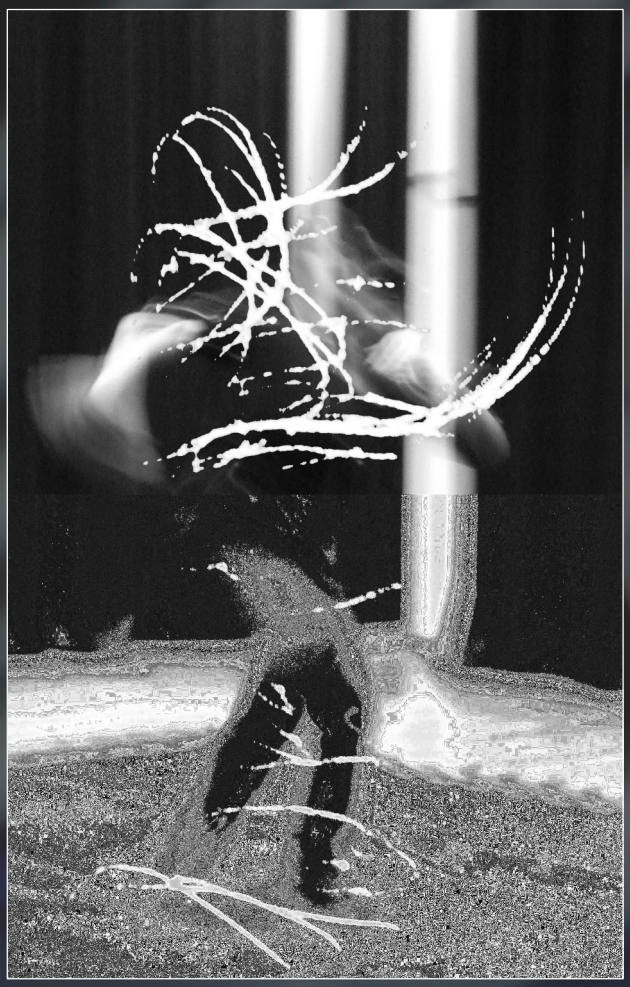
Data Services for **A**ssociated **M**otion Capture **U**ser **C**ategories

AHRC/EPSRC E-Science Demonstrator EP/E005624/1



AHESSC Report

Data Services for **A**ssociated **M**otion Capture **U**ser **C**ategories

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Contributors / Co-Authors

Principal Investigator: Sally Jane Norman, Culture Lab
Co-Investigators: Sian Lawson, Centre for Rehabilitation and Engineering Studies (CREST)
Patrick Olivier, School of Computing Science
Paul Watson, North East Regional e-Science Centre (NEReSC)

Research Associates:
Anita Chan, CREST
Martyn Dade-Robertson, Culture Lab
Jonathan Hook, Paul Dunphy, School of Computing Science
Hugo Hiden, NEReSC

Technical developers:
Daniel Jackson, Informatics Research Institute
Dave Green, Culture Lab

Artist practitioners:
Tamara Ashley, dancer-choreographer, Laban notator
John Ferguson, musician, PhD student, Culture Lab
Heart Performance Company, improvisational dancers
James Mooney, violinist, Culture Lab
Sally Jane Norman, kobudo (Japanese sword), Culture Lab
Rick O'Shea, juggler and acrobat
Gretchen Schiller, dancer/ choreographer, Brunel University/ Mo-vi-da
Peter Wiegold, conductor, Brunel University

Culture Lab – Newcastle™
Newcastle University
Grand Assembly Rooms
Kings Walk
NE1 7RU

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AMUC AHESSC REPORT

1. Background

AMUC (***A****ssociated* ***M****otion capture* ***U****ser* ***C****ategories*) is an exploratory project focused on interdisciplinary differences encountered in the gathering and processing of motion capture data, and use of these differences to inform design of a motion capture database to be deployed across the Grid. Formulated in response to the AHRC-EPSRC call for small-scale e-science demonstrators, this six-month project sought to lay the basis for longer-term development of e-science resources for Arts and Humanities research involving interdisciplinary collaboration. Moreover, with a view to establishing the reciprocity on which collaboration depends, it aimed to demonstrate the potential value of arts and humanities driven research for the broader e-science technology development community.

In pragmatic terms, the project's main goal was to propose a prototype data retrieval tool, allowing movement features or sequences to be called up from a motion capture database. Motion capture recordings produce a high dimensional dataset which is both continuous (through its reflection of a dynamic process) and discrete (through its division into sampling intervals or rates), where the tracking and processing of markers on a moving body can potentially be made to yield multiple kinds of information. Exploitation of a dataset of this complexity calls for novel index-based retrieval tools, where annotated data features can be identified in response to multiple, composite query criteria. To answer this challenge, the AMUC Sketch Retrieval Client harnessed graphic input via an electronic tablet so this could be used as a query mechanism, time and position signals obtained from the sketch being mapped/ matched to the properties of data streams stored in the motion capture repository.

In keeping with the funding call directives, the AMUC project was built around a core Arts and Humanities constituency from the live performance sector, engaging with practitioners and theorists from dance and choreography, music (instrumental, compositional, conducting), juggling and acrobatics, and martial arts. Practitioners offered a broad spectrum of movement techniques and approaches, translated as highly diverse metadata environments and requirements. Bioengineering experts accustomed to capturing and analysing large amounts of complex human motion data were closely involved in recording and post-production processing activities, i.e. providing data for integration into the prototype retrieval tool. Computing science skills mobilised for the project ranged from programming to design of interfaces and interactive display systems, development of automatic graphical recognition means, and Grid computing competencies (projection of workflow enactment systems, server distribution logics, etc). Humanities specialist input on information system design and navigation informed overall reflection and discussion. Creative and technical expertise with digital images and motion capture (filming, recording, editing, referencing for optimal access) were key to overall project logistics and organisation.

2. Significance for research

Much recent work has involved creation of motion capture libraries for cinematographic and games industries, as well as for edutainment, advertising, training manuals and simulators [1]. This activity tends to focus on commodified products for predefined target groups rather than on building frameworks to optimise shared resources generated by the user communities themselves. Yet the latter resources are increasingly valuable given the current escalation in content growth (e.g. uploads of motion capture sequences via Web 2.0), and the need such content creates for new kinds of search and retrieval methods. The development of motion capture databases thus appears to offer a particularly interesting area for testing novel Grid affordances.

This pilot project sought to stake out original terrain by brokering collaboration across usually separate research fields to open up reflection on the "living specifications", "global instrument chains" and "legitimate peripheral participation" that are powerful shaping factors in emerging e-science research according to Dan Atkins, Director of the NSF Cyberinfrastructure Office [2]. Despite these exciting new perspectives, Atkins considers that there is still a dearth of research designed to explore the collective knowledge-shaping potential of e-science resources, and that much work continues to focus on conventional, conveniently measurable processing metrics which ignore the behavioural drivers on

which broader e-science uptake and development depend, instead of explicitly addressing the novel social and organisational implications of Grid computing.

