No. 2

‘Choreography from Bits and Bytes: Motion Capture, Animation and Software for Making Dances’

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In November 1999, I received an invitation from Armando Menicacci and Emanuele Quinz to write a chapter for a new book they were planning on the theme of digital technologies and dance. I had given a presentation on motion capture and dance projects for them at the ‘Bolzano Dance Festival’ in June 1999 coinciding with using materials collected during my work on the ‘Digital Theatre: an Experimentarium’ project.[1] They accepted my proposal to develop that talk into a paper, only requesting that I develop some of my “thoughts on the machine/body interface issue.”[2] Other authors in this book include: Thecla Schiphorst, Mark Coniglio, Paul Kaiser, Stelarc, Kitsou Dubois, Susanne Kozel, Michel Bernard and Bojana Kunst.

[1] Documentation website: http://www.daimi.au.dk/~sdela/dte/ (accessed 7 May 2010).
[2] Email to the author, 3 Nov 1999.

Choreographing in Bits and Bytes:

motion capture, animation and software for making dances

(This is the pre-translation English version as submitted for publication in January 2000. Illustrations in and the referencing system of the published Italian version are used.)

Abstract:

The video camera has, since the early 1980s, become a ubiquitous tool for choreographers. It is used as part of the creative process, to document and preserve dances and to record video dance that is made solely for the screen. In the last few years, dance artists have increasingly begun to make use of a new imaging technology known as Motion Capture. Motion Capture refers to the electronic hardware and computer software that makes possible the digital 3-D representation of recorded moving bodies. This article covers some of the history of Motion Capture technology as well as the work of several dance and multimedia artists who are using it in their work. It will also make some speculations about how Motion Capture, just as video before it, may in the future move into common usage by dance artists.

Introduction

Motion Capture refers to the computer hardware and software that makes possible recorded digital 3-D representation of moving bodies. Recording sessions involve the placement of markers or sensors on strategic positions on the body that provide the basic information for the computer software. The expense of these systems, which includes the cost of the equipment as well as the expertise to run it, is enormous with developments being driven primarily by those industries such as medical, military, entertainment and advertising that have the necessary capital.

These costs, combined with a basic distrust in 'technology', resulted in little interesting artistic work being done within the dance field until recently through the efforts of a small but determined artistic vanguard of dance and digital artist collaborators. This includes Paul Kaiser and Shelley Eshkar working with Merce Cunningham and Bill T. Jones (USA); Kirk Woolford with Susan Kozel (UK); Bruno Martelli with Ruth Gibson (UK), Yvonne Fontijn with Karin Post and Michael Schumacher (NL); Richard Lord with Christian Hogue (UK); Sally Jane Norman (FR); Dorte Persson (DK); etc.

Making the Invisible Visible: Scientific Progress in the 19th Century

Most accounts of the history of motion capture refer to the work of Etienne-Jules Marey and Eadweard Muybridge. Both men were late 19th century pioneers in the recording and analysis of movement, and both men are credited with having contributed greatly to the evolution of photographic techniques that led to the invention of cinema. However, as Marta Braun proposes in her book on Etienne-Jules Marey titled *Picturing Time*, the enormous differences between Marey's photographic study of locomotion and Muybridge's has not been fully appreciated.[1] Before Braun's book no full account of the impact of Marey's work had been published, and she persuasively argues for a fuller recognition of the influence his work has had in particular on the developing 19th century science of physiology.

Etienne-Jules Marey began studying medicine in Paris in 1849 at a time when the study of physiology was about to emerge as a science in its own right. According to Braun, amongst the many reasons for this was the "assimilation of physics and chemistry as explanatory models for physiological processses".[2]

N.B. all footnote websites cited accessible as of January 2000.

1 Marta Braun. *Picturing Time: The Work of Etienne-Jules Marey (1830-1904)*. Chicago, IL: University of Chicago Press, 1994.

