participation had contributed to the design of screen shots for the decision support interface on both the static (home hub) and the mobile device. A series of iterations, starting with paper prototypes had led to the final designs.