**Keynotes and Invited Talks**

**Keynote: Visualisation: Art vs Science**  
Jon McCormack, Monash University

Visualisation is a process of transformation, allowing perception of the imperceptible or invisible. While scientific visualisation is often concerned with transforming data into images, in this talk I will present research concerning the transformation of process into images. Generative systems are procedural or rule-based process descriptions that typically generate data many orders of magnitude greater than their specification, posing a number of visualisation challenges. Working with computer models based on biological development and evolution, I have developed a number of generative visual and interactive artworks based on the idea of visualising process. These artworks share a common goal with scientific visualisation in that they are attempting to bring form to what cannot be directly perceived. Equally as interesting is how convention and culture come into play in the way we think about visualisation: does our way of seeing determine what we want to see?

Image caption: Jon McCormack, Fifty Sisters (detail) series of 50 procedurally generated images. Commission for the Ars Electronica museum, Linz, Austria. © 2012 Jon McCormack

**Keynote: Extreme Structural Engineering**  
Frieder Seible, Monash University

Extreme events for our structural inventory are events that test the structural system well beyond the elastic range into the non-linear range and all the way to failure. Extreme events can be natural hazards such as earthquakes, hurricanes, or wildfires, or man-made hazards such as terrorist attacks, bomb blasts, and accidents. The assessment, analytical modelling and the response simulation of our structures to extreme events will be the topic of this lecture together with a discussion on how we can validate the numerically simulated response to these events. The value of large or full scale experimental testing under realistic loading protocols will be discussed and demonstrated.

**Invited Speaker: From big data to smart knowledge - integrating multimodal biological data and modelling metabolism**  
Falk Schreiber, Martin Luther University

Modern data acquisition methods in the life sciences allow the procurement of different types of data in increasing quantity, facilitating a comprehensive view of biological systems. As data is usually gathered and interpreted by separate domain scientists, it is hard to grasp multi-domain properties and structures. Consequently there is a need for the integration, analysis, modelling, simulation, and visualisation of life science data from different sources and of different types.

This talk focuses on these two aspects: firstly methods for the integration and visualization of multimodal biological data are presented. This is achieved based on two graphs representing the meta-relations between biological data, and the measurement combinations, respectively. Both graphs are linked and serve as different views of the integrated data with navigation and exploration possibilities. Data can be combined and visualized multifariously, resulting in views of the integrated biological data. Secondly methods to reconstruct, simulate, and analyse detailed metabolic models are...
presented. We will focus on stoichiometric models, and see how different types of data are used to gather new insights into metabolic processes shown on an example of metabolism in plants.

**Invited Speaker: The Visualising Angkor Project at Monash**

**Tom Chandler, Monash University**

The Visualising Angkor project explores the 3D generation and animation of landscapes, people, soundscapes and architecture in a medieval century Cambodian metropolis. The resulting scenes draw upon a wide range of archaeological and historical data, from bas-reliefs to Chinese eye-witness accounts and extensive mapping undertaken by the Greater Angkor Project and the EFEO. Through the creation of virtual models based on a range of archaeological, art historical, architectural, and cartographical research, these visualisations aim to explore new ways of teaching history, and testing how historical assumptions about Angkor can be made more precise.

In comparison to the familiar historical staples of Rome, Greece and Egypt, the virtual image of Angkor remains unexplored. The recent inclusion of Angkor as a subject of study in the Australian national High School history curriculum is timely, but it also presents some interesting challenges.

**Invited Speaker: Quantification and Visualisation of 4D data.**

**Andreas Fouras, Monash University**

NHMRC Career Development Fellow & Assoc/Prof of Mechanical Engineering  
Research Head, Laboratory for Dynamic Imaging

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**Presentations**

**MASSIVE Overview**

**Wojtek J Goscinski, Monash University**

The Multi-modal Australian ScienceS Imaging and Visualisation Environment (MASSIVE) is a national imaging and visualisation facility established by Monash University, the Australian Synchrotron, the Australian Commonwealth Scientific Industrial Research Organisation (CSIRO), and the Victorian Partnership for Advanced Computing (VPAC), with funding from the National Computational Infrastructure and the Victorian Government. The MASSIVE facility provides hardware, software and expertise to drive research in the biomedical sciences, particularly advanced brain imaging research using synchrotron x-ray and infrared imaging, functional and structural magnetic resonance imaging (MRI), x-ray computer tomography (CT), electron microscopy and optical microscopy.
Over the last twelve months, a unique collaboration has occurred between CSIRO scientists and artist, in unifying their scientific and creative research interests. This presentation, Visualising Science Through Art, will describe the process and challenges of establishing StellrScope, Centenary of Canberra's Science Art Commission exhibited at Questacon.

We present extracts relating to the production of the works, such as, the StellrLumé Domes that use Spatial Augmented Reality (SAR) techniques to bring computer graphics into the human-scale physical environment. The Questacon audience became active participants in order to experience the entire narrative of wheat experimentation and food crops, where as, the StellrScope holograms using 3D data as the foundational component of the hologram, entertained the audience by trying to grab the virtual seeds from the picture. The 3D printed titanium insects, a result of researching the weevil insect as pest in wheat, provides another case study of this collaboration bringing together expertise across CSIRO, including the Australian National Insect Collection, Computational Informatics and Future Manufacturing.