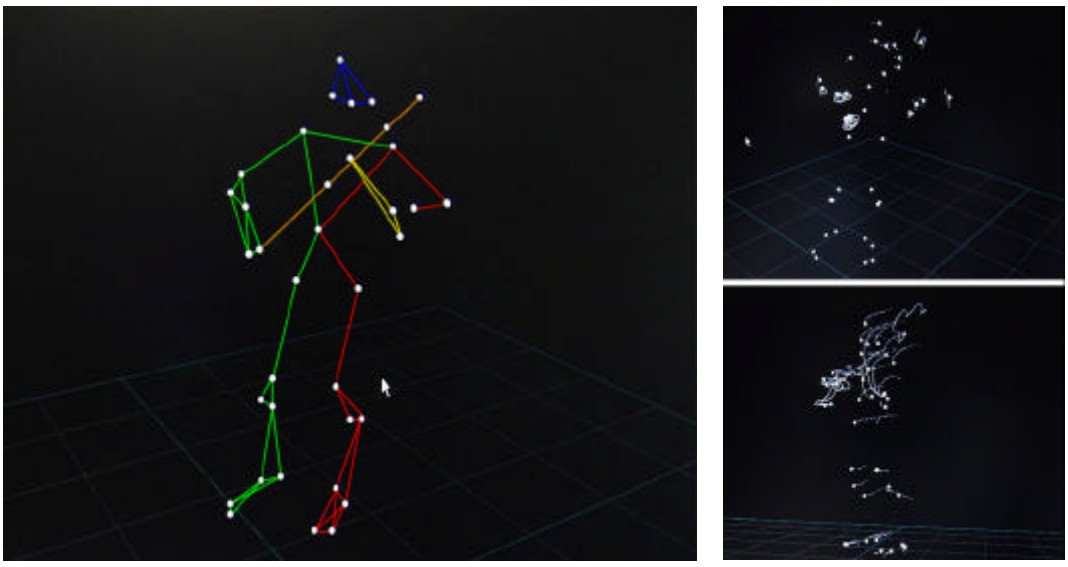
The project's aptitude to rally an unusually interdisciplinary community around an arts and humanities initiative is largely evidenced by the contributions of non-funded co-investigators Sian Lawson (CREST), Paul Watson (NEReSC) and Patrick Olivier (IRI-Computer Science). Potential findings of the AMUC project, specifically manifest as a novel database query system, and more generally as the creation of an interdisciplinary collaboration, motivated co-investigators who coordinated specialist science aspects of the programme which crucially included monitoring the processing of motion capture data (bioengineering), and developing the graphical interface and writing software for the prototype retrieval system (computing science). NEReSC technical director Hugo Hiden informed discussion on potential Grid deployments of the tool. This readiness to invest non-funded time testifies to the team's recognition of the project's pilot value and research significance, and was particularly motivating for the Research Associates.

Similar recognition of research value was encountered amongst performing artist partners, whose contributions substantially outstripped the modest allocation foreseen for the acquisition of motion capture data. The inclusion of performance techniques including conducting, juggling and acrobatics, and integration of professional dance notation competence, provided the project with a strongly informed performing arts platform from which to reflect on future database needs and applications.

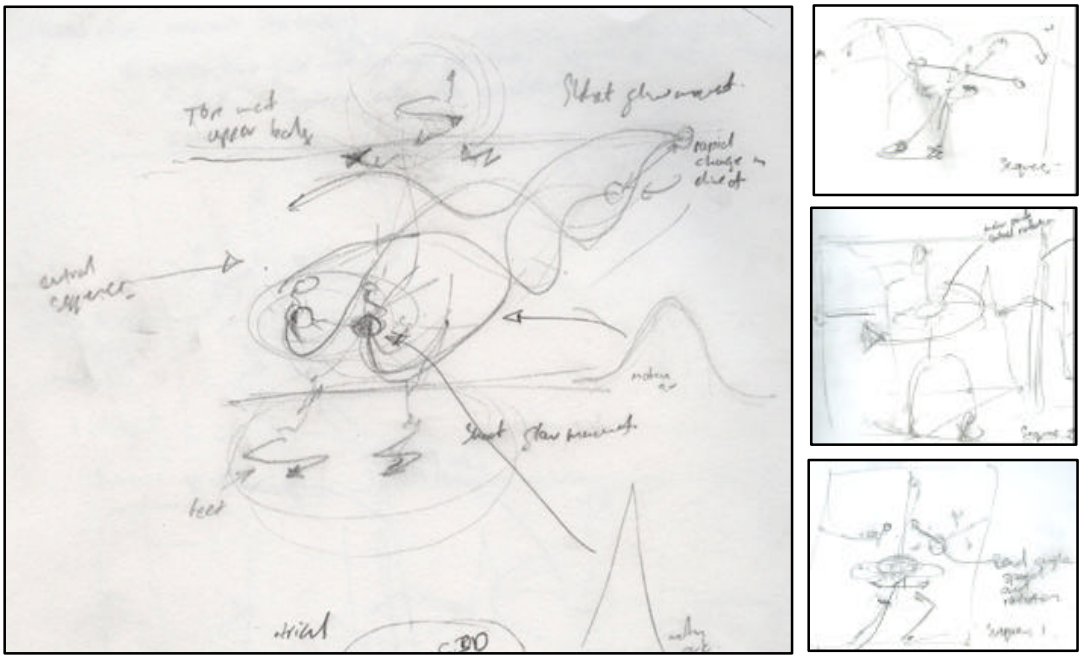
3. Materials and Methods

3.1 Expressive Gesture

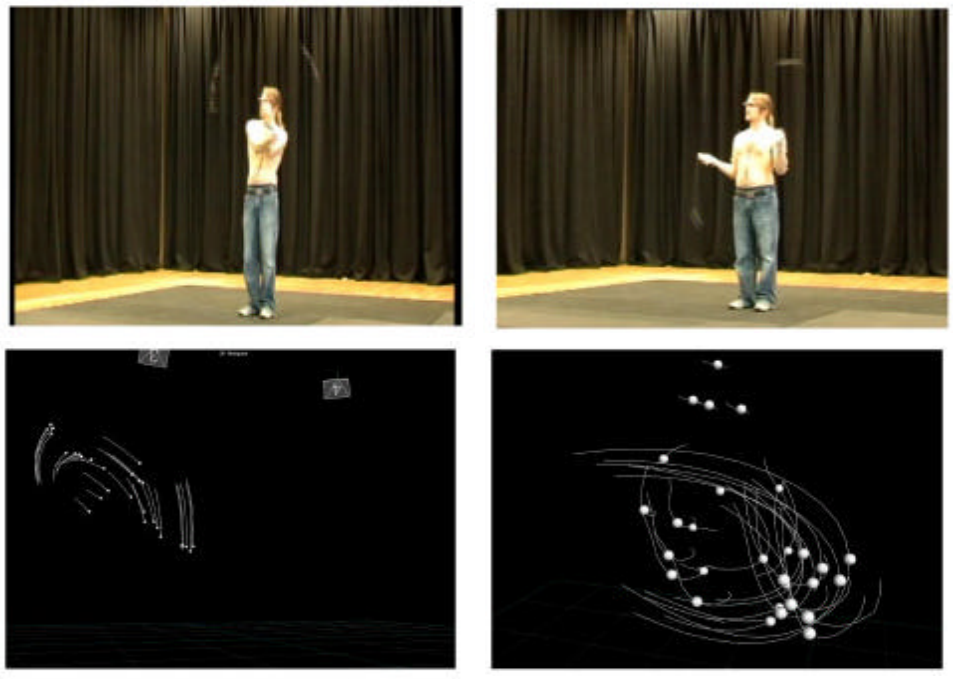
Interdisciplinary differences with respect to reference terminologies and annotation methods were evident throughout the project, commencing with constitution of the motion capture data base in keeping with the standard anatomical templates used by bioengineers and animators. This allows for subsequent processing and cleanup of data with custom software provided with the Vicon optical capture system and the widely used Bodybuilder programme. Marker emplacement was an interesting issue: data capture of relevance to a musician (e.g. hand and finger movement for a violinist, but also torso and shoulder flexion corresponding to different kinds of instrumental attack) does not necessarily correspond to that sought by a biomechanics or animation expert.



