Choreographing the Extended Agent:
performance graphics for dance theater

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August 2005

This version prepared for online dissemination differs slightly from the copy presented to MIT; specifically a number of minor errors have been corrected.

This copy may be found at http://openendedgroup.com.

Abstract

The marriage of dance and interactive image has been a persistent dream over the past decades, but reality has fallen far short of potential for both technical and conceptual reasons. This thesis proposes a new approach to the problem and lays out the theoretical, technical and aesthetic framework for the innovative art form of digitally augmented human movement. I will use as example works a series of installations, digital projections and compositions each of which contains a choreographic component — either through collaboration with a choreographer directly or by the creation of artworks that automatically organize and understand purely virtual movement. These works lead up to two unprecedented collaborations with two of the greatest choreographers working today: new pieces that combine dance and interactive projected light using real-time motion capture live on stage.

The existing field of "dance technology" is one with many problems. This is a domain with many practitioners, few techniques and almost no theory; a field that is generating "experimental" productions with every passing week, has literally hundreds of citable pieces and no canonical works; a field that is oddly disconnected from modern dance's history, pulled between the practical realities of the body and those of computer art and has no influence on the prevailing digital art paradigms that it consumes.

This thesis will seek to address each of these problems: by providing techniques and a basis for "practical theory"; by building artworks with resources and people that have never previously been brought together, in theaters and in front of audiences previously inaccessible to the field; and by proving through demonstration that a profitable and important dialogue between digital art and the pioneers of modern dance can in fact occur.

This thesis will do this because of its methodological perspective — that of biologically inspired, agent-based artificial intelligence — and the technical depth to which this idea is taken. The representations, algorithms and techniques behind such agents are extended and pushed into new territory for both interactive art and artificial intelligence. In particular this thesis will focus on the control structures and the rendering of these extended agents' bodies, the tools for creating complex agent-based artworks in intense collaborative situations, and the creation of agent structures that can span live image and interactive sound production. Each of these parts becomes an element of what it means to "choreograph" an extended agent for live performance.

Acknowledgments

When I was sixteen I was taken by a rather odd idea (it was from Xenakis, I believe, although he is not to blame) that to be a great artist, I should study theoretical physics at the University of Cambridge. I learned a great deal during that time, and my approaches to difficult problems —and to the technicalities and potentials of the unknown — have remained unchanged since that time.

But the main thing that I learned is that to be even a good artist it's important to work with great people. **Bruce Blumberg** got me over to The Media Lab as part of the then recently formed Synthetic Characters Group; I learnt a lot from Bruce, of course, but above all I learnt how to make things — to start them, finish them, show them to people and then make them better. Throughout that time and after, **Tod Machover**'s vision in general, and interest and encouragement in particular, has proved more valuable and important than I've had an opportunity to admit before. Despite sharing a much shorter relationship, **Mark Goulthorpe** has caused me to rethink the relationship of my work to a broad intellectual community.

Many thanks are due to my good friends and colleagues **Paul Kaiser** and **Shelley Eshkar** who are collaborators on all of my works that involve human motion in any way — *Loops*, *Loops Score*, *22*, and *how long*... Without your minds, eyes, hands and hearts, these pieces and the years spent building them are inconceivable.

To **Trisha Brown** — my monitor is so blank without your points of movement hidden upon it.

To my fellow members of the **Synthetic Characters Group** and my fellow graduate students at **The Media Lab** — in particular **Bill Tomlinson**, **Matt Berlin** and **Ari Benbasat** — you have been the source of the magic material which is the difference between idea and reality.

And finally, to my wife, **Alison James**, who has been with me since the early days in Cambridge — you have been the great reason and the great love that has remained constant.

Marc Downie
August 23, 2005 — NewYork

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Introduction

The marriage of dance and interactive image has been a persistent dream over the past decades, but reality has fallen far short of potential for both technical and conceptual reasons. This thesis proposes a new approach to the problem and lays out the theoretical, technical and aesthetic framework for the innovative art form of digitally augmented human movement. I will use as example works a series of installations, digital projections and compositions each of which contains a choreographic component — either through collaboration with a choreographer directly or by the creation of artworks that automatically organize and understand purely virtual movement. These works lead up to two unprecedented collaborations with two of the greatest choreographers working today; new pieces that combine dance and interactive projected light using real-time motion capture live on stage.

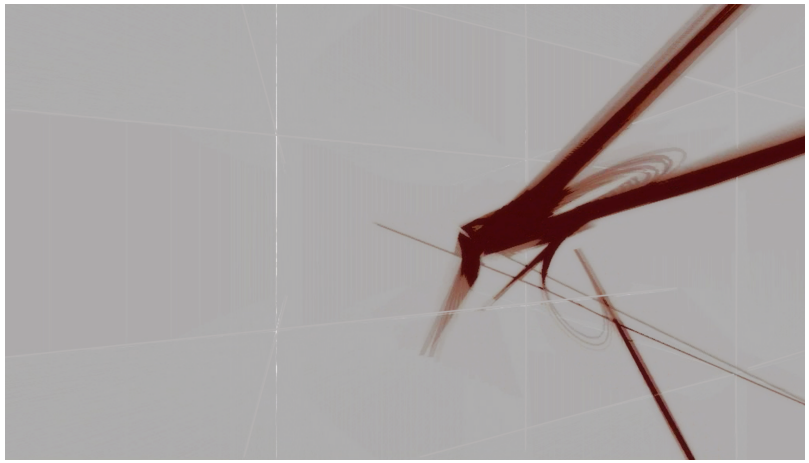
This thesis will achieve its goals because of its methodological perspective — that of biologically inspired, agent-based artificial intelligence — and the technical depth to which this idea is taken. The representations, algorithms and techniques behind such agents are extended and pushed into territory that is new for both interactive art and artificial intelligence. In particular this thesis will focus on the control structures and the rendering of the these extended

from *Loops* (inverted)

agents' bodies, the tools for creating complex agent-based artworks in intense collaborative situations, and the creation of agent structures that can span live image and interactive sound production — each part an element of what it means to "choreograph" an extended agent for live performance.

In this document I will present five principal artworks developed over a period of four years. The earliest of these is *Loops*, an installation work. A "digital portrait" of choreographer Merce Cunningham, *Loops* takes as its point of departure a "motion-captured" performance of Cunningham performing his 1970s dance for hands of the same name. Since its premiere in Cambridge in 2001, this piece has toured extensively — garnering an honorable mention at the Ars Electronica festival in 2004, installations at the Institute for Contemporary Art in London, and the Acm Siggraph 2002 conference and, as part of a Cunningham "event", a showing at the Festival d'automne. Paris. The piece was created as an interactive work, but is not interactive in its current version. It remains a "live" work in the sense that it is computed, that is, made, live. As such, the work never repeats; rather, it is perhaps the first point of contact between Cunningham's "discovery" of the creative potential of chance procedures and artificial intelligence's deployment of probabilistic techniques. Although *Loops* was constructed in collaboration over a short one-month period, it offers many early examples of what I consider to be the creative strengths of my agent-based practice.

Proceeding chronologically, the next principal artwork is *The Music Creatures* — a series of interactive, multi-screen installations. This thesis will focus on the most recent of the series, the 2003 installation commissioned by the Ars Electronica festival. These creatures offer small, "animal-level', musical intelligences; inspired by, but not based directly upon, the acoustic abilities of birds. The creatures come in four varieties, but each creature makes sound solely by manipulating its virtual body, and the growth and appearance of that body is governed by the creature's learnt understanding of its acoustic environment. While this work