This intersection of science and art, within the fields of computational informatics, material science and entomology is truly a creative catalyst for imagination, ideas and innovation, particularly through the technical and aesthetic processes in which scientist and artist collaborate.

From ideas to animation - Case studies
Kristina Johnson, CSIRO

This presentation is a review of my first year working as a specialist animator and 3D artist for CSIRO’s eResearch Program. Several visualisation and animation projects from different research domains will be presented, accompanied by informative stories about how they were created.

It is unlikely that an animator and a scientist will think about a project in the same way all of the time, so how can miscommunication be kept to a minimum? What types of questions need to be asked? How do art and science combine to decide what science should look like when animated, even if it cannot be observed directly? Why isn't the final animation going to look exactly like reality? Why do big budget Hollywood special effects movies usually make an appearance in these discussions? How does an animator interpret scientific terminology? How do scientists and animators confuse each other with rough sketches? What is the clearest way to communicate an idea to the viewer?

Discover animation and the art of not getting lost in translation.
Triangulation of Social Network Analysis utilizing SiroSOM, UCInet & Keyplayer
Rebecca Clunn, Griffith University
Anne-Maree Dowd, CSIRO
Arthur Poropat, Griffith University
Sheryl Ramsay, Griffith University

While the growth of network analysis and its methodological approaches increase exponentially, there are few studies in which multiple methods of analysis are applied to the same data set. This presentation will demonstrate a triangulation of methods of analysis upon a single data set and discuss the theoretical and practical implications thereof.

The data examined is a longitudinal social network study of an unbound performance art network, thought to have commenced c1975 and consisting of more than 3000 artists. An historical / comparative, cross-sectional approach using archival data was utilized. Cross-sectional samples were taken from the earliest found archival trace of the networks existence [1975] to present; decade slices were selected to create bi-partite matrixes. Each individual matrix was compiled to a single matrix consisting of 943 nodes and 95 events.

Three software systems; SiroSOM, UCInet and Keyplayer were utilized to analyse and visualize the data. These packages were selected due to their unique and complementary strengths for network analysis and visualization. The findings from these three methods of analysis were then compared and triangulated in order to demonstrate a multifaceted view and provide a deeper understanding of the networks’ evolution and function.

This paper outlines the quantitative methods undertaken to achieve the mapping results, demonstrates the strengths and utilities of each software system and presents results from a structural analysis, theoretical and practical implications, followed by plans for future research in this area.

Criteria for Good Network Visualization
Peter Eades, University of Sydney
Karsten Klein, University of Sydney
Seok-Hee Hong, University of Sydney

Visualizations of networks are now commonplace: social networks, biological networks, computer networks, and many others. The edge of research is now at the scale problem: how to visualize very large networks, consisting of hundreds of thousands of nodes and edges.

The classical criteria for good network visualization, based on intuition and introspection, were first developed about 30 years ago by Kozo Sugiyama, Carlo Battini, and their colleagues. All of these are “readability” criteria; examples include:
- The number of edge crossings should be small;
- Show symmetry;
- Avoid bends in the edges;
- Euclidean distances in the visualization should approximate graph-theoretic distances in the network;
- Avoid placing nodes very close together.

Based on the classical criteria, many algorithms to “untangle” a network have been proposed, implemented, analysed, and have become commercially available.

About 20 years ago, Helen Purchase and her colleagues scientifically validated some of the classical criteria with a number of human experiments. However, the scale of modern networks has outstripped these classical criteria. It is not clear whether the same principles now apply.
In this talk we review the classical criteria, and describe a new framework for evaluating network visualization. We suggest how new criteria could be needed for the visualization of very large networks.

**WebCoLa: Constraint-based Network Layout in the Browser**

Tim Dwyer, Monash University

Visualising graph or network data is of ever-growing importance as technologies like "graph search", graph databases and the semantic web become mainstream. Tools that can provide high-quality diagrammatic renderings of such networks in accessible forms are therefore critical. In this talk I will present a new library for putting high-quality graph layout on the web. WebCola.js [1] is an open-source JavaScript library for arranging your HTML5 documents and diagrams using constraint-based optimization techniques.


It has an adaptor for d3.js that allows you to use WebCoLa as a drop-in replacement for the D3 force layout. The layout converges to a local optimum unlike the D3 force layout, which forces convergence through a simple annealing strategy. Thus, compared to D3 force layout:

- CoLa achieves higher quality layout;
- is much more stable in interactive applications (no "jitter");
- it is less scalable to very large graphs.

However, it works well on an average machine on graphs with fewer than 100 nodes.