Images above indicate kinds of outputs attainable with the motion capture system, which were considered variably useful by persons from different disciplines. Whereas bioengineering analysts are not necessarily interested in bodily imaging per se, but may rather focus on statistical graphs representing variations in joint forces, performing artists may favour renderings more evocative of moving bodies, such as those featuring temporal trails at joints/ marker emplacements.

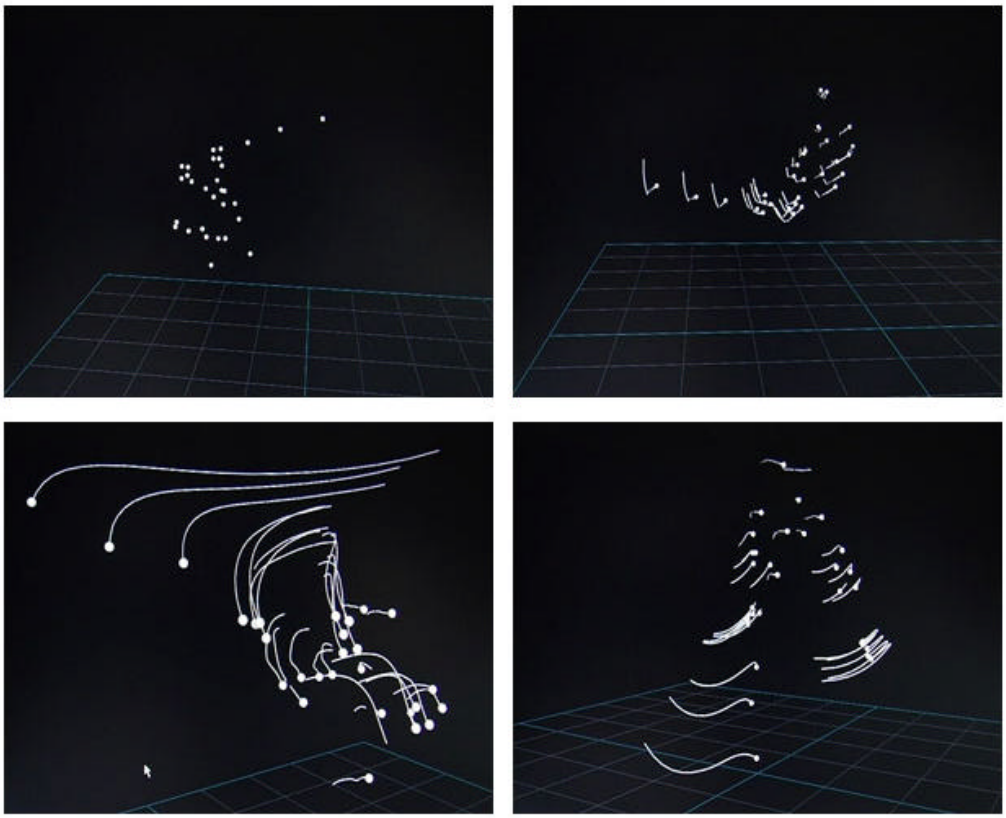


The value of freehand drawing to transcribe human motion was gauged. Martyn Dade-Robertson, whose background in architecture and design usefully complements his recent work on user interfaces and navigational systems, produced freehand sketches during capture sessions, where the mix of graphic and textual annotations to determine body positions and trajectories served as an instructive counterpoint for digital photographic, film and motion capture transcriptions. The loosely figurative reproduction of observed movement on which this kind of motion recording is based contrasts strikingly with the abstract graphic input used to search and retrieve motion data on which the AMUC sketch-based query tool depends.

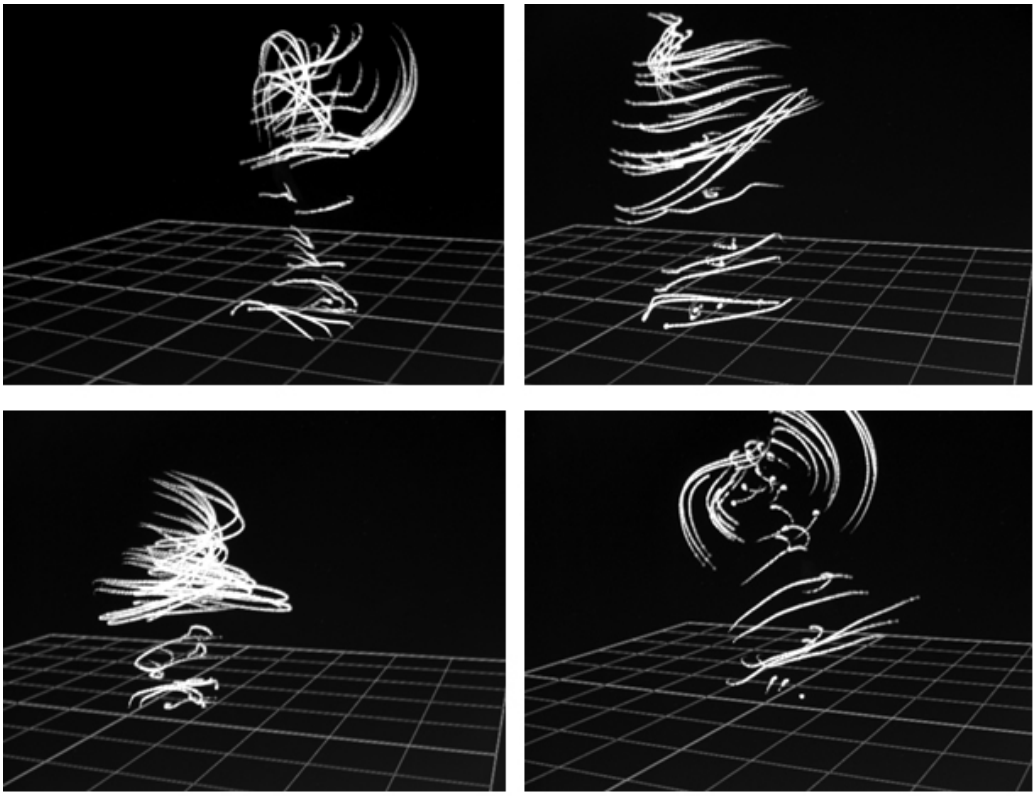


Capture of motion by juggler and magician Rick O'Shea provided insights into expert manipulation of objects in space. Sequences recorded with and without mark-up of juggled objects were compared to see what kinds and levels of information were respectively added and lost under these conditions. Legibility of eye-hand coordination from motion capture readings was discussed, as was evidence of weight and kind of objects handled as a function of gestural amplitude.