2 Ibid. p. 9.

Marey's theory of physiology was that the body was an "animate machine" whose motion would be subject to the universal laws of physics that might be applied to any moving object (animate or inanimate). He set out to prove this firstly by inventing a series of graph-making instruments in the late 1850s. With these instruments he was able to monitor movements invisible to the human eye and make them visible by tracing them onto a "smoke-blackened cylinder". Marey fabricated an extensive array of mechanical recording devices which not only involved inventing the tracing mechanism, but also the creation and placement of various movement trackers and sensors.

(See **Illustration** in the published Italian version. Thesis Page 395 Figure No. 10: Illustration of Marey's bird apparatus)

Amongst these instruments was an apparatus built to register the trajectory of the wing of a bird in free flight, a device which would register the up and down and back and forth movements of the wings simultaneously. It "could transmit to a distance any movement whatever and register it on a plane surface".[3] These and other studies of bird flight were important to the foundation of aviation in Europe and America.

By the late 1800s, Marey had begun to use the camera in his scientific studies of human and animal locomotion, slowly replacing his mechanical graphing instruments. Still, technological invention would continue to be an essential feature of Marey's work, and eventually he was to develop a motion picture camera (the precursor to the commercial motion pictures) to allow him to further refine his studies.

[3] Etienne-Jules Marey quoted in Braun. *Picturing Time: The Work of Etienne-Jules Marey (1830-1904)*. p. 35.

Throughout the 20th century animation artists would study images of movement made by Marey and Muybridge because of the details and deconstruction of motion that could be derived from them. However, in the last two decades and this one in particular, computer animation techniques have evolved to the point of practically replacing hand drawn animation skills - in particular when it comes to creating human motion. Since the early 1980s, animators have been using software based systems capable of simulating human and animal locomotion. It is in this software that we can also discover the influence of Etienne-Jules Marey. His scientific work contributed to the discovery of the laws governing physiological processes - as expressed in mathematics. Some of these mathematical expressions are used in the underlying algorithms in today's computer animation and movement analysis software programs.

For example, take *SIMM* (Software for Interactive Musculoskeletal Modeling), a software system that allows one to create and analyze graphics-based models of the human musculoskeletal system.[4] The software is designed to be used by biomechanic researchers, neuroscientists, kinesiologists, biologists, computer scientists, human factors engineers and animators. Embedded in its complex "knowledge based systems" (software which uses biomechanical information about how the human body behaves in motion) are mathematical equations derived from the laws of physics as they apply to human movement. Some of these equations have their origins in 19th century research of physiologists/ scientists like Marey.[5]

Motion Capture and Simulation in the 20th Century

Some early 20th century animation artists did rely on a type of 'motion capture' known as rotoscoping in which "photographed motion was used as a template for

4 *SIMM* (Software for Interactive Musculoskeletal Modeling) http://www.musculographics.com/.
5 For a brief description of 'knowledge based systems' see Wes Trager's online article entitled: 'A Practical Approach to Motion Capture: Acclaim's optical motion capture system' prepared for SIGGRAPH 94.
http://old.cs.gsu.edu/materials/HyperGraph/animation/character_animation/motion_capture/motion_optical.htm

the artist/animator who traced individual frames of film to create individual frames of drawn animation".[6] One often cited example where this method was used is the Disney film *Snow White* produced in 1937. Rotoscopy was used wherever a more 'human-like' as opposed to cartoon-like rendering of human movement was desired.

In the early 1960s, Boeing Airplane designers built the first graphical digital simulation environment for trying out takeoffs and landings. They also created the first digital human to use in testing out pilot movement in the cockpit. However, it would be another twenty years before biomechanics laboratories had enough computing hardware power to build the more sophisticated software systems for simulating human movement that began to make their way into the computer graphics community. These software systems would be 'knowledge based' as mentioned above - utilizing some of the mathematical expressions of the physical laws of nature searched for by Marey. Out of these developments emerged two powerful software tools for modelling or animating human movement in computer graphics environments. These were the practice of using a skeleton to control a 3-D character and inverse kinematics. "Inverse kinematics was a great breakthrough for 3D character animation, providing a 'goal-directed' approach to animating a character. It allows the artist to control a 3D character's limbs by treating them as a mechanical linkage, or kinematic chain".[7]