**A Web Visualization Service**

Justin Freeman, Bureau of Meteorology
Duan Beckett, Bureau of Meteorology

We have developed a web based visualization service for the purpose of creating high quality, engaging and informative visualizations of environmental modeling systems. This system has been successfully applied to the multiyear BLUElink OceanMAPS model datasets. The visualization service is comprised of a WebGL user interface and a server side OpenGL application. This system architecture has many advantages over traditional software deployment methods and enables visualization service users to focus on data exploration and discovery. By decoupling the user interface from the visualization engine we have developed a software framework that allows users to easily access and explore remote data sets. The system is accessible through web browsers that support the WebGL standard and is not reliant on any additional software being installed on the users machine. The colocation of the visualization engine with the model data allows the service to take
full advantage of High Performance Computing infrastructure and server side visualization hardware, avoids the transfer of large data sets over the network and enables users to engage with the data without the overhead of learning how to operate the underlying rendering software.

Molecular Visualisation in Drug Development
Raymond S. Norton, Monash University
David K. Chalmers, Monash University
Martin J. Scanlon, Monash University

Drug design and development is a major focus of several research groups in the Medicinal Chemistry theme within the Monash Institute of Pharmaceutical Sciences. Docking and molecular dynamics simulations underpin many of our molecular design projects. The ways in which we utilise visualisation will be illustrated with three current projects:

1) molecular dynamics studies of ligand binding to fatty-acid binding proteins (Figure A)
2) the elaboration of fragment hits against the malaria surface antigen AMA1 1,2
3) the design of potent and selective potassium channel blockers (Figure B) for the treatment of autoimmune diseases


Visualising Aerosol Particles
Jonathan Khoo, CSIRO

Jonathan will present a high-level overview on how to visualise the concentration and transport of aerosol particle data. CSIRO chemical-transport modelling system is a popular modelling software package used by air quality consultants, scientists, and government bodies to derive understanding of emission, transport, and chemical transformation properties. We take the output of 1.5TB from the most recent high-resolution runs from Raijin (NCI's supercomputer) and transform it into something simple that everyone can appreciate.
Do Tiled Display Walls really work in large scale astronomical visualisations?
Bernard Meade, The University of Melbourne

A Tiled Display Wall (or TDW) combines many smaller resolution monitors into a single high-resolution display. The first large-scale TDW in Australia, the OptIPortal, was launched at The University Of Melbourne in 2008, however, the take up by researchers was much less than anticipated: researchers were used to working with small displays, zooming in and out of large images to examine detail. Why should they spend large sums of money on something they have been able to successfully do without? However, the size of images and data have increased to such a degree, that it becomes much harder to connect the detail to the context. This is particularly true in astronomy, where vast regions of a high resolution image may be completely featureless, or where small scale influences on large scale structures can only be identified when seen together.

Here, we ask the question: Does increasing the display size improve our ability to identify key features? We have begun a series of experiments to determine the advantage TDWs might have over traditional displays. Using high resolution Hubble Space Telescope images, participants are required to search for increasingly elusive targets on a desktop display and a TDW. Here we present results from this experiment, comparing the effectiveness of the display environments for feature searches in ultra-high definition images.

UWS Wonderama Lab - 2013 Update
Andrew Leahy, University of Western Sydney

The Wonderama Lab is a small facility based at the University of Western Sydney. We have a passion for multi-screen immersive visualisation, with a focus on outreach and engagement. With a limited budget we use commodity hardware, free software and API’s as much as possible. We’ve built good relationships with the Sydney Powerhouse Museum and Google Australia & US which has led to some exciting projects.

Such as: a multi-projector interactive installation at Powerhouse Museum; a vehicle simulator for UWS Solace entry in the World Solar Challenge; Chromebox-based Liquid Galaxy for Google at the Gartner ITXpo; UWS B.CompSci & B.Music students working together on our Kinect Surfer system; camera sync for Cesium virtual globe.

The Cube: Large scale visualisation for research and public STEM engagement.
Tim Gurnett, QUT

The Cube at Queensland University of Technology is a high resolution display and interaction system open 7 days a week to the general public, high school education programs, University teaching, and the wider research community. The total visualisation surface exceeds 190m2 and is comprised of 14 high-definition projectors and over 40 multi-touch screens over 2 storeys in 6 configured zones. In this presentation, I will describe the impressive scale of the physical spaces and their technical capabilities, design rationale and practical day-to-day operations. I will introduce the range of interactive content available, and discuss the unique opportunities that the Cube offers to explore and research large scale, collaborative interaction and visualisation.
The New UTS Data Arena
Ben Simons, UTS

The University of Technology Sydney (UTS) is about to build a new visualisation facility called the Data Arena, housed at the entrance of the new Information Technology & Engineering Building under construction on Broadway in Sydney. This talk will describe the hardware and software under development, and a couple of initial projects already underway, one of which involves Fashion Models, Photogrammetry, Houdini, and Unity-3D.

