

## **Creativity in the Arts and Design through Computational Agent Modelling (CADCAM)**

### *Aims and objectives of the basic technology research.*

This research proposal will focus on a wide ranging exploration of the nature of artistic creativity through the direct linking of the creative process in Visual Art, in Literature, in Architectural Design and in Music Composition to the Computational Modelling of these processes and the manipulation in a digital form of the artistic artefacts in question. A wide range of artistic processes and media will be examined in a tightly coupled research community which will, at the same time, extend and progress the agenda both in terms of creativity and criticism in the artistic field but also in the development of computational models, software and compute resources to support artistic activities and in software agent technology.

### *The excitement and novelty of the research challenges to be addressed.*

Civilisation depends as much on the spiritual and intellectual activities of art, literature, music and design as it does on science and technology. This innovative project attempts to build across these fields in practical ways which will benefit and develop both. Many people gain enormous pleasure and stimulation from literature, visual art, buildings and landscapes, music and this is greatly enhanced by a deeper appreciation and understanding of how artists generally approach their work and what the intermediate stages in the construction of an artistic artefact might be. Even art of an apparently simple form, such as the paintings of Piet Mondrian, have many deep complexities, Mondrian wrote extensively about his *plastic art*, its theory and interpretation. His paintings often took many months to paint and he kept making changes to the painting in order to capture more closely the representation of the semantics of his intention.

A key approach to understanding cognitive processes is the building of computational models which replicate, in some suitable way, some aspect of the process. If we interpret creativity as a cognitive process then we can contemplate such an endeavour. However, creativity is likely to be built around a number of, possibly distinct, subprocesses, some of which might conflict, or at least create dynamic tensions, the result of this being the masterpiece. This creativity is an emergent phenomena manifested in the interaction of a community of internal inspirational subprocesses guided by some strategic - or possibly random - defining mission or artistic objective. We will evaluate machine learning techniques to explore how to enhance and refine the software agents, using existing examples of created work as guides to these learning processes.

This approach to understanding the artistic process has never been attempted before in such a broad and detailed way. We will pose a number of fundamental questions about the nature of the artistic/creative process and try to establish to what extent there are similarities between the mental models and processes that seem to be involved in different artistic pursuits. Does, for example, the poet structure his/her approach to the design of a poem in a broadly similar way to that used by a painter or a composer? If not is this because of the fundamental differences between the media - a poem and a piece of music are inherently linear but a painting is generally not.

Could the insights gained into the creative process allow us to design software that better supports the design process, that releases artists from some of the constraints imposed by their physical materials and world and could this lead to new types of hybrid art and products that transcend conventional boundaries? These questions will stimulate the further development of computer science in two ways:

- the development of more sophisticated software for the manipulation of digital artefacts in a semantically meaningful way for artists and those interpreting their work as well as more general technical advances;
- the extension of software agent technology through the development of new types of agents and the creation of artistic agent systems that can create in an autonomous manner thus extending the boundaries of art and the technology.

### *The significance of the selected research area, how this meets the vision of Basic Technology and contributes across a spectrum of subjects.*

This proposal builds on some basic research achievements such as computational modelling and software agents together with the development of powerful digital objects repositories and applies them to new areas involving art, design, literature and music in order to advance our understanding of the creative process. New applications of the technology will emerge into many areas of human artistic activity and design.

### *Nature of the research team.*

The research team is a collaboration of senior researchers from the fields of:

Computer Science (software agents, sound modelling, natural language processing, machine learning), Architecture (design and modelling of real and virtual building environments), History (Virtual reality and historical research), Music (Computer music, performance and composition), English (Computational analysis of language structure and use), French (Computational analysis of mediaeval texts) at the University of Sheffield. Research Centres such as the Humanities Research Centre, the Institute for Language and Speech (ILASH) and the Centre for the Understanding of Digital Objects (CUDO) are already successful collaborative partnerships whose success is a result of their strong multi-disciplinary interactions. These collaborations lie at the heart of this proposal.

Within the Computer Science department strengths in this area include the work of Wilks et al on literature and poetry, the work of Green et al on speech and music and the work of Niranjana on machine learning applied in several domains. Linking these will

be Holcombe's fundamental work on software agents, agent modelling and applications in abstract art. All of these interact directly and successfully with the researchers in literature, architecture, history and music. The Faculty of Engineering's 'Poet in Residence' would also be involved.