In the early 1980s, the MIT Architecture Machine Group and the New York Institute of Technology Computer Graphics Lab experimented with optical tracking of the human body.[8] Again, the limitations of computer hardware at that time prevented

[6] Wes Trager. ‘A Practical Approach to Motion Capture: Acclaim's optical motion capture system’. SIGGRAPH 94. http://old.cs.gsu.edu/materials/HyperGraph/animation/character_animation/motion_capture/motion_optical.htm

[7] Wes Trager. ‘A Practical Approach to Motion Capture: Acclaim's optical motion capture system’. SIGGRAPH 94. http://old.cs.gsu.edu/materials/HyperGraph/animation/character_animation/motion_capture/motion_optical.htm

[8] David J. Sturman. ‘A Brief History of Motion Capture for Computer Character Animation’. SIGGRAPH 94.

certain developments the software engineers knew would be possible eventually. Towards the end of the 1980's, Motion Capture as we think of it today began to appear: as a sophisticated means for recording the motion of objects, usually human or animal, playing back this motion in a 3-D digital space and allowing that motion to drive a variety of animated forms both human and non-human. Rotoscopy in 3-D without the laborious task of human hands tracing movement.

Over the next five to six years the rapid growth of Motion Capture technologies would be spurred on as much by the commercial entertainment industry as it had been since the 60s by medical, scientific and industry research. Today, Motion Capture is considered a viable option for computer animation production with current developments moving in the direction of more affordable animation programs and camera based capture systems which will utilize sophisticated machine and computer vision software (software which can simulate the way the human eye sees depth and movement). I will return later to make some predictions about the possible use of these cheaper, more available systems in the dance field.

Types of Motion Capture for Dance Artists

There are a range of different input devices which have been developed for recording the position of selected points on the moving body and making this information available to the computer software, e.g. prosthetic, acoustic, magnetic and optical.[9] For the purposes of this article, I am only going to discuss magnetic and optical systems in the context of several different motion capture projects involving dance artists. I will avoid providing overly technical details, a fair amount of which is available on the internet. Comparison figures on motion capture technologies that are best for dance artists are not easy to come by. Each system

http://old.cs.gsu.edu/materials/HyperGraph/animation/character_animation/motion_capture/history1.htm

9 For a brief description of these systems see Wes Trager's 'A Practical Approach to Motion Capture: Acclaim's optical motion capture system'. SIGGRAPH 94. http://old.cs.gsu.edu/materials/HyperGraph/animation/character_animation/motion_capture/motion_optical.htm

vendor will tell you their system is the best and very technical information is impossible to interpret without specialists. Those interested in beginning to experiment with some of these technologies might be advised to attempt to contact some of the dance artists I have written about here.

(See **Illustration** in the published Italian version: Thesis Page 395 Figure No. 11: magnetic motion capture system being used by a dancer)

Briefly, magnetic motion capture involves the use of a centrally located transmitter that emits a strong magnetic field and a set of sensors that are attached to various parts of the dancer's body. Each of these sensors provides a data stream that consists of 3-D positions and orientations for the sensor. Some magnetic systems have wires running from each sensor almost all the way to the computer (e.g. Polhemus Flock of Birds). Other systems are wireless and use radio transmitters and receivers to send the data to the computer (e.g. Ascension MotionStar Wireless). The wireless systems provide a greater possibility for unencumbered movement in the space - but one is still limited by the size of the magnetic capture field that may be only a few meters in diameter. Magnetic motion capture will provide a large quantity of uninterrupted motion capture data which does create the possibility of working with it in real-time in a performance context - in other words you can see the animation being driven by the dancer who is wearing the sensors (for a related artist's project see Susan Kozel's *Figments* described later).

Optical motion capture systems work with the use of directionally reflective balls or markers placed at strategic points on the dancer. These systems require at least three cameras and often use more. Optical systems can offer the dancer the most freedom of movement since they do not require any cabling. However, they have the drawback of suffering from 'occlusion', which is what happens when a reflector is lost or hidden from the viewpoint of the camera. This results in a gap in the data stream that the software repairs using tracking algorithms that can make the interpolation across the missing section in the movement. These algorithms are extremely complex and are based on an understanding of how the human skeleton behaves - once again knowledge derived from the science of physiology.