Immersive visualisation research at the University of Warwick, UK
Alex Attridge, University of Warwick
Mark Williams, University of Warwick

My presentation will give an overview of visualisation projects being undertaken by WMG at The University of Warwick, UK, and the technologies being utilised by ourselves and our industry partners. The fields in which we work include automotive design review, communication and correlation of non-linear impact simulation, visualisation of laser and X-ray CT data, and interaction with architectural and construction data. The presentation will cover the hardware and software being used, both at WMG and within our industry partners, workflows that have been developed to deliver the specific outcomes required from our project partners, and some of the industry benefits that have been achieved through collaborative R&D projects with our group at WMG. I will also present a couple of case studies where I’ll look in more detail at some of our more challenging projects, and look forward to future research projects and opportunities, including our recent discussions with Monash Racing and the visualisation of our respective Formula SAE race car designs.

The Monash CAVE2 Facility
David Barnes, Monash University
Toan Nguyen, Monash University
Paul Bonnington, Monash University

The Monash CAVE2 (TM) Facility is Monash University's new flagship visualisation system. CAVE2, designed and built at the Electronic Visualisation Laboratory (EVL) at the University of Illinois at Chicago (UIC), is a hybrid display system, capable of supporting ultra-resolution 2D information display and immersive, realtime, tracked 3D rendering in a single hardware solution. Monash University has partnered with EVL to build the second CAVE2, extending EVL's design to a 20-column display delivering 84 million pixels, a 22.2 channel sound system, and a dedicated compute cluster with combined compute and graphics capabilities exceeding 90 Teraflops.

CAVE2 is supported by three independent, significant middleware components. CalVR, developed by the Immersive Visualization Laboratory at Calit2 at the University of California at San Diego, is a long-standing and robust object-oriented C++ framework for delivering tracked 3D rendering on a variety of display systems with key features including volume rendering and a plug-in system for developing new capabilities. Omegalib is a newer framework, developed by EVL at UIC, intended to simplify the development of advanced 3D applications for display on systems scaling from desktop non-stereo systems, through
virtual reality hardware such as the Oculus VR headset, to full-size immersive environments like the CAVE and CAVE2. Key features of Omegalib include its Python API which provides a low-barrier entry point for researchers familiar with Python, and a deep and capable C++ API for more advanced operations. Finally, the Scalable Adaptive Graphics Environment (SAGE, developed by EVL), delivers a 2D collaborative environment on tiled display systems, with 2D and 3D image display, H.264 video playback, PDF display and laptop display via the VNC protocol.

CAVE2 at Monash is the final piece in a long-term strategy at Monash University to develop the "Microscope of the 21st Century", and builds on Monash's investment and partnership in advanced data collection facilities like the Australian Synchrotron and Monash Biomedical Imaging (the "lenses"), and in High Performance Computing facilities such as MASSIVE (the "filters"). CAVE2 delivers the "viewfinder" and is thus expected to underpin research and discovery across a range of disciplines including engineering, science, medicine and social sciences. Specific early objectives include supporting experiments in neuroimaging, drug design, computational fluid dynamics and geographical informatics.

**NEUVis: Affective and Effective science visualisations for non-scientists**
**Phillip Gough, CSIRO and University of Sydney**

This presentation outlines Non-Expert User Visualisation (NEUVis). There is currently an interest among the general population that complex scientific research be communicated and disseminated. While scientific research is taking place, it is often beyond the understanding of many non-scientists. In order to address this issue there is a trend to visualise information specifically for non-expert users. Designing a visualisation for non-expert users is an ill-defined and challenging problem; many of the design constraints for non-expert user visualisation will not exist when visualising for domain-expert users. In contrast, domain-expert visualisations, such as is commonly used in the sciences, are complex, but tame problems. The nature of non-expert user visualisations means that it is more suited to design and art practitioners, as it is in line with the problems that they usually address. To establish this, we will outline wicked problems, and outline how non-expert user visualisation can be fit into this category of problems.

This presentation will include examples of collaborative art projects that have visualised data for the non-expert user audience. These will be contrasted with examples from CSIRO which involves complex visualisation for domain-expert users. This presentation will also include an introduction into research being undertaken at The University of Sydney, in collaboration with CSIRO, that investigates the problem of visualising science for the non-expert user.

(Image credit: Photo by Phillip Gough; Reefs on the Edge (2011), Installation Artwork design by onacioV)
Paul McIntosh - Vespa Labs Visualisation Techniques – Monash University

This is a talk on visualisation techniques applied to the Vespa Labs racing vespa. This shows techniques applied to the OpenFOAM CFD analysis of a Vespa at high speed. The presentation should be of interest to researchers running parallel visualisations on MASSIVE or researchers undertaking CFD simulations.

Multispectral Visualisation for Handheld 3D Thermography
Stephen Vidas, QUT
Peyman Moghadam, CSIRO Computational Informatics

As both handheld sensor technology and computing power increases, the opportunity exists to easily generate photorealistic and accurate 3D models in real-time. For visualisation of the output of a 3D thermography system, a method has been developed which combines both visible-spectrum and thermal-infrared data for display to the user. This enables a viewer to discern temperature differences within the model, and simultaneously interpret text or symbol based labels that are invisible in the thermal modality alone. Furthermore, a novel colour mapping has been developed which seeks to achieve both perceptual uniformity and an intuitive appearance.

