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The evolution of the Mars Daisy

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Introduction

The xxxxxxxx approached xxxxxxxx with a view to exploring the way in which visualisation could be used to assist in the communication and development of their CCARC with different skill sets. The final animation has been used to publicise and explain the work of the group to wider audiences who may be unfamiliar with the domain and as a teaching resource in both faculties.

This paper explores the role of this form of graphical representation in facilitating communication during concept design, education and dissemination and the process by which the animation was developed.
A brief introduction to Cogent Computing

Pervasive or ubiquitous computing may be defined as a field of computer science considering the use of computers, embedded within and intrinsically part of, larger devices or objects. Future environments could become saturated with computing and wireless communication that is seamlessly integrated with human users through intuitive user interfaces

The CCARC is interested in pervasive computing, especially the technologies and social impact of pervasive computing in sensor networks, industrial and information design, multimedia, visualisation, computer supported cooperative work and other areas.

Clearly such research is of considerable importance and will form the next stage of the Information Technology revolution. However, with worldwide falling recruitment in computer studies and difficult concepts to portray to the public if they are to become stakeholders in development, there is a pressing need to consider more innovative ways of presenting scientific breakthroughs and information. One way of achieving this is through the use of more effective means of communication.

Dürsteler (2002) defines 'information visualization' as 'the process of knowledge internalisation by the perception of information' and traces its origins to 38,000 BC in the cave paintings of the Dordogne. One of the latest forms of information visualization is animation. This has been used particularly to tell stories and sequences of events, or to show series of changes over time.

The context - Cogent Sensors

Pervasive computing pertains to a scenario where networked, environmentally aware computing technology can be embedded in any product. Crucially, the user interface of a pervasive system is intended to cause the user to feel as if the technology is aware of and participates in their world, as opposed to the user having to learn about the (virtual) world of computer interfaces in order to achieve their goal. The forecast social impact of this paradigm shift is immense and to date, awareness, even amongst computing students is limited. Although the area has so far benefited from enormous research efforts, tomorrow's "dream applications" are commonly designed (and then presented) using a bottom-up approach from the level of physical components and computational algorithms, building up to functional systems.

This is an exciting area. However, much of the excitement and lifestyle changes which may arise from the introduction of pervasive computing are either not shown, or are lost in the bottom up approach usually presented. A "top-down" view in the presentation/dissemination of ideas and concepts would ease the communication and exchange of ideas with unmotivated and less technologically aware audiences. So, rather than look at the minute details of the operation of cogent sensors, we have commenced with an animation of a usage scenario, without looking at the operational details.

CCARC have developed a 'dream application' (Newman et al, 2005) relating to space exploration in which thousands of microsensors (DAISIES) are deployed on a planet (Mars) to perform environmental monitoring and report their findings, via satellites, back to Earth. The microsensors could offer a more fault-tolerant method of planetary exploration than the use of a single highly functional "rover". The scenario also highlights a number of technical factors such as the release and deployment of the sensors, the types and quantity of information that might be gathered from the network, and the mechanisms required to transmit that information back to earth thereby facilitating conversation amongst the group and helping to schedule work activities. From this scenario, CCARC have outlined the design for the node including provision for the required transducers, the signal and data processing circuitry, the data transmission and reception equipment and the actuators required to deploy and maintain the sensor on station.

The development of the scenario has led to a specification using contemporary, widely available hardware. The DAISY can communicate optically, harvest solar energy, and gather sense data (using image, atmospheric and soil chemical sensors, a magnetometer and a seismic detector). The basic dimensions of the mote hardware inside the DAISY are 20mm by 7.5mm.

Why animation?

We are now at a stage where education is not confined to schools and universities, it occurs throughout life, either within the confines of industry, especially in knowledge-based organisations, or through life-long learning. Audiences and presenters/commissioners of teaching and training material are therefore mature and sophisticated, having been exposed to a rich, varied and high quality visual culture. They need to communicate about technical, scientific, conceptual and managerial information within and between large scale companies and institutions: the information may appertain to physical devices and principles such as the operation of machines, chemical compounds or drugs; or address concepts such as safety procedures, aspects of learning and training, the communication of decision making, marketing and research processes.