Because of 'occlusion', optical systems tend not to provide the same real-time possibilities for using motion capture as the magnetic, but this is changing as computers become increasingly more powerful. Optical systems do have the reputation of being able to provide the most accurate motion capture data or representation of human movement through the use of a large number of reflectors. This is one of the reasons Paul Kaiser and Shelley Eshkar of Riverbed used it in their motion capture projects with Merce Cunningham and Bill T. Jones.

Before I start to elaborate on some specific projects involving dance artists and motion capture, I will just briefly mention here some of the hardware and software systems they have used. Ascension and Polhemus produce wired and wireless magnetic systems; Vicon and Qualisys build and market optical systems. Three of the industry leaders for animation software specifically engineered to work with motion capture data are Maya, Softimage and 3-D Studio Max. These names will appear again and links for these and other companies are provided in the Appendix.

Workshops and Laboratories

The dance field suffers from the difficulty of gaining access to the human and equipment facilities necessary to explore the possibilities of some of the emerging technologies. Motion Capture, being one of the most interesting for dance, is no exception as it is very expensive and requires software specialists. Because of this, the context for experimentation with technologies usually needs to be formally organized and the necessary funds obtained. I would like to mention some of the workshop/ laboratory style events that have been organized to give dance artists access to motion capture. Out of these projects has evolved a wider basis of expertise and knowledge about the potential for these technologies as well as a commitment to explore the possibilities further.

Digital Dancing was a one to three-week workshop organized in London each autumn from 1994-1998 by Terry Braun of Illuminations.[10] For some of those years, Braun was able to provide access to motion capture technologies that were explored in the workshops by Ruth Gibson and Bruno Martelli (a choreographer/ multimedia artist partnership), by Richard Lord (choreographer), and Susan Kozel (choreographer and scholar).

In September 1996, the Theatre Lantaren-Venster in Rotterdam organized the *Cyberstudio* in collaboration with Motek, an Amsterdam based commercial motion capture house.[11] This workshop brought dance and digital animation artists together to explore the possibilities for motion capture technologies. Motek contributed both equipment and computer specialists.

Real Gestures/ Virtual Environments was a two-week laboratory organized by Sally Jane Norman in August 1998 to take place in two phases - firstly at the International Institute of Puppetry in Charleville-Mézières, France and secondly at the Zentrum fur Kunst und Medientechnologie (ZKM) in Karlsruhe, Germany.[12] This project was designed to investigate interrelationships between traditional puppetry and digital animation and utilized motion capture systems.

From February to May 1999, the *Digital Theatre Experimentarium*, a project I was

10 Terry Braun, Illuminations/ Braunarts. http://www.braunarts.com/; Digital Dancing Websites. http://www.braunarts.com/digidancing/

11 Future Moves/ Cyberstudio Website. http://www.ipr.nl/~future-moves/ Motek Website. http://www.motek.nl

12 The Centre for Art and Media Technology (ZKM), Karlsruhe. http://www.zkm.de/

involved in, took place at the University of Aarhus, Denmark.[13] Throughout February and March several seminars and workshops were organized to explore the theatrical potential of Motion Capture, Computer Animation and Projection Technologies. Performers and digital artists Yvonne Fontijn, Susan Kozel, Paul Kaiser and Shelley Eshkar were consulted and invited to contribute to the seminars. An Ascension Motion Star Wireless system with seven sensors, on loan from the former Denmark Lego Wizard Group, was used with the Maya computer animation software program.

The research goals of the Experimentarium were:

- To experiment with what to capture and how (e.g., body parts, different kinds of movement, children, etc.)
- To take the motion capture data and experiment in the animation program with human and non-human representations
- To investigate live performance interaction with projected motion capture - both in real-time and postproduction [meaning pre-recorded]
- To use the motion capture data to work outside of the animation program to drive other effects (e.g., sound)
- To reflect on assumptions about movement, time and space - actual and software based

During the month of May, two projects were followed to completion and public presentations given. One of these was a dance piece that attempted to integrate on a single stage live performers with post-production motion capture animations. A month is only enough time to experiment with a possible process for achieving this.