Avizo and Avizo Fire: 3D Visualisation and Analysis Software
Matthieu Niklaus, FEI
New developments in Drishti
Ajay Limaye, ANU

I will be presenting some new developments in Drishti. Among them are multiperspective camera and precomputed lighting.

Multiperspective Camera - A multiperspective image can be described as multiple views of a single scene from different perspectives. These views are joined seamlessly to form an image that is a coherent whole.

Lighting - Ability for coloured lighting, ambient occlusion as well as point and directional light sources.

Voluminous - A web based volume renderer.
Drew Whitehouse, ANU

A progress report will be given on the status of the Voluminous project. Voluminous is a volume rendering application that runs on GPUs in “the cloud” and is accessed through a modern HTML5 web browser.
High resolution anatomical modelling for biomechanical analysis
Colin McHenry, Monash University

The Functional Anatomy and Biomechanical Laboratory (FABLAB) at Monash University focus on high resolution three-dimensional anatomical modelling to analyse form/function relationships in both human and animal models. Here we describe the process of generating complex anatomical 3D models through segmentation of CT and MRI datasets, and how these models can be used for finite element simulation to predict the biomechanics of these systems under real life situations.

We have modelled the cranium and jaw muscle anatomy of a variety of species of crocodiles, goannas and kingfishers, and applied finite element analysis to document the biomechanics of feeding methods and predictors of strength within the skull. We then applied a similar method to the extinct marine reptile Kronosaurus through the digital reconstruction of a fossil skull to predict the feeding ecology of this species. Mammalian species analysed with this approach include marine mammals, fossil humans, other species of hominin apes (chimps, gorillas, and orang-utans), dogs, cats, and marsupial predators.

The same techniques can be brought to bear on biomedical systems; we are developing models for clinical treatments for shoulder injury, pelvic organ prolapse and prosthetic joint replacement. These are based on a complete anatomical model which was created from a co-registered dataset of CT and MRI images taken from a human cadaver, as well as clinical scans. The shoulder project will investigate the effects of lack of functioning of a single muscle in the rotator cuff region and predict which muscle needs to be trained to compensate for this lack of movement. The pelvis model will be used to model pelvic organ prolapse to predict the optimal position for a surgical mesh to hold the organs in place and a model of the knee joint will be used to determine the strain occurring within a healthy knee and the replication of this within a prosthetic design to reduce the need for repeat surgery.

Capture true-colour 3D models of insects for entertainment, biosecurity and science
Chuong Nguyen, CSIRO
David Lovell, CSIRO
Rolf Oberprieler, CSIRO
Debbie Jennings, CSIRO
Matt Adcock, CSIRO
Eleanor Gates-Stuart, CSIRO & ANU
John La Salle, CSIRO & Atlas of Living Australia

3D insect models are very useful in many applications including education, entertainment, biosecurity and research. However, capturing 3D insect models from real specimens is quite challenging. Their small size is one of the main obstacles. Currently the main method is Micro Computed Tomography (Micro CT) which can capture detailed 3D volume model of insect specimens but without the colour information of the insect appearance. Such colour information is key information to recognise insects and their body parts. Alternative methods, such as laser scanning and image-based 3D reconstruction techniques, so far produce low-quality 3D models of insects.

We present 3D insect scanning system that can successfully acquire high-quality true-colour 3D models of insects from around 3mm to 30mm in length. Colour images are captured from different angles and focal depths using a digital single lens reflex (DLSR) camera rig and two-axis turntable. These 2D images are processed into 3D reconstructions using software based on a visual hull algorithm. The resulting models are compact, afford excellent optical resolution, and
can be straightforwardly embedded into documents and web pages, and viewed on mobile devices. The system is portable, safe, and relatively affordable, and complements the sort of volumetric data acquired by Micro CT.

Our 3D insect scanning system provides a novel way to augment the description and documentation of insect species, reducing the need to handle or ship specimens. It opens up new opportunities in harvesting data for research, education, art and entertainment with potential applications in biodiversity assessment and biosecurity control.

Exhibition – CAVE2 Presentations

Lightbridge
Chris Henschke, Australian Synchrotron

The affective relationship between observer and observed is paradoxically a cornerstone of contemporary particle physics, and yet rebukes the dogma of removed objectivity of science and perception. Lightbridge is a hybrid art / science project which reimages and recontextualises scientific theories and processes, shifting the empirical perspective and playing with the concept of the observer affecting the observed - a cornerstone of experimental physics. Lightbridge appropriates the 'Geant' particle physics simulation software developed by CERN and used at the Australian Synchrotron, taking particle accelerator simulations and real synchrotron data and turning it into unique visual forms. This is visually manifested through a combination of realtime digital 3D modeling, 3D printed kinetic sculpture and projection mapping. Lightbridge was developed during Chris Henschke's 2010 Synapses residency at the Australian Synchrotron, supported by the Australia Council and the Australian Network for Art & Technology. For a prototype demonstration, see the ISEA exhibition documentation video:
http://www.youtube.com/watch?v=A1ehrrAiOG4&feature=c4-overview&list=UUMzZHdF0pZBT0IYotljB5A