To meet these demands, companies may hand over responsibility for their external advertising and publicity campaigns to specialist agencies who can produce material to the necessary quality. However, internal training and awareness programmes that are vitally important in terms of making known the activities and aims of the organisation, often do not receive the budget, care or specialist attention they warrant even though the employees, delegates, directors, visitors who attend these sessions are indeed the same persons who are immersed in the televisual culture of the wider community. They tend to judge the informational diet served to them by similar standards to the programmes seen outside. No matter how worthy a subject matter may be, if the method of presentation does not engage and judged as substandard by the viewer, then that subject matter will not be seen to its advantage. This applies equally well to the development of material for teaching within our institutions where material should also be developed bearing in mind the principles of multimedia design for learning (for example, Mayer, 2001).

The design brief and the emergent purposes of the animation

The CCG believed that a "top-down" view, both in the design phase and the presentation/dissemination of ideas and concepts phase would be more fruitful both technically and in order to ease the communication and exchange of ideas within the technical development team. So, rather than look at the minute details of the operation of cogent sensors, we have commenced with an animation of a usage scenario, without looking at the operational details.

The evolution of the Mars Daisy

The animation progressed from a series of discussions between the co-authors, to the generation of concept sketches, a narrative, storyboard, key frames, animated slide, animation with text, to a full animation with voice-over. Discussion not only enabled the creation of the animation but also contributed to the work of the group through the exchange of ideas at a conceptual level. This progression is shown in Figures 1 to 4. Concept sketches produced by Robert Newman were used as a base for full-colour visualization by two assistant artists under the direction of John Burns.

Discussions that took place during this process served two purposes; firstly to make the concept of the keyframes clearer, and secondly, to provide a vehicle for CCRG to discuss how the sensors would work in practice. A visual style was developed that took into account the many aspects of the subject, for instance;

- the vastly differing scales of sensors and landscapes
- the relative distance across which communication must take place; and,
- the necessity for the viewpoint to change smoothly between all of these whilst allowing the viewer to visually navigate those spaces in the reading of a coherent story.

Whilst computer-based programs were used in the creation of the animations, some of the visual language used looked towards 19th century European landscape painting in the depiction of dramatic vistas and unexplored locations.

In order to visually portray their functions and attributes, the illustrations adopted metaphorical and analogous tropes whilst retaining pictorial similarity required to keep the visual description of the sensors within the depiction of the landscape. [8]

The animation has taken over 300 hours to complete, and is now over 9 minutes in length. The text and music has been replaced by a voice over and we are preparing to show the animation in more public arenas. The animation serves a number of purposes and its production reflects the changes in the techniques, systems and procedures available to those wishing to communicate visually within the recent past. Many of those tools have now been reduced to a fraction of their previous cost and yet have become increasingly sophisticated and flexible.

Figure 1 . Sketch of the release of the DAISIES in orbit

Figure 2 . Visualisation of the release of DAISIES

At one end of the scale are computer based graphics and animation tools that many non-specialised users have access to; at the other end of the scale are the visually creative industries who may use similar, but higher specification, tools and will employ specialists to use them.

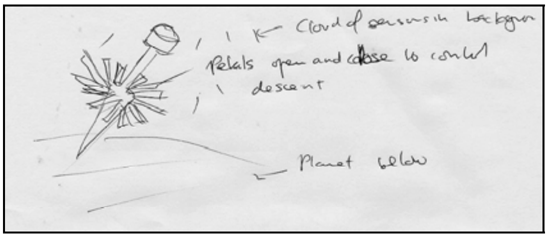

Figure 3 . Sketch showing the petals of the DAISY

Figure 4 . The DAISY network

Although not used quite so much in earnest as facilities within commercial production houses, the first, non-specialised toolsets sitting within desktop computers present an considerable and increasing level of sophistication. The products of the second, production oriented, 'high-end' toolsets must have maximum effect and are often, at least after a short research and visualisation stage, delivered to have as much impact as possible within a necessarily short viewing time. Client visuals and storyboards allow some initial interaction between the concerned parties but from quite early in the project the emphasis is on driven design with perhaps a modicum of evolution.