The intention of the proposal is to fund a wide range of researchers, both PDRAs and PhDs from all the participating departments and centres to work closely together in small groups on related activities. All the researchers will be located in the new CUDO premises and each team will comprise computer scientists building digital environments and agent models in conjunction with researchers from the application domains in visual art, architecture, literature, history and music. In this way many synergies will develop not only between the computer scientists trying to build models and representations of the artistic process and the artefact but also between teams working on different artistic media and processes.

#### *Outline of proposed methodology.*

The underlying methodology is the construction of digital repositories to represent the many types of artistic artefact and the creation of basic software components to manipulate these repositories and their contents. This foundation will be the basis for the development of agent based models of creativity. This will be achieved by analysing the creative processes and extracting plausible rules for the development of artistic forms and structures. These will be integrated into autonomous *artbots*, autonomous software that can be guided to produce creative work. These systems will be validated against real artefacts and design processes and adapted through adaptive learning techniques to refine and evaluate them. Insights gained from these activities will provide inspiration for the sort of design support that artists working with digital objects might need.

A number of key research directions will be based around the following themes:

1. *Digital objects: standards, representations and repositories.* The development of Digital Objects technology and Multi Media generally is progressing at an exceptional rate, stimulated largely by the wide availability of powerful desktop computers and the internet. It is vital that the emerging standards such as MPEG-7, MPEG-21 ..., languages such as SMIL (Synchronized Multimedia Integration Language) and software to support these are involved at the outset if the work is to be future proofed. We intend to develop repositories of digital objects - sound archives, visual art archives, text archives and visual 3d archives - using new technologies based on XML. A key issue will be to develop these repositories to support the research into the application of digital objects in the other parts of the project.

2. *Architectural design and creativity.* There will be three related strands of work, the development of visual and acoustic models of buildings and the urban environment and the validation of these models against real-world human experience. We shall further explore visual interactive models of buildings particularly studying the way in which they can be captured with low levels of labour from the real world or from drawings. We shall also explore how such models can be established from many locations with many contributors and how such models can be made available interactively across the Internet. Tapping into the new Web standards (e.g., XML, SVG, X3D, MPEG-4) and Internet-enabled open platforms, the visual modelling research aims to develop the basic technology for creating Multiplex Open Virtual Environment (MOVE). MOVE will extend conventional Virtual Environment (VE) capabilities to allow simultaneous multi-dimensional modelling (e.g., 2D mapping, 3D modelling, 3D modelling in time with ambient intelligence transmitted in images, sounds and texts). The MOVE technology will facilitate multi-disciplinary collaborative development of both open and proprietary data repositories for creating dynamic VE that can be reused for unforeseen purposes. Computational agents will be built to explore these resources and will be guided through the extraction of plausible design rules and processes towards the generation of outline building concepts.

We shall explore the acoustic environment of both interiors and exterior urban space. We shall examine how the visual models can be used to input the geometric and material information into the acoustic models. We shall explore how the acoustic models can be represented back to users in conjunction with the visual models, so that users may be able to experience both visual and acoustic information about places simultaneously including urban streetscape and soundscapes. Unlike conventional acoustic modelling, we will pay particular attention to the acoustic design of a space *sequence*, not only a single space. In this respect, real-time auralization would be very important—this is also useful when designers want to change certain building components and then listen to the difference in acoustic performance. To achieve this, research would be needed to simplify the algorithms and to verify the simplifications. The principals uncovered during these exploratory processes will be encapsulated within design agents in order to allow the generalisation of this knowledge to other, similar, problems.

We shall conduct research to validate these models at *two* levels: the *digital* level and the *human experiential* level. Models must be accurate in terms of their pure digital information.

#### 3. *Music - composition and performance - Modelling virtual instruments and acoustical environments*

From its origins in pure tape composition, electroacoustic music has developed in a number of important directions. An important factor here is the relationship between electroacoustic music's more abstract computer-based implementation, and the character and influence of instruments and acoustical environments. Electroacoustic music has increasingly involved the use of virtual instruments as compositional tools, and the interaction between computers and live instruments. Agents will be defined that provide experimental implementations of the cognitive activities inherent in the creation of these compositions and validated against the relevant critical criteria for music composition.