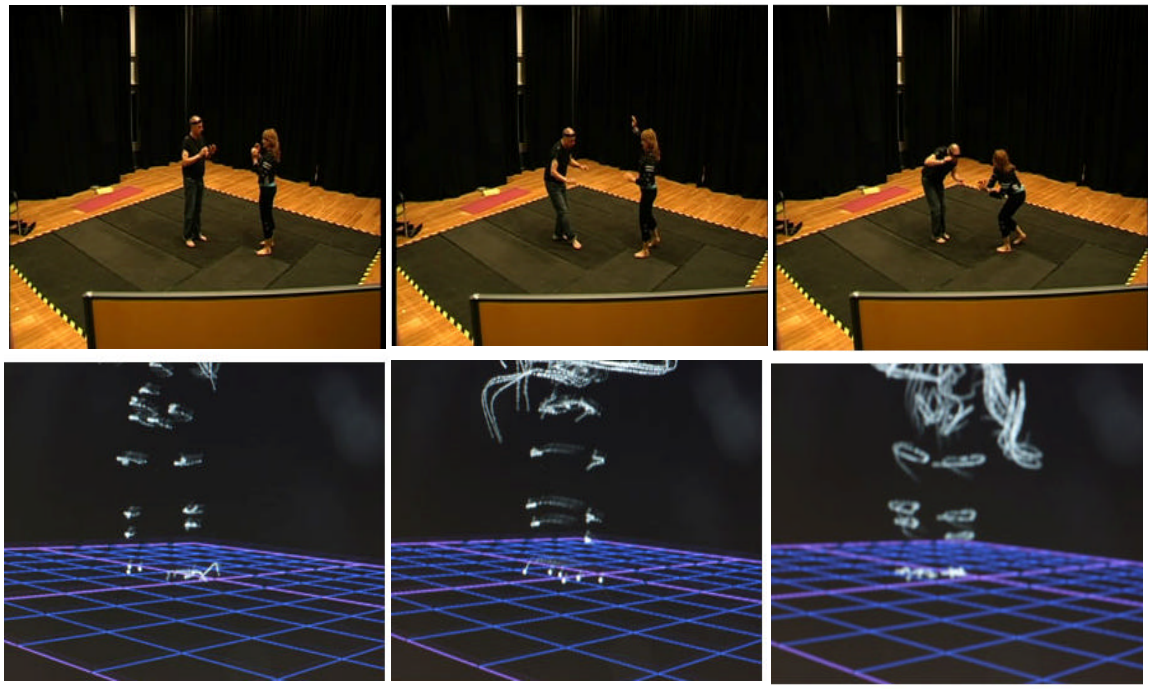
A session involving capture of a set of "kamae" or guard positions adopted in kobudo, traditional Japanese martial art using a sword, likewise involved data acquisition with and without marker positioning on the bokken (wooden training sword), to compare visual renderings and their legibility under these two conditions. The guards demand particular kinds of wrist and arm torsion on the sword devised to facilitate its raising and lowering; these placed specific demands/ constraints on marker emplacement. The "kamae" were captured as isolated movements, and also as a continuous sequence. Capture was performed for frontal guard positions and for more open sequences employing different orientations within the capture area. Motion capture is relatively widely employed in martial arts for pedagogical and self-assessment, so datasets of this kind are of interest for a broad user community whose needs in terms of visual information can be readily characterised.



A combination of improvisational dance and yoga sequences performed by dancer-choreographer Gretchen Schiller ranged from simple walk cycles up to full range body motions, and from subtle weight transfer sequences to high-amplitude gestures. Certain movement sequences related to the Laban kinesphere using standing position as a referential, and the dancer's upper body structured improvisation tended to focus on shaping and gouging space through movement. Fast and sustained gesture, and emphasis on the points and ways of initiating movement, were core to the session.



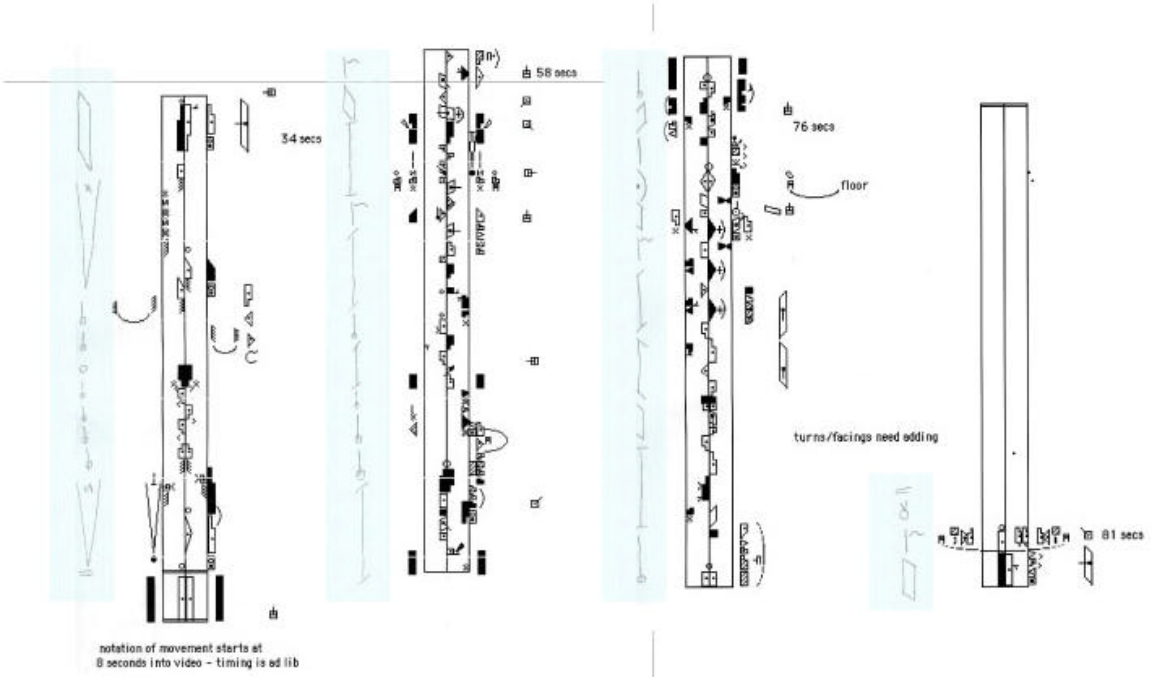
Conductor Peter Wiegold recorded gestures used in contexts ranging from symphonic orchestras to small improvisation ensembles. Beat dynamics as a function of scores and styles (e.g. Mozart versus Beethoven) were recorded for a given musical command such as "cut-off". Because Peter does not use a baton, expressivity of hand movements is particularly important and again, as was the case for the earlier violin capture session, appropriateness of the capture system and of the standard marker emplacement template was challenged. Sequences were recorded with "imaginary" music and with an accompanying recording of a symphonic work Peter had conducted, triggering discussion about the ways the capture data was recorded and reviewed under these different circumstances. Of particular interest was the hybrid nature of the conductor's gesture, which is both subjectively expressive, conveying a musician's interpretation of a score, and at the same time strongly socially inflected as a directive system. These characteristics make a conductor's gesture potentially interesting for a wide range of movement specialists in the performing arts and in social interaction. In turn, cross-sector interest of this kind places particular demands on how data is captured, rendered and annotated for future users, offering rich subject matter for human gesture-focused e-science work.