Visualisation of the Monash Motorsport M13 Formula SAE Car and Aerodynamics Package
Marc Russouw, Monash Motorsport
Scott Wordley, Monash University

Monash Motorsport would like to present a rendered model of our 2013 Formula SAE car showing where improvements in the aerodynamics package were made. Such improvements were possible due to a strong focus on vortex management and interaction across the full car. This in addition to other qualitative studies of quantities such as total pressure, streamwise and transverse velocity fields around the 3D car model enabled the aerodynamics team to improve the downforce generated by the car by more than 20% for only a 10% increase in drag. This would not have been possible without strong emphasis on the use of visualisation techniques throughout the design phase. Extensive and systematic post processing of our CFD results allowed us to identify many areas of improvement on the car which had previously been overlooked.
High resolution fractal rendering and animation in the CAVE2  
Owen Kaluza, Monash University

Getting huge scientific data sets ready for use in high tech visualisation facilities can initially take a bit of time and effort. As a test case, fractals, with their inherently infinite resolution, offered a great way of instantly showing the capabilities of the CAVE2’s huge 27K x 3K (80MP) display resolution.

The CAVE2 offers several different visualisation platforms for software, having already rendered some high resolution fractals for static display I’ve attempted to build a real-time fractal animation renderer using both the SAGE and OmegaLib platforms.

I’ll show some fractals based on highly modified Mandelbrot & Julia set formulae with interactive zooming and changing of parameters as well as some animations of dynamically rendering fractals with fluid parameter adjustments.

Personal Care? Triclosan contamination of benthic communities  
Phillip Gough, CSIRO and University of Sydney  
Xavier Ho, CSIRO and University of Sydney

This visualisation shows the effect of triclosan contamination on marine benthic communities. Triclosan is a common antimicrobial compound found in personal care products, such as toothpastes, liquid soap, and detergents. A recent study showed that sediments at high levels of triclosan affect the marine benthic communities through contamination from sewage waste [1]. Natural Resources Defense Council reported that personal care products sold between 2004 and 2010 in the US contained increasing triclosan concentrations [2]. Marine benthic communities will be at risk if this trend continues. The purpose of this visualisation is to convey this human impact issue to the general public.

Traditionally, the scientific community focused on allowing domain-experts free exploration of data through visualisation. Because the general public may not necessarily be aware of the potential impact of and meaning behind scientific research, we have created a visualisation specifically to communicate the intent of this research. Our approach puts an emphasis on the end-user’s needs, that is a user-centric rather than data-centric visualisation. The result is an artistic explanation of data that also guides the end-user through information from a domain in which they have no previous expertise.


Exhibition – Poster & 3D Printing

Superficial anatomy of the Upper Limb  
Michelle Quayle, Monash University  
Paul McMenamin, Monash University  
Justin Adams, Monash University  
Colin McHenry, Monash University

The Centre for Human Anatomy Education in the Department of Anatomy and Developmental Biology at Monash University is working towards the creation of a set of 3D printed anatomical models for use in
medical education. This model was created from a CT scan of a human upper limb specimen. The CT scan images were converted into a 3D model file which was digitally hand coloured and then 3D printed on the Department's ZPrinter 650 full colour powder printer.

Anatomy of the hand
Michelle Quayle, Monash University
Paul McMenamin, Monash University
Colin McHenry, Monash University
Justin Adams, Monash University

The Centre for Human Anatomy Education in the Department of Anatomy and Developmental Biology at Monash University is creating a collection of 3D printed anatomical specimens for use in medical education. This model shows the deep muscles, tendons, nerves and arteries of the hand, and was created by CT scanning the original prospected specimen, creating a digital 3D surface, and then digitally colouring the model. The coloured model was printed using the Department’s full colour ZPrinter 650 3D printer, which uses a powder material and coloured binders to produce the model.

Capture of Omni-Directional Stereoscopic Panoramic Images
Paul Bourke, UWA
Volker Kuchelmeister, UNSW

A number of stereoscopic cylindrical displays have been developed over the years, the most recent being the CAVE2. Some of these, unlike the traditional CAVE environments, provide a seamless 360 stereoscopic image without corners [AVIE] and thus can support a heightened sense of immersion. Most immersive displays that consist of discrete walls rely on head tracking and are thus only intended to be a single person experience. For cylindrical displays a method is well known by which stereoscopic panoramas can be presented without the need for head tracking, these stereoscopic pairs are generally referred to as omni-directional [Ishiguro et al, 1992][Bourke 2006]. This allows large cylindrical displays to be constructed that support multiple person audiences with each person potentially looking in a different direction. As projector and display resolutions improve one of the challenges is how to generate sufficiently high resolution omni-directional stereoscopic content for such displays. This can be achieved for CG and realtime graphics by either a discrete multipass approach or a continuous algorithm usually implemented with a vertex shader. Capturing sufficient resolution omni-directional stereoscopic photographs is more challenging.