The first step in the process was for the choreographer to create movement material that could be captured. Experiments were set up to discover what would work best

13 Digital Theatre Experimentarium. http://www.daimi.au.dk/~sdela/dte

using the magnetic system and Maya. Based on what was discovered, several minutes of movement material was choreographed and motion captured. Because there were only seven sensors, all of the material was captured twice, once with the sensors placed on the upper torso (head, shoulders, elbows, wrists) and once again with the sensors placed on the lower part of the body (three moving down the spine, the knees and ankles). The two data sets were then assembled together, one on top of the other, using Maya's hierarchical skeletal system and inverse kinematics (both these software tools are 'knowledge based' and mentioned earlier).

(See **Illustration** in the published Italian version: Thesis Page 396 Figure No. 12: basic skeleton with 14 sensor points)

Once the motion capture data was assembled and cleaned up in Maya, the search for an appropriate form (sometimes referred to as skin or geometry) was begun. Experiments ranged from extremely abstract forms to more human-like. In the end, a form was chosen which gave the smallest indication of where the head, hands and feet were. It is worth noting here that much of this process was conducted via the internet. The animation artist would come up with suggestions and email them to the choreographer. There are several stages in the early animation process when the motion capture data combined with the hierarchical skeleton system is still relatively small and can quite easily be emailed back and forth.

(See **Illustration** in the published Italian version: Thesis Page 396 Figure No. 13: scenographic design of the space)

The scenographic design of the space was developed with the assistance of Italian projection artist Luca Ruzza. A design was conceived using both front and rear projections in order to give the animations a three dimensional quality. Using two 3.5 x 4 meter pieces of Altoglass in the back for rear projection and a large single piece of Trevira, a transparent net material which catches the projection, for the front projections we were able to create a 3 meter corridor between the two projection areas where the dancers could work. The animation projections were synchronized so that action on one screen would have choreographed consequences on the others.

Many discoveries were made during this final part of the Digital Theatre Experimentarium - especially about the difference in time scale between animation and live performance production processes. This difference in scale resulted in a situation where the fully rendered animations were not available to be seen in the space until the final day - therefore making it practically impossible to integrate it with the live material. It would also have worked better to involve animators and choreographers together on site for much more of the time. Computer animation artists are quite used to working remotely on commercial animation projects, but in this case the abstract demands of the choreographer were impossible to convey via standard storyboarding or other means. In the end, only a couple of minutes of the original motion captured material were utilized, but it was used repeatedly from different perspectives - not only from sides, back and front, but also from the impossible perspectives from above and below (a benefit of 'choreographing' in digital space).

Artistic Projects

Workshops and laboratories are important contexts for discovery and learning, but they rarely result in compelling artistic work for two reasons. Firstly, they are usually not long enough and secondly, they often bring together collaborators (dance and digital artists) for the first time. The projects I am going to share with you now come under the category of "artistic projects", as they involve ongoing collaborations and longer working processes. Each has also achieved, in my opinion, an important 'artistic' as different from 'research', result. That said, I have chosen not to report in very much depth on the aesthetic implications of each work, a fact that may disappoint any readers searching for this type of discourse. I have focused rather on some of the practical aspects of the work as well as relationships that interest me in my own research into the different systems of knowledge production.

Software kinesthetics: the convergence between choreography and robotics

Two of the most interesting recent works were created by Riverbed, the digital arts partnership of Paul Kaiser and Shelley Eshkar.[14] Their project with Merce Cunningham, titled *Hand Drawn Spaces*, premiered as a 4 minute film installation at the international graphics trade show SIGGRAPH in July 1998. *Ghostcatching* with movement captured from Bill T. Jones, premiered as an 8.5 minute film installation at the Cooper Union in New York City in January 1999. Both of these works also helped to bring a new level of visibility to dance and technology projects generally.