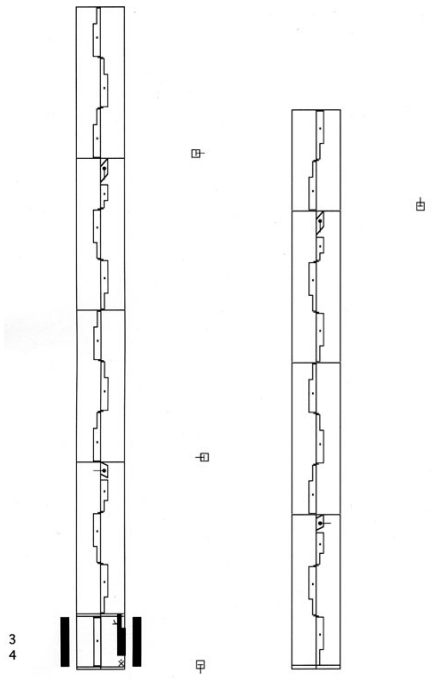


A session was devoted to capturing different kinds of interaction between Gretchen Schiller and Peter Wiegold. From the obvious starting point which consisted of "conducting" dance, the session proceeded to explore ways of avoiding reciprocal mirroring and simplistic mappings in responsive, gestural dialogue-type situations. Musician John Ferguson, specialised in improvisatory techniques, joined the session and played guitar to add a further layer to the interaction. Relations between the musician, conductor and dancer rapidly acquired exciting fluidity and complexity, with shifts in steer of improvisation architecture (music ranging from accompaniment to dramaturgical interaction with the other two performers).

Viewing the motion capture data after the session had a disinhibiting effect, and the relatively abstract trajectories reflected - and encouraged - types and ranges of gesture that would probably not have been inspired by realistic film footage. This session raised the question of possibly using capture data as a score for improvising artists, which would in turn place a new set of constraints on indexing. This led to concrete discussion about the design of data annotation and retrieval processes which might accommodate developments of this kind.

Performer-notator Tamara Ashley generated a set of drawings using LabanWriter software, to provide an alternative reading or transcription of capture data from Gretchen Schiller's improvisational dance sequences. The graphs below show an example of an 81 second session, noted using both Laban and Benesh notation systems: Benesh notation is written by hand on the left in the light blue boxes, and Laban notation is shown on the right. The drawings, which should be read from bottom to top and from left to right, show the difference in levels of abstraction and expression between the two systems. Benesh tends to be used to represent general expressions without giving details of specific motions whereas Laban is used to represent a detailed account of a particular movement sequence. For this reason Benesh is often used to help in the process of choreography whereas Laban is used as an archive for specific performances so that they can be accurately reconstructed. The complexity of this sequence provided a particular challenge to capture, as the movements were non-rhythmic and performed without sound, which can offer a useful time framework for post-performance analysis. A frontal position (with relation to an imagined stage) also had to be assumed.





3.2 Sketch-Based Data Search and Retrieval System

Exploration of the motion capture data base integrating the above-described materials, using the sketch-based search and retrieval system, proceeds as follows:

- The user inputs a sketch using a mouse/pen/on-screen tablet.
- The user can choose which "streams" are searched by means of a filter.
- The user can choose which "indexer" is used (i.e. which features of the data are being searched).
- The user's input is processed by the indexer to find features that can be searched upon.
- A search against the existing (pre-indexed) data set is performed.
- The results are ordered by closeness of match.
- The user can view a video of each match.

Key terms employed for design of the system are as follows:

- sequence -- a motion captured event, e.g. a motion-captured jump and twirl. Can have associated meta information (date/time, marker positions, location, keywords, etc), captured video, etc.
- stream -- a single stream/data channel of information. For example, the 3D coordinates of a single marker over a whole sequence.
- feature -- some aspect of a stream that can be identified, and thus can be used to index on. For example, a rapid change, a peak, or inactivity.
- index -- quick look-ups for features. Required so that the whole of the data does not need to be processed and searched every time.
- indexer -- extracts "features" from a channel so that they can be indexed.
- search -- in combination with some search parameters, performs feature extractors on the input data, and runs a search on the database to find the closest matches.
- "channel synthesizers" -- creates new streams (channels) from one or more existing ones. Existing ones (currently processed off-line): position to "velocity", velocity to "acceleration". Future ideas include: multiple position to "symmetry", multiple positions to "potential energy", a history of movements to "excitement", etc.

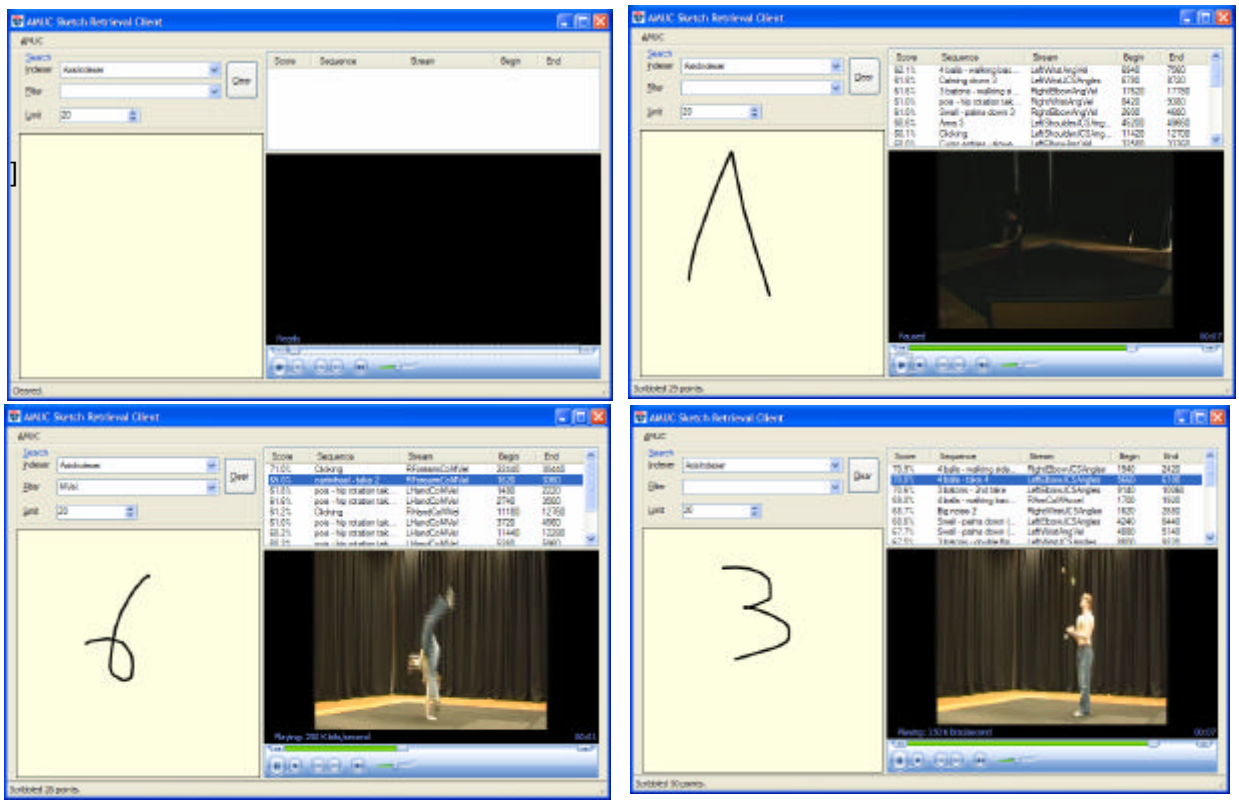
Searching in the proposed system consists firstly of identifying a meaningful channel of data and secondly of identifying “features” in the input and mapping them to “features” in the dataset, where useful channels of data may include position, velocity, acceleration, symmetry, potential energy, “excitement”, etc. Features are identified by the indexer which detects, for example, a rapid change, a peak, or inactivity. Indexes allow quick feature searches, so that the whole of the data need not be processed and searched for each enquiry.