One option that mimics the continuous algorithm for CG has been the construction of a rotating slit camera, one such camera is known as the RoundShot. These consist of twin cameras offset horizontally from the axis of rotation. Two long rolls of film are exposed continuously as the camera pair is rotated through 360 degrees. Unfortunately, since these use film in order to acquire the required resolution, their future is uncertain. Additionally they require not insignificant costs for drum scanning as well as image processing and alignment in post-production.

The poster presents a digital method of capturing high resolution stereoscopic panoramic images. Furthermore, perhaps surprisingly, it achieves this by employing a single camera.

A digital alternative for the film based rotating slit camera has been developed, figure 1 (right). It is based upon a motorized rotating head and employs either a digital video camera (Red Scarlet) or a SLR camera (Canon 5D MKIII). Only a single camera is required, two vertical stripes are extracted from each frame, these are each arranged consecutively to form the stereoscopic panoramic pairs. This technique has a significant advantage in that the inter-ocular separation can be
Historically one of the issues of using a video camera had been the limited vertical resolution. While this improved with HD video where one can acquire a vertical resolution of 1920 pixels (mounted sideways), the recent releases of 4K video cameras such as the RED enables one to capture stereoscopic panoramic pairs that match the resolution of many cylindrical displays. The problem until recently with the use of still cameras, while they may provide superior resolution they have been limited in their frame rate for full resolution photographs. The Canon 5D MKIII was tested because it can record full frame stills at 6 frames per second. This has allowed stereoscopic panoramas to be captured at 5K vertical resolution and in less than one minute.

3D Reconstruction and Printing for Rock Art Archaeology
Paul Bourke, UWA

This poster along with associated 3D prints will present work being undertaken with the Centre for Rock Art Research + Management at The University of Western Australia. It will discuss the pipeline from initial photography on a rock art site, the photogrammetry to reconstruct 3D models as a recording of the art, and finally closing the loop by printing 3D models for a more tactile representation.

"Monster" 3 printed examples from a larger project to image volumetric data of a garden slater, or Isopod, imaged with 3D Microcomputed X-ray Tomography
Erica Seccombe, ANU
Tim Senden, ANU
Ajay Limaye, ANU

Printed on a Z Printer 650, for the exhibition, Science Fiction, Canberra Contemporary Art Space, 2013

Components from Monash Centre for Additive Manufacturing
Dr Robert Hobbs

Machine Study 4
Chris Henschke, Australian Synchrotron
Accelerated Computing Workshop 2013

Presentations

Ultra Fast Simulations for Ultra Cold Atoms
Chris Watkins, Monash University

Ultra cold atomic physics has been growing in leaps and bounds over the past decade. Since the first experimental realisation of a Bose Einstein Condensate (BEC) in 1995, researchers have been investigating its usefulness in fields as diverse as quantum computing, quantum information, quantum simulation, highly sensitive accelerometry and high resolution magnetometry. Given the vast applications of these cold gases the understanding of their behaviour is of the utmost importance. The popularisation of the Graphics Processing Unit (GPU), found in most modern desktop computers, has brought the age of supercomputing into the hands of average scientists. Using the highly parallel architecture the GPU we have been developing code that will allow us to probe the interesting quantum behaviour of ultra cold atomic gases.

The project development has two distinct streams, the first focuses on one of the cooling stages required to achieve BEC. The final stage of cooling is known as evaporative cooling and relies on the preferential removal of the hottest atoms in the gas. However, the simplest experimental set up for executing the evaporative cooling is prone to atom loss that results in unwanted heating. This loss is the result of a purely quantum effect, known as Majorana Loss, that is not well understood for a large ensemble of atoms. We have developed a CUDA implementation of the Direct Simulation Monte Carlo technique that takes advantage of the discrete nature of the atoms in the pre-condensed gas cloud. We have also developed a semi-classical technique which allows us to simulate the interplay between the classical Newtonian motion of the atoms in the gas and the evolution of the internal quantum state of the atom, which is at the heart of the Majorana loss.

The other stream investigates the behaviour of a gas after it has undergone a quantum phase transition into the BEC regime. Using a Finite Element Method that utilises the benefits of the Discrete Variable Representation (FEM-DVR) we aim to solve the three dimensional multi component Gross-Pitaevskii Equation. We can exploit the sparseness of the FEM matrices by using the prebuilt sparse BLAS libraries that ship with the CUDA API. The aim of these simulations is to provide real time visualisations of the evolution of the internal state of a multi component BEC with a strong focus on the experimental details. This will allow us to guide real experiments and provide insight into possible research directions.

Scientific Applications Development: Why Code When You Can Draw?
Mohamed Almorsy, Swinburne University of Technology
John Grundy, Swinburne University of Technology
Richard Sadus, Swinburne University of Technology
Willem van Straten, Swinburne University of Technology
David G. Barnes, Monash University
Owen Kaluza, Monash University

Developing complex scientific applications that can process large-scale datasets requires effective utilization of modern computational platforms including grids, clouds, multi-core and many-core processors,
and the ever-increasingly general-purpose graphical processing units (GPUs). Scientists, who are expected to leverage such platforms, face numerous challenges including lack of abstract domain models, lack of common parallel programming models, unsuitable development environments to assist them, and ultimately most are domain experts and not parallel and distributed programming experts. Currently, most tools aimed at supporting scientists in realizing such applications are either very limited to specific domains and technology, or require significant development using low-level code.