The study of the history and aesthetics of performance has been transformed by the development of the recording industry, and by the presence of substantial archives of recording in many parts of the world that document a hundred years or more of musical performance. These archives are increasingly based on digital formats of one kind or another, which together with digital editing systems offer the prospect of powerful methods for documenting and analysing the history of musical performance. However, the

detailed analysis of musical performance from acoustical sources is still in its infancy, and the current methods are haphazard, diverse, lacking in power and sophistication, and extremely labour intensive. The aim of this project, in close conjunction with research in the recognition of speech and gestures, is to develop more effective, labour-saving and powerful methods for retrieving data (primarily in the domains of timing, intensity, and timbre) from digital encodings of recorded performances.

*4. Approaches to literary analysis in French manuscripts.* To explore relationships between the different layers of meaning encoded within a manuscript: information contained within the text, in the ways in which the text is encoded graphically, in the ways in which text is presented on the page – and in relation to images/illuminations – as well as the iconographical information contained within those images or illuminations. Comparing the ways in which different scribes divide the content of a narrative into episode or chapter blocks and the different ways in which this information is conveyed in the visual presentation of the manuscript folio; exploring how the different ways in which the meaning of a text may be encoded in a manuscript affect its reception: for example, does the presence of cues/meanings on multiple levels imply a particular level of literacy in the reader, or a particular relationship with an oral culture/tradition?; exploring the relative importance of the various modes for conveying information and their interaction with aesthetic or creative aspects. The rules uncovered during this analysis process will be the basis for an agent based approach to literary criticism and analysis. Again validation with real scholarly examples will be vital.

*5. Historical reconstructions in virtual environments.* The work on creating virtual models of the, now ruined, Cistercian monasteries will be developed to provide a greater understanding of how these communities developed over time. These reconstructions will be created from site plans, antiquarian drawings and early photographs as well as the surviving standing (and fallen) fabric. Different models will illustrate the separate phases of architectural development of the ecclesiastical and claustral buildings between their twelfth-century foundation and the Dissolution of the Monasteries, thereby contributing to scholarly debate about the architectural history of each monastery. A digital archive for the Cistercians in Yorkshire will be created, this will seek to digitise a range of texts, visual images and artefacts illustrative of Cistercian thought, culture, economy and daily life, illustrations in Cistercian manuscripts from the region and beyond and archaeological and art historical artefacts. Historical and economic principles for the development and use of these buildings will be extracted and computational models investigated to establish how such communities evolved and adapted to changing circumstances and opportunities. These communities were created explicitly by their communities in order not only to express their spiritual beliefs but also to support their material needs in the environment that was available. This provides an example of the interaction between ‘pure’ creativity over a long time period but also functional evolution within a complex and demanding environment. The creative developmental agents identified will be validated against historical research and a new approach to the social and economic analysis of such activities will be developed.

*Evidence of disciplines working together and value of any proposed collaboration.*

In such a wide ranging collaboration it is clear that there are many disciplines working together, Computer Science, Architecture Humanities, Fine Art and Music. The common environment and many common research issues will unite the researchers in a common undertaking. Exploring synergies and contrasts between both research methods and academic disciplines will further enrich the work.

*Outline of management structure.*

The management will be through a senior management committee comprising the principal and co-investigators supplemented with external advisers. Project teams will be established and co-ordinated through regular meetings of the entire research community involved in the Centre.

*Arrangements for take up (e.g. IPR ownership) and dissemination of results.*

The potential beneficiaries can be identified as: academic researchers in the Humanities; researchers in Computer Science and those interested and involved in the exploitation and utilisation of archival content and resources based on a variety of cultural activities. Humanities research will benefit from having more sophisticated software support to enable them to interact in richer and more fruitful ways with their cultural material and archives. Computer Scientists will benefit from being involved in the pioneering of new multi-media systems, languages and from interesting new challenges to the field generated from novel application ideas. Consumers and commercial organisations will benefit from increased access to rich multi media based systems containing rare and important artefacts and cultural material.

The research will be disseminated through academic publications, putting both resources and public domain software on the Web. Postgraduate research and masters students will receive training during their activities in the Centre. The Government, through the regional development agencies, Yorkshire Forward and Sheffield First have identified the current high tech. services strengths of Sheffield to be in the domains of multi-media and cultural content and are preparing to invest up to £40m of EU Objective 1 in the support of expanding these activities (letter attached). The University of Sheffield has also received Objective 1 funding for supporting *spin off* companies and will be using part of the new HSL site, which will also house the Centre, for incubator units. There is, therefore, a very clear opportunity to develop commercial activities based on this research.