Data flow:

- Sequence -> Indexers* (extracts features) -> INDEX
- Sketch input -> (filtered to remove noise) -> Indexer (extracts features) -> Matching algorithm** (produces RESULTS) <- INDEX

(* The indexer is selected by the user)
(** Matching algorithm takes a filter parameter to select the channels)

Screenshots



While the indexers necessarily remain somewhat coarse with respect to retrieval functions in this prototype tool, they are offered as initial examples of descriptors that can be applied to a motion capture database, and as a starting point for more refined indexation systems which might build on composite functions, integrating conjunctions into query formulation, or on cumulated search findings via use of previous matching history data. The main virtue of the proposed system is that it polarises attention on the ways one might attribute features to elements in a database and the ways one might formulate queries to retrieve elements from that database. When questions are posed in an open, abstract manner, it is hard for non-initiated users to grasp their implications. On the other hand, in the eminently practicable AMUC environment, the possibility of launching queries and displaying results prompted constructive approaches to tuning the system for individual or sector needs.

4. Achievements

4.1 Coupling of Conceptual and Pragmatic Work

Achievements can be seen schematically to involve two tightly interwoven areas of activity:

- articulation of a framework for dialogue about human motion data engaging performing arts practitioners and theorists, bioengineers, designers, programmers and Grid specialists;

- implementation of a prototype sketch-based system to retrieve motion capture image sequences from a database, to anchor practice-led discussion and definition of future Grid-based developments.

Both areas of activity were underpinned by a mix of conceptual and pragmatic concerns: the framework for dialogue was based on and developed through practical experimentation acquired during motion capture recording sessions, while invention of the prototype AMUC tool called for a highly creative conceptual approach to data retrieval systems. A longer term research project would be more iterative than was possible here, and would systematically feed interdisciplinary terminological and methodological insights about human motion into the design, testing, and development of a data retrieval tool. Nevertheless, despite the constraints inherent to a six-month pilot project, the project's major achievement can be seen as enhanced understanding of the complexities

of database indexing and querying issues, with particular reference to data pertaining to human motion. By generating highly visual, readily graspable correlations between indexer terms and retrieved motion capture sequences, the string-matching technique proposed by the AMUC tool successfully promoted dialogue between different types of end-users of motion capture data, as well as between the performing arts and computer science research communities.

While the tool's playful simplicity makes it attractive to even the most analytical users (the power to call up live action video sequences through a rough sketch tends to be intriguing), it draws attention to crucial questions of indexation and labeling that determine database usability. During the project, engagement with a sketch-based data retrieval tool that overrides specialist text references was seen to encourage cross-sector exchange and engagement of a broad spectrum of users. Consequently, we consider that this "intuitive" tool opens up perspectives for developing new, shareable approaches to annotation and mappings amongst usually separate user groups.

4.2 Cross-Project/ Interdisciplinary Communication Methods

One of the project's achievements was its use of a cross-project communications and organizational system, set up in the form of a wiki which ensured availability of working materials for the overall team. In addition to initial background information, materials notably included resources generated during motion capture trials (October 06 – March 07), uploaded to the "Motion Capture Acquisition" work package, and information about Grid database and retrieval tool design, uploaded to the "Grid Infrastructure and Services" work package. There were additional evaluation and dissemination work packages, maintaining overall project visibility. A key resource created on and with the wiki consisted of a set of documents describing work methods for distinctive core tasks. These documents enhanced collective understanding of the constraints, requirements and metadata for these activities:

- The technician responsible for digital imaging drew up an overview document explaining the Vicon motion capture equipment configuration and calibration, showing links between marker/ trajectory data and parallel reference video recordings, and providing details of pipeline operations preceding batch exportation to create input files for each sequence, automatically labeled with all metadata input during the capture process.

- The bioengineering research associate produced sample files of marker and modeling data, together with an overview document providing details of the steps necessary to ensure biomechanics processing of capture data, using the Vicon workstation and macros from the associated Bodybuilder script.

- The Grid specialist defined a storage interface for all elements of the system, including indexing processes to perform feature extractions on stored motion capture data, possibly via multiple "back end" computers with a technology such as GRID-SAM (Grid Submission & Monitoring Service: http://gridsam.sourceforge.net/2.0.1/index.html) or proprietary infrastructure such as the Sun GRID Engine (http://gridengine.sunsource.net/)

- The computer scientists documented research ranging from initial motion capture file parsing to review of database storage requirements, proposal of a web-based video retrieval system, investigation of feature recognition software functions, and exploration of various sketch-based input methods. Retrieval tool design, written in C# on the .NET framework, and principles underlying string matches, limit and cutoff fields are explained.

- The RA who coordinated humanities input and set up the wiki created project overviews for internal and external communications purposes, based on collated updates of activities from the different work packages, drawing on his experience testing software and interface prototypes, he likewise coordinated and documented the proposed evaluation framework for the demonstrator.

Upon completion of the project, this set of documents provides a valuable overview of activities and a shared resource for planned publications and future funding applications. Additionally, it interestingly mirrors the interdisciplinary investigatory practice implemented for AMUC, providing insights into respective reference environments, methodologies and terminologies that serve as currency for the arts and humanities, bioengineering and computing science collaborators. Through the diversity of the

documents and research languages it integrates, the AMUC wiki stands as a fitting reflection of this unique collaboratory undertaking.