(See **Illustration** in the published Italian version: Thesis Page 396 Figure No. 14: still image from *Hand Drawn Spaces* by Merce Cunningham and Riverbed)

For *Hand Drawn Spaces*, Cunningham choreographed and motion captured 71 short phrases. The animation mapped onto this data had a hand drawn appearance, hence the name. The selection and joining together of the sequence of the recorded phrases was done with the help of new animation software developed specifically for the project titled the 'motion flow editor'. For Riverbed's work with Bill T. Jones, the challenge was partly to 'test' the potential for the motion capture technology to record the personal movement subtleties of a particular and unique dancer.

As Paul Kaiser is also contributing to this book I am going to limit my report on both of these projects – in anticipation that he will cover this in more detail. If not, the

[14] Riverbed Website. http://www.riverbed.com

Riverbed website is a rich source for information about their work (see Appendix).

Working with Riverbed in refining the animation software for their projects with Merce Cunningham and Bill T. Jones were computer animation innovators and artists Michael Girard and Susan Amkraut. In an interview with Paul Kaiser, they discussed the evolution of some of their groundbreaking animation work. In the 1980s, Girard was one of the first to introduce gravitational dynamics into the computer animation process. Prior to this, computer animators had focused on developing software solutions that would "imitate what traditional animators do - that is, to come up with a set of keyframes and then interpolate what comes in between."[15] Girard was one of the first to realize that physically-based (or 'knowledge based') software solutions could better imitate what the human animator drawing in-between the keyframes had always known intuitively about human movement and physiology.

Girard and Amkraut became less concerned with how their animations looked and more concerned with how they actually functioned in movement terms. One of the fields they investigated to find the physically based algorithms that could be used in computer animation was robotics. Robotics engineers are more interested in the autonomous locomotion of their robots than in their appearance. "We were fortunate that Ohio State University had one of the premier programs on walking and running machines in the country. Marc Raibert's work on running machines was particularly amazing. Some of the same algorithms used for making robots walk and run could also be used in computer animation, especially the crucial notion of inverse kinematics."[16]

[15] Michael Girard in an interview with Paul Kaiser, published online. http://www.riverbed.com/ (look under 'Conversations' and 'Unreal Pictures')
[16] Michael Girard in an interview with Paul Kaiser, published online. http://www.riverbed.com/ (look under 'Conversations' and 'Unreal Pictures')

(See **Illustration** in the published Italian version: Thesis Page 397 Figure No. 15: image of 'spring turkey' robot from MIT LegLab under direction of Marc Raibert)

The refinements Michael Girard and Susan Amkraut brought to the Riverbed dance projects focused on the development of the Motion Flow Network. The Motion Flow Network was an innovation that allowed for one motion captured dance phrase to connect to another. The computer software used physically based gait shifting algorithms (derived from robotics) amongst others to make a smooth interpolation between the two phrases. Here again we see mathematical equations, some of which are the offspring of innovations and discoveries from the end of last century, being used to provide contemporary computer software solutions. In this case, it's a poetic convergence - knowledge of human movement derived from the investigations of a century ago, used in computer software designed to move 20th century robots, and eventually participating in the choreography of a digital dance project.

Shifts of Time: Dancing with your 'in between'

Susan Kozel and Kirk Woolford form the company MESH Performance Partnerships. Kozel, a dancer, choreographer and scholar, has been exploring dance and technology overlaps in her work for several years. Woolford is a visual artist and computer programmer who has collaborated before on dance and technology projects. Their recent work together, *Figments*, uses motion capture technologies and computer animation in a unique way. *Figments* involves the performance of a live dancer wearing several motion capture sensors (a combination of magnetic and ultrasonic systems). The position and orientation of these sensors is displayed in real-time on a screen animating a very simple stick figure. Also projected on the screen is a pre-recorded sequence using the same data points and simple stick figure. Between these two figures a third body/ figure is created by the computer software - referred to by Kozel as the 'virtual body' - which is a modulation between the real-time movement and the pre-recorded sequence. Kozel, the dancer in the work, discovered that this 'virtual body' - computationally generated as something 'in between' herself in the past and herself in the present - at times took on the quality of another sentient being.[17]