There are times however, when a given scenario provides an opportunity for the best of both tool set scenarios to come together; namely the use of resources that are available but which are not required to be used constantly together with forays into 'higher-end' resource. The Mars DAISY project provided such an opportunity.

The relationship between the differing options as previously described is outlined in order to draw attention to how the Mars DAISY animation came to be produced. Members of the Mars DAISY team operate also within each of the sectors mentioned.

It was proposed at the start of the exercise that the animation would also form a development tool in addition to being a communicator to outside parties, stakeholders etc.

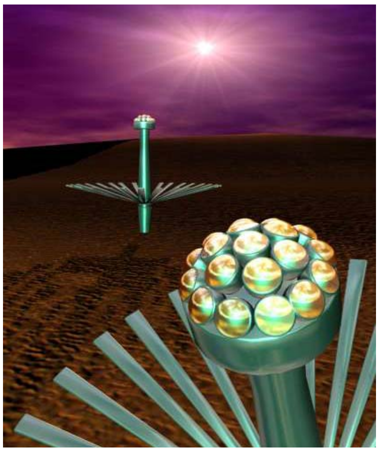

Figure 5 . Optical Sensors and solar energy gathering 'Petals' used by the DAISY

An important plank in this structure should include the use of some specialist tools but also soft and hard wares as available to non-specialists. This is an important point as it would mean that the animation would have time to evolve alongside developments in the design of the sensors themselves and their methods of deployment and use. We aimed to examine whether or not the ready availability of relatively fast and sophisticated visualisation tools combined with on-site user expertise would permit animation to function as an exploratory device in addition to being a presentation tool. It is true that within certain product and process design and development activities there have, for a number of years, been available computer-based methods of generating real-time visual representations of formulae, molecular structures, medium flow, procedural analysis, collision detection and element interaction etc. Many of these procedures employ software to compute and display in graphical and time-based form the interactions between components, forces and other behaviours as derived from data input. Such valuable techniques and procedures tend to rely heavily on computation of data which is then depicted by procedurally generated graphics. In recent times these relatively simple, almost real-time generated graphics have been supplemented by pre-rendered, pre-animated and texture-mapped objects as used in gaming situations.

When such a project reaches the stage at which graphic artists and animators become more involved in the representation of the project's outcomes in fully detailed, highly resolved and narrative-active images the larger part of the product development work will have neared completion. Animated and still graphics generated from this point onwards would usually be seen as marketing artefacts perhaps drawing on, and embellishing, the previous, above-mentioned, formative graphical work. Some highly finished proposal and concept graphics may have been commissioned at a very early stage but again, these would most likely not interface with the visuals as developed within the product design process.

The Mars DAISY project was unique in that the graphical elements were developed in a visually creative, narrative based and highly finished manner alongside the development of many aspects of the DAISY sensor itself. The involvement of animators and artists throughout the project rather than solely at the later presentation and marketing stage allowed for a dual strand system of development and visualisation. Benefits as perceived by members of the product development team of having access to atmospheric images and animations as the project developed included attracting interest, funding and recruitment to the team. Added to this was the focus directed on certain aspects of the technical nature of the project as prompted by the demands of a higher level of visualisation.

Often it is only when something is visualised to a highly finished level that certain design details or procedural points can be seen to require attention. The levels of detail required to visualise an artefact to a realistic state can prompt the team to consider aspects of the project that might have been overlooked or left until later. On the other hand, given that the production of animated graphics (even taking into account the availability of tools to hand) can be a large drain on artist hours it can often mean that when changes are required they can be quite time consuming. The inverse of this is, of course, that such a situation may well happen anyway but much further down the line when perhaps a large project has finally been visualised to high finish for the first time. In such a situation large amounts of changes may well be required but within a greatly foreshortened timescale. The Mars DAISY project, due to its combining of higher level visualisation/illustration with ongoing product development allowed for re-thinks to take place based on the continuous flux of opinion and information as it passed between the design, development and visualisation elements of the team.