4.3 Evaluation of the Demonstrator to Ground Future Research

Although the highly experimental nature of the AMUC demonstrator ruled out a full scale functional software evaluation, it was possible to carry out a heuristic participatory design based evaluation providing valuable feedback on functionality of the demonstrator software, and a framework for testing its future iterations. Key issues raised during this preliminary evaluation pertained to:

- quality of initial data: because this factor determines effectiveness of an indexer, it would be crucially important in an open Grid-based system where manual motion capture data cleanups may not be as readily performed;

- nomenclature/ terminology for defining queries grounded in multiple disciplinary provenances: in the absence of a common, pre-existing vocabulary, the naming of indexers is a determinant factor for user engagement;

- query input system: the sketch interface provides one input device, which might be enhanced by adding text indexers, physical devices with direct joint articulations, machine vision based techniques, etc.;

- legibility of the algorithmic process matching queries and data: optimal uptake requires user understanding of how queries are represented, and the possibility to gauge accuracy of retrieved data against input queries.

These issues were highlighted as key to future development, subsequent to evaluations performed with a range of users from different research sectors involved in the project, including performing artists, computing scientists, interface designers and Grid computing specialists. Informal experimentation by these stakeholders predictably revealed variations in experience of constraints and areas demanding future research focus. At the same time, however, this evaluation phase provided an additional layer of readily shareable information, pragmatically grounded in use of a single cross-sector tool, about the partners' respective work environments and requirements. Whereas some minor challenges are being solved as part of the finalisation of the demonstrator, many provide a significant endeavour for further research and technical innovation. Consequently, rather than an exhaustive evaluation, the framework established for the prototype was designed to offer the critical context in which development of a full scale future application can be measured.

5. Problems/ Issues

While novel kinds of collaboration are crucial for development of e-science, the creation of a working consensus around distinctive sets of terminologies, methodologies and time frames employed within different disciplinary environments takes time and effort. For AMUC, implementation of a new interdisciplinary community for a six-month project was challenging, requiring management under pressure of complex development processes. Interdependence of work methods usually confined to their respective disciplines can lead to tension as research outputs depend on the meshing of effort, and cultural differences blur one's ability to appreciate work ensured in unfamiliar domains. While this is inherent to any project structured as interrelated components or work packages, it sometimes felt particularly acute in the context of AMUC's time frame and ambitions.

In many ways, problems resulted from the project's high research potential, since frustration chiefly arose from the lack of time to investigate exciting, unprecedented perspectives that emerged throughout the work period. Given the impossibility to explore such avenues, they were carefully monitored and noted as areas for future development. Some of these areas pertain to individual disciplines involved in AMUC, e.g. testing of indexing possibilities specifically formulated from the bioengineering standpoint, or deeper comparison of locomotor languages employed in "socially" expressive gesture like conducting, in the corporeal aesthetics of dance, or in the particular kinds of virtuosity that characterise juggling and acrobatics. In more general terms of Grid implications, the

integration of heterogeneous data and reference systems as a starting point for devising a search and retrieval system challenges the expediently normative data often used in scientific experiments. The latter experiments thus tend to perversely belie the complexity and integrative power on which Grid computing strengths depend. Here again, AMUC provides a valuable counter-example of interest for research areas involving supercomputing and complexity.

On the whole (and this is of course easier to state with hindsight!), the focus on creative practice remained a highly motivating force for the research team. Hands-on experimentation aimed at devising an interdisciplinary, integrative data mining system tended to effectively rally research energies, upstaging disciplinary differences and frustrations. The problems and issues which invariably arise within an innovative, risk-taking environment can be considered as representing a valuable capital of acquired know-how for future interdisciplinary research.

6. Future Work Enabled

Pending identification of an appropriate funded framework for pursuit of this work, investigation opened up by this project can be envisaged along generic and specific technical lines as follows:

6.1 General interdisciplinary research perspectives

- Apply the system to an experimental art-making environment that favours creative retrieval and use of data: situated expressive gesture (e.g. from a rehearsal or performance) might be captured to a Grid enabled data source, and artists might use this material in combination with a Grid service provided by (e.g.) CREST bioengineering experts to select fragments with particular mechanical properties, which might serve to drive some piece of digital art or artifact, or to allow gesture-based search of the activity through sketching. Usage of the tool would thus impact the realm of live creation as opposed/ in addition to being used in the more “static” area of documenting and archiving human movement.
- Enrich interdisciplinary collaboratory activity by harnessing sector-specific search patterns to form part of a broader query/ retrieval environment.
- Constitute a larger data set to perform a thorough evaluation of the system drawing on the preliminary evaluation framework devised for the pilot, in order to constructively challenge the debate underpinning “specific-versus-generic” e-science tools.
- Publish findings in specialist areas corresponding to all disciplines involved, in co-authored mode to ensure interdisciplinary relevance. Current publications projects include articles on technical aspects of the sketch-based query system, on design considerations affecting the creation and uptake of multimodal database navigation systems, on the implications of developing interdisciplinary taxonomies to define and describe human motion, and on comparative readings and mappings of artistic and technical data pertaining to human motion.

6.2 Specific technical developments

- Implement the prototype across the Grid: distribute the database over multiple physical data-stores. Queries can be sent to a single web service that makes requests to each database, collating responses into a single client response. As the data must be run through each indexer, new indexers may need to be published as a web-service either by individuals or via one or more centralized servers, and registered on an indexer database. The data can then be incrementally indexed by each data-store (motion capture uploads planned as a web 2.0 application).
- Develop customisable indexers to enlarge potential uses/ user groups: expose an Application Programming Interface so that new indexers can be authored, allowing an indexer to access one or more data channels and return identified indexable features.
- Refine the tool to exploit deeper biomechanics analysis of the captured data, searching for forces and torques at the joints/ joint coordinate systems, etc., in ways likely to promote dialogue between bioengineering and performing arts researchers.

- Create more complex search patterns through the use of conjunctive queries and previous matching history data.
- Integrate multiple sketch types into the GUI (notation systems, etc), and diversify potential input devices (tablet, touch screen, haptic device, etc).

7. Impact and Benefits to the Arts and Humanities Research Community

The project's impact and benefits stem from its implementation of a novel database search tool, generating cross-sector perspectives amongst stakeholders usually working within terminological and methodological confines of specific disciplines. While AMUC emphasises often underestimated power and transferability of tacit specialist knowledge, equal importance is attached to specialist knowledge and behaviour not readily amenable to interdisciplinary transfer: ostensibly simple features one user needs to extract from a database may be complex or irrelevant for another user. Cultural differences like these must be identified in order to create a genuine collaboratory. AMUC successfully created the prerequisites for such activity by contextualising distinctive working procedures and pragmatically focussing on a cross-sector tool.

The fact that we were able to involve a range of performing arts practices and expressive gestures in order to constitute our initial database heightened relevance of the project for a wider arts community. At the same time, the different levels of ease with which these different kinds of expressive human motion could (or could not) be captured and reproduced made the project more complex than if it had focused on a single or limited repertory of expressive movement. This complexity was all the more appreciable given our wish to challenge reductively generic views of practices, needs, and systems that in reality may be extremely different. Overall, this pilot project opens up original interdisciplinary dialogue on database configuration and exploitation, in ways that are reciprocally challenging and beneficial for a wide array of stakeholders. Dissemination activities have prompted curiosity, enthusiasm and the desire to collaborate in future projects. Thanks to specific Research Council and AHDS activities, the AMUC team appears to be reasonably well identified by the e-science Arts and Humanities community, and is keen to contribute to ongoing e-science discussions and developments.