In this presentation, we introduce our work-in-progress of using domain-specific visual languages (DSVLs) to provide multiple abstraction levels supported with a web-based toolset to better enable the engineering of scientific applications for big data problems. Our approach is based on modeling sequential problem specification details, planned parallelization aspects, and various deployment scenarios using a set of abstract DSVLs. Then, using our code generation component, we use these three-perspective model to generate the corresponding parallel programs adopting suitable parallel programming models including MPI, OpenCL, or OpenMP as needed. A change in the program target deployment platform or the intended parallelization paradigm will be automatically reflected on the resultant parallel program. We plan to extend our approach to help in deploying, monitoring, and debugging the resultant program. Furthermore, we are working on reengineering existing sequential and parallel programs to reconstruct their corresponding models. This is expected to help researchers in maintaining and customizing existing parallel applications. We will demonstrate our current toolset, Horus, to develop an exemplar scientific application.

Accelerating particle radiotherapy applications with OpenCL
Filippo Ammazzalorso. University of Marburg
Tomasz Bednarz, CSIRO
Urszula Jelen, University of Marburg

Background and purpose. Common computational tasks for radiation therapy, such as image registration (for patient positioning) or dose computation (for treatment planning), often involve stencil-like computations on relatively large data sets. Such data-intensive operations are well suited for acceleration on many-cores architectures such as modern CPUs or GPUs. In state-of-the-art high-precision external beam techniques, like radiotherapy with carbon ions, speedup of time-consuming tasks like beam-setup optimisation or dose computation could have beneficial effect on quality of patient treatments, enabling more frequent and precise dosimetric assessments. It also opens new ways for interactive adaptive particle therapy.

Material and methods. Previously developed, highly-optimized single-threaded C/C++ code performing robust planning (beam-setup optimisation) and dose computation for carbon ion therapy was ported to OpenCL and benchmarked on NVIDIA GPU and multi-core CPU.

For the problem of robust planning through the Port Homogeneity Index analysis, the computationally intensive step of pencil scoring, where densities along beam tracks are extensively compared within a neighbourhood, was parallelised and applied on 10 skull base cases. Test architectures were an Intel Xeon 4-core W3530 2.8GHz with 12 GB RAM and a Fermi Tesla C2050 with 3 GB RAM.

To achieve fast dose computation, the engine for absorbed particle dose was rewritten to exploit data-parallelism on a GPU and tested in different synthetic phantoms on a Xeon 8-core E5-2650 with 128 GB RAM and a Kepler Tesla K20 GPUs with 5 GB. Results were compared
in terms of dose distributions, dose-volume histograms and speed.

Results. In the robust planning task, which was directly converted to OpenCL, the obtained numerical results were matching native host calculation outcomes. On the GPU, an increase in speed of at least one order of magnitude was observed. Similar level of acceleration was achieved in the dose computation task. Numerical results of the multi-threaded version, which required engine redesign, were matching the single-threaded version results.

Discussion and outlook. We demonstrated that state-of-the-art radiotherapy with carbon ions can benefit from GPU acceleration in two of its key problems: dose computation and robust treatment planning. Speedup can turn robust planning into an interactive step and, with fast dose computation, allows to perform more accurate and frequent patient QA, going towards future adaptive particle therapy. The use of OpenCL allows to maintain a single CPU/GPU parallel implementation.

**Paths to accelerated graphics and computation from web apps**

*Owen Kaluza, Monash University*

I'd like to share some of my experiences with accessing high performance graphics and compute hardware in web browsers gained through developing a web application for my personal interest in fractal art combined with explorations in providing web based tools for my professional activities in scientific computing & visualisation.

Newly emerging standards (the now well established WebGL and nascent WebCL) are providing unprecedented levels of client side hardware access to web browsers. Utilising these can have amazing results and offer a short cut to cross-platform GPU support but come with their own unique set of difficulties and platform inconsistencies.

The other side of the coin is utilising resources on the server side. There is huge ongoing investment in cloud based resources and associated impetus to develop online tools and workflows. Providing server side computing/graphics power helps support the proliferation of portable low-powered devices with a consistent user experience limited only by image data transfer times but how does it compare to the snappy interactivity of client side solutions when the local hardware is up to the task?

Demo/case-studies:.

Is it really worth all this effort to try and get everything to run in a web browser? The ability to create access-anywhere tools, server side storage and sharing of data and the ability to build innovative user-interfaces for exploring and collaborating with data offers huge potential.

I hope to illustrate some of the utility of these aforementioned efforts by demoing my web application for computation & rendering of high-quality fractal images and animations in real time at http://fract.ured.me. This has been the vehicle through which I've learnt about most of these technologies experimentally before applying some of the techniques further with scientific use cases.