(See **Illustration** in the published Italian version: Thesis Page 397 Figure No. 17: the performer Susan Kozel an *Figments*, MESH Performance Partnerships)

Data Driven: human movement in non-human forms

Yvonne Fontijn and Dutch choreographer Karin Post have been collaborating on motion capture and animation projects for a few years now. Fontijn works as an animation artist for Motek, an Amsterdam based commercial motion capture house (mentioned earlier). This affords her unique access to the technologies necessary for her projects and gives her the opportunity to experiment and explore over a longer period of time. She uses both optical as well as magnetic motion capture systems and the Softimage computer graphics program. Approximately two and a half years ago, they did a motion capture session in which the movement of the torso and arms was captured from one dancer (Karin Post) and the movement of the pelvis and legs from a tap dancer.

This data sat stored in the computer for several months before Fontijn decided to use it in creating an animation film installation entitled *Upper/ Lower* for the *Traces of Science in Art* exhibition at Het Trippenhuis in Amsterdam in late Spring 1998. In order to get as far away from the representation of a human figure as possible while still retaining the special movement quality of motion capture… she superimposed the upper torso from Post directly on top of the lower half from the tap dancer.

17 Susan Kozel and Kirk Woolford. 'Utterance 5: Mesh Performance Partnerships'. On Line: Performance Research. Vol. 4: No. 2, Summer 1999. p.61.

What you see in the mesmerizing animation is a series of abstract shapes, which are animated with human movement. Once you are informed that it has been motion captured, it is possible to identify in the shifting forms the occasional and recognizable rhythm of the tap dancer's feet. If uninformed, one sees the film as an animation with highly organic movement - the source of which would be difficult to determine.

Catching Time: from ephemerality to solid form

In Denmark, choreographer and performer Dorte Persson heard an interview on the radio with a new commercial motion capture facility in Copenhagen.[18] She contacted them and offered an exchange – motion capture data (herself dancing) that they could use in animation work for assistance on an artistic project she had in mind. Using one of their magnetic motion capture systems with 14 sensors, Persson improvised and captured several sections of movement. Working ONLY with the movement trajectories of each sensor, she selected a 2.5 minute piece of movement from the sensor on her left foot and a 10 second piece from the sensor on her right hand.[19] Still working only with the trajectories of the movement, she had a representation of the pathways the sensors had travelled in three dimensions created in the animation software (3-D Studio Max). The intention was to meld these trajectories into a three dimensional sculpture out of solid aluminium piping (1.2 cm in diameter).

(See **Illustration** in the published Italian version: Thesis Page 397 Figure No. 16: image of the sculpture from Dorte Persson)

Originally, it was hoped that a machine (such as those used for making furniture) linked to the computer could be used to meld the aluminium into the 3-D form

18 Mocap Copenhagen. http://www.mocap.dk
19 For a videoclip sample of the 10 second trajectory of the right hand see Dorte Persson's website at http://www.koreograf.dk

directly from the digital data. However, these machines were not flexible enough to conform to the complexity of Persson's captured movement pathways. Eventually, it was necessary to print out several viewpoints of the sculpture on blueprint forms and take them to a jewellery craftsman who had the proper tools and skills to create the sculpture by hand. The 2.5 minute movement section used up approximately 80 meters of the aluminium piping.

Persson's title for the work is *Moments of Invisibility* that appropriately captures the essence of the piece. It was exhibited at the Art Crash Festival in Aarhus, Denmark in May 1999 and since then at the Modern Art Museum in Brandts Klædefabrik, Denmark. A simple concept, it elegantly illustrates some of the potential of motion capture technologies for dance artists. By making solid both the ephemeral qualities of dance and digital imagery, *Moments of Invisibility* captures time and brings an articulate fourth dimension to the three dimensions of visual phenomenon. In so doing, this work resonates with the work of Etienne-Jules Marey who also spatialized time with his graphic instruments and cameras in his pursuit of the understanding of movement.