8. Evidence of Value/ Dissemination Activities

Presentations of the project at various dissemination events have triggered a wide range of responses, including amongst members of the games community targeted by an EPSRC-organised workshop held in November 2006 (cf. infra, "Games and Digital Media"). An AMUC presentation at the Open Grid Forum held in Manchester in May 2007 led to ongoing discussion with Robin Crompton, who analyses locomotor activity in large primates at the Primate Evolution and Morphology Group (Liverpool University), and is interested in Grid-based use of motion capture, notational systems, and the design of dedicated search systems for materials generated from field expeditions [3].

The project has initiated exchange with a range of stakeholders in the international community engaged in motion capture, performing arts and digital technology. These include Vancouver-based motion capture pioneer Tom Calvert, who leads development of Credo Interactive 3D character animation software [4], and Francois-Joseph Lapointe, Montreal-based biologist whose collaboration with dancer Martine Epoque underpins the emergence of a field of "choreogenetics", using genetic algorithms to generate human-computer choreography [5]. It is hoped that future work stemming from this pilot project will allow development of these contacts via reciprocally defined research activities.

Researchers interested in AMUC's proposal of a radically new database search system include partners of the North East Regional e-Science Centre faced with the issues of modelling complex data flows. Dominic Searson, from Newcastle University's School of Chemical Engineering and Advanced Materials, sees the heterogeneous, interdisciplinary materials brought together in the AMUC environment as posing data management challenges which, in terms of their complexity, are usefully akin to those raised by modelling chemical plant processes. Searson's reflection converges with that reported by numerous colleagues who have discovered that the messy, fuzzy heterogeneous data generated by arts and humanities undertakings constitutes a valuable test-bed for e-science

developments insofar as these target the Grid-based integration of multiple kinds of resources for multi-user, multidisciplinary access [6].

Additionally, certain obviously aesthetic aspects of AMUC resources appeal to e-science developers keen to extend Grid computing beyond the realm of "hard" science, as evidenced by publication of an "Image of the Week" feature in the international online journal "International Science Grid This Week" [7], and by positive feedback encountered at the Duke University HASTAC (Humanities, Arts, Science Technologies Advanced Collaboratory) conference [8].

Relevant dissemination events (project-funded) attended during the grant duration are as follows:

- EPSRC-organised workshop on "Games & Digital Media: Value of Collaboration Industry – Science Base". On invitation, an AMUC poster was presented at this London event (11/06), which provided a valuable networking platform.
- HASTAC conference on "Electronic Techtonics: Re-thinking the Interface", Duke University, Durham, April 07. Contacts made include the Open Croquet team at Duke (Julian Lombardi et al) [9], and Allison Clark from the National Center for Supercomputer Applications/ University of Illinois at Urbana-Champaign [10].

Relevant events (non-funded) attended upstream of the grant duration are as follows:

- "All Hands", September 06, Nottingham; posters at AHRC and NEReSC booths (participation in AHRC workshop);
- Digital Resources for the Humanities & the Arts, 09/06, Dartington College (paper) [11].

Relevant events (non-funded) attended downstream of the grant duration are as follows:

- Open Grid Forum, Manchester, 05/07 (presentation at Arts & Humanities session) [12]
- EPSRC-AHRC-JISC end-of-grant workshop, London, 06/07 (presentation)
- JISC Visualisation workshop, EVA, London, 07/07 (presentation) [13]
- AHDS Performing Arts Summer Workshop, 07/07, National e-Science Centre, Edinburgh (presentation) [14].

Further planned dissemination events (non-funded) are as follows:

- "All Hands", Nottingham, 09/07 (poster)

9. Conclusions about e-Science

Grid-enabled activity can create common research ground for very different disciplines and fields of work, promoting new forms of mutually beneficial exchange and collaboration. By focusing specifically on issues of shareable terms and methods in an interdisciplinary environment, AMUC offers a pragmatic platform allowing the performing arts community to co-develop and test potentially Grid-based resources with colleagues from bioengineering and computing science. Under such circumstances, the e-Science context favours a kind and depth of encounter that could not otherwise be envisaged: data mining and tagging questions previously considered by Grid novices as abstract or secondary to their work in fact prove to be critical when they seek to explore resources in which they have powerfully vested interests, including as "prime movers" of motion capture data. Relations between query formulation and mined data are thus made acutely apparent, inciting users to become directly and creatively involved in data labeling alongside their scientific colleagues. Working across an e-science initiative thus opens up possibilities for interdisciplinary exchange and sharing of work methods: ways of describing and recording events that tend to remain tacit knowledge amongst artists may keenly interest and inspire their scientific counterparts, whose approaches may in turn elucidate and inspire new research avenues for arts and humanities practitioners and theorists.

In light of this experience, e-science appears uniquely as an arena for seeding collaborative behaviours and inhabiting research with "living specifications" (Atkins). Contrary to activity focused on tool and technology development, supercomputing capacity and information pipelines, arts and humanities e-science emphasises cultural factors determinant in the shaping of distributed, interdisciplinary patterns of dialogue that are spearheading today's and tomorrow's research.

Notes

1. Generic motion capture libraries include the 1650-trial resource established by Carnegie-Mellon University http://mocap.cs.cmu.edu/. Motion capture equipment suppliers often build accompanying libraries; cf. for example http://www.animazoo.com/bvh/.

2. Atkins' keynote at the 2006 UK National "All Hands" e-science conference, http://www.nesc.ac.uk/talks/ahm2006/keynote3.pdf

3. http://www.liv.ac.uk/premog/

4. http://www.siat.sfu.ca/faculty/tom_calvert; http://www.charactermotion.com/

5. http://www.informatik.uni-trier.de/~ley/db/indices/a-tree/l/Lapointe:Fran=ccedil=ois=Joseph.html

6. "Whereas scientific data tends to be large scale, homogeneous, numeric, and generated (or collected/ sampled) automatically, humanities data has a tendency to be fuzzy, small scale, heterogeneous, of varying quality, and transcribed by human researchers: making humanities data difficult (and different) to deal with computationally. However, ascertaining how large scale processing of this type of data can be undertaken will be useful for computer science (…)." Melissa Terras, ReACH: Researching – Science Analysis of Census Holdings, AHRC Arts and Humanities e-Science Workshop Series, Project Report, http://www.ucl.ac.uk/reach/

7. http://www.isgtw.org/?pid=1000424, "Running AMUC: Motion Capture on the Grid"

8. http://www.hastac.org/informationyear/conference

9. http://croquetconsortium.org/index.php/Main_Page

10. Head of Digital Equity Initiatives at the National Center for Supercomputing Applications, Clark was HASTAC session chair and participant at the 2006 OGF Arts & Humanities Workshop (cf. infra).

11. Cf. Norman, S.J., "Generic Versus Idiosyncratic Expression in Live Performance Using Digital Tools", Performance Research, Volume 11, No.4, December 2006, pp.23-29.

12. OGF report, Issue 50, NeSC News, p.3 http://www.nesc.ac.uk/news/newsletter/May07.pdf

13. Workshop on "New Directions in e-Science and Visual Perceptions", http://www.eva-conferences.com/eva_london/workshop_6

14. http://wiki.esi.ac.uk/Digital_Representations_of_Performing_Arts