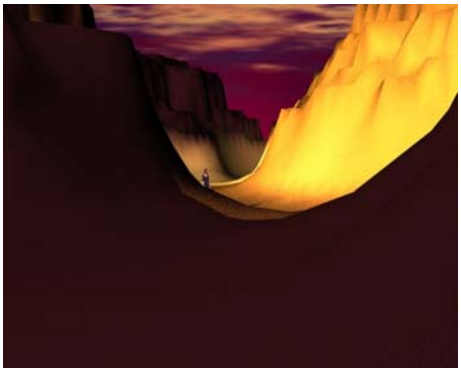

Figure 6 . A virtual representation of the surface as generated from data gathered by the DAISY network

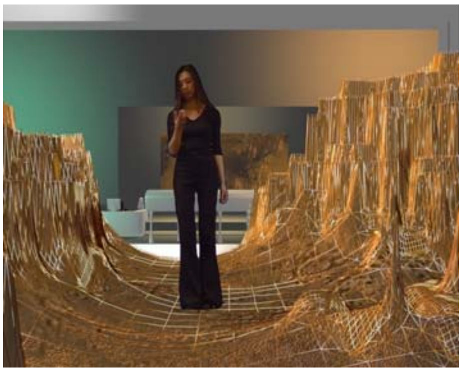

Figure 7 . An observer within the 'tele-presence' room

Further, in their summary role as marketing and publicity devices, the graphics thus produced had a pace and style that could echo the evolutionary nature of their creation. We believe that this method of working does deserve examination as to how it may become applicable across a wider range of scenarios. A highly beneficial spin-off of working in this manner was the observed sense of common ownership regarding the products, research, visualization and presentation across all involved parties that developed throughout the project's life span.

Evaluation of the effectiveness of the animation

…in facilitating collaboration between the two research groups

The collaboration between the two groups has been on going for over a year, and will hopefully continue in the future. Although, at one level CSAD were providing a service to the CCG, both groups have benefited. Firstly, CSAD staff and students have enjoyed development of the live project, which has also been used to illustrate animation techniques and inspirational sources to undergraduate and postgraduate students in the School. Secondly, Burns was commissioned to design the book cover of Gaura and Newman (2006) Thirdly, in terms of supporting the design process, we have witnessed the way in which the animation has contributed to the advancement of knowledge and understanding of the CCG, and made comparisons between the problems some of the group had in accommodating the 'liberties' we have taken in developing the visualisation as a graphical representation. Fourthly, from a design research perspective, we have been able to study the way in which this particular form of representation has been used to facilitate the work of the group.

It is hoped that future collaborations between the two groups will emerge considering the role of different forms of visualisation in facilitating brainstorming and communication with difficult scientific concepts and looking at other ways to disseminate information to the wider public (e.g. as art performances, or more active forms of participation)

….in facilitating the design activities of the CCG

During the detail design of the animation a questionnaire was distributed to team members responsible for its development (i.e. the coauthors and the animators) to determine whether there were any differences of opinion with regard to the purposes of the animation, process, concepts to be portrayed, benefits, surprises and problems that had arisen. Clearly, such factors address wider issues than can be dealt with here, such as corporate strategy, interdisciplinary working and group dynamics.

Both groups agreed on the purpose of the animation, the way it would be used, the concepts that were to be portrayed, thereby indicating the success of the initial discussions and the initial concept sketches. Both groups expressed pleasure at working together on a project that furthered the research interests of both groups. Naturally the CCG were more detailed in their outline of the key concepts that could be portrayed. Surprise was expressed on how some apparently clear and unambiguous concept drawings could be (mis)interpreted. In such cases the drawings became a vehicle for more detailed discussion of operational details that had not been previously considered. Additionally some concern was expressed concerning the nature of the scenario and the extent to which it would create an appropriate mindset in the audience.