Future of Motion Capture

The workshops/ laboratories and artistic projects I have written about represent just the beginning. Organizations devoted to the documentation and preservation of dance (such as the National Initiative to Preserve American Dance) are considering the possibility of using motion capture. Links are being established between the choreography software tools such as Lifeforms and motion capture which will allow for greater manipulation and editing of motion capture data. Research projects into artificial creativity, such as *Coppelia* at Surrey University in the UK, are creating software that can generate dances from libraries of motion capture material.[20] With the ease of transportation via the internet, raw motion capture data can be easily

[20] Coppelia Website. http://www.ee.surrey.ac.uk/EE/VSSP/groups/human/coppelia.html

'emailed' anywhere in the world. This could be a boon for the dissemination and teaching of dance and choreography if the issues of intellectual copyright are solved.

In the future, as cheaper and simpler camera based systems for motion capture are developed and hardware and software prices drop, we will see dance artists using motion capture technologies to look at their dance material in three dimensions as part of their creative process in the studio. It is likely these systems will use some form of software engineering referred to as computer vision, sometimes called image understanding. As mentioned earlier, this is software that can simulate the way the human eye sees depth and movement. Like some aspects of movement modelling, it is also 'knowledge based' in that it incorporates an understanding of the physiology of perception into its algorithms.[21] These systems will do away with the need for the encumbering wires of the magnetic and ultrasound systems and even the round reflective markers of the current optical systems. They will also make it possible for the capture of multiple persons in the space.

Still, these newer, cheaper forms of motion capture will not replace video, because the fidelity of the two dimensional video image will remain of a higher affordable quality for many years to come. Three dimensional motion capture systems that can track movement of fingers and facial expression are being developed, but these will remain out of reach for the average dance maker. What we will see in the studio is a combination of both sources of information used to review one's dance material from every possible viewpoint and to replicate and blend movement phrases together in software programs such as the Motion Flow Network mentioned earlier. These systems should be within the reach of most dance artists within 8 to 10 years. And, as with all new technological forms of image production, this new way of looking at

[21] Descriptions of ‘computer vision’ can be found in the class information in various computing science departments at university sites, e.g. http://www.cs.umass.edu/autogen/cmpscidescf99.html and http://www.cc.gatech.edu/classes/cs7322_97_spring/info.html. A commercial site providing an interesting camera based system is SIMI/ Reality Motion Systems at http://www.simi.com/en.

movement material during the making process will influence the art of making dances.

Postscript

I am not the first to suggest that video and computers will someday be used together in the dance studio. Merce Cunningham, always far ahead of his time when it comes to exploring new technological possibilities in the dance making process, made the following speculation in the late 1960s.

"It seems clear that electronic technology has given us a new way to look. Dances can be made on computers, pictures can be punched out on them, why not a notation for dance that is immediately visual? There have been some slight experiments that I know of made in this direction, probably there are a good many more by now. A situation that strikes me as being immediately accessible to the dancer would be roughly like this: two screens, video or otherwise, synchronized as to time, and the same size. One would have the dance on it as performed by a soloist or group, that is, a performance complete with costumes, etc. if essential. Next to it, on the second screen, images in stick-figures that work in depth."[22]

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Appendix

Motion Capture Systems:
Ascension - http://www.ascension-tech.com/
Polhemus - http://www.polhemus.com/home.htm
Vicon - http://www.vicon.com/
Qualisys - http://www.qualisys.com/

Animation Software:
Maya - http://www.aliaswavefront.com/pages/home/index.html
Softimage - http://www.softimage.com/
3-D Studio Max - http://www.softimage.com/
Kayadera's FilmBox - http://www.kaydara.com/

[22] Merce Cunningham. *Changes: Notes on Choreography*. Ed. Frances Starr. New York: Something Else Press, Inc., 1968 (no page number). Merce Cunningham's website is http://www.merce.org.

Commercial Motion Capture Houses:
Motek - http://www.motek.org
Mocap Copenhagen - http://www.mocap.dk

Artist's Websites:
Riverbed - http://www.riverbed.com
Dorte Persson - http://www.koreograf.dk
Mesh (Susan Kozel/ Kirk Woolford) - http://www.mesh.org.uk/
Miscellaneous Reference:
Motion Capture Research Website -
http://www.visgraf.impa.br/Projects/mcapture/index.html