Prior to the use of the material for teaching processes, the slides were shown to the wider CCG for comment. This produced a lively debate dealing with issues such as conventions in animations (eg the shortening of time, use of light to denote sending of signals), the nature of visual representation, audience characteristics (sophisticated viewers, subject experts or novices) and the impact this would have on their ability to detect/tolerate inaccuracies without losing confidence in the scenario, the main purpose of the animation. At a second level, discrepancies were noted in the modelling of the environment – such as the meteorite impact, the use of light/colour to represent transmission of signals, the density of the network. The third level of debate centred around questions the group had not considered, such as clustering of signals, organisation of polling, transmission duties, amongst the sensor groups, detailed design of the sensors.

From experience, we know that such debates are common. We have provided a visual representation not a representation of the actual event. The misrepresentations and ambiguities focus the attention of the wider group on issues they may have not addressed thereby enabling opportunities for clarification and new research directions. Providing opportunities for such discussions is clearly an important benefit of generating visual representations

…in dissemination

The animation has evolved during the course of the year, and has been viewed as a work in progress by the group. As such, we have always used the latest version in dissemination activities, explaining the developmental/design context to audiences. For example the first version of the animation was a powerpoint presentation interleaved with text, this was gradually replaced with animated sequences, the order of which was dependent on the needs of the CCARC (for example, if they felt it necessary to consider the distribution of the sensors on the planet. The versions have been shown at conferences, undergraduate and postgraduate recruitment days, and on opening days of the Design Institute and the CCARC.

… in teaching

An increasing amount of research is exploring the potential of different combinations of multimedia to support education. Animations have been found to increase motivation (Rodgers, 1995), aid the quality of learning (Stephenson, 1994), enhance communication of concepts involving time and motion (Hays, 1996) and the visualization of "invisible" dynamic processes that otherwise would need to be understood through abstract concepts (Huk et al, 2003). Researchers have concluded that multimedia presentation enables people to understand things that would be very difficult to grasp from words alone. When both words and pictures support each other, students construct verbal and pictorial mental models and build connections between them. As well as the capacity of animations and illustrations to portray information differently, benefits may also be derived from reductions in cognitive load through the use of a second cognitive channel (Mayer, 2001).

A case in point here is the emerging area of pervasive computing. Pervasiveness is foreseen as the "next big paradigm shift" in computing, making computing available everywhere, anytime. The forecasted social impact is immense and to date, awareness, even amongst computing students is limited. Although the area has so far benefited from enormous research efforts, the tomorrow's 'dream applications' are commonly designed (and then presented) using a bottom-up approach- from the level of physical components and computational algorithms, building up to functional systems.

The animation has been used in the delivery of lectures on pervasive computing to Masters students. Following the recommendations of researchers such as Mayer (2001) and Roßling and Freisleben (2000) these were integrated into the lecture. The stills were displayed as a PowerPoint, remaining on screen for approximately a minute whilst a particular point was discussed. After the lecture students were given a chance to ask questions on the material before completing questionnaires and engaging in small group discussions about the added value of the animation and screen shots in the lecture. Such a question is believed to be compatible with the argument put forward by Mayer (2001) regarding the affordances of different media in enabling students to build up representations of the material.

All students saw value in the use of graphical material in textbooks and lectures as augmentation, to provide an overview of basic concepts or more detailed explanations. Some regarded the graphical material before the written. The graphics provided 'an image in the mind, which will be easy to visualise the whole problem clearly'. Comments also confirmed the different affordances of the media and that the graphics had allowed them to focus on the problems, and had provided additional stimulation. Most of the students were able to provide detailed answers about the main issues in the development of cogent system technology and its application. However, most were unable to visualise usage scenarios that did not involve space travel or geographic modelling and were unable to imagine sensors with different appearances

Conclusions

The creation of the Mars Daisy animation has been successful, in that it has led to a purposeful collaboration between the two groups, centred around the creation of an animation. Creating the visualisation required the CCARC to think more clearly about the details of the sensors, and provided an opportunity to bring the whole group up to speed, and quickly initiate new members, thereby facilitating their own design practice.

The animation itself has been used successfully to teach and enthuse staff and students outside of CCARC, for example in recruitment fairs and centre promotion. A more considered use of visual representations is clearly relevant to an academic and scientific community that needs to make its results more accessible to the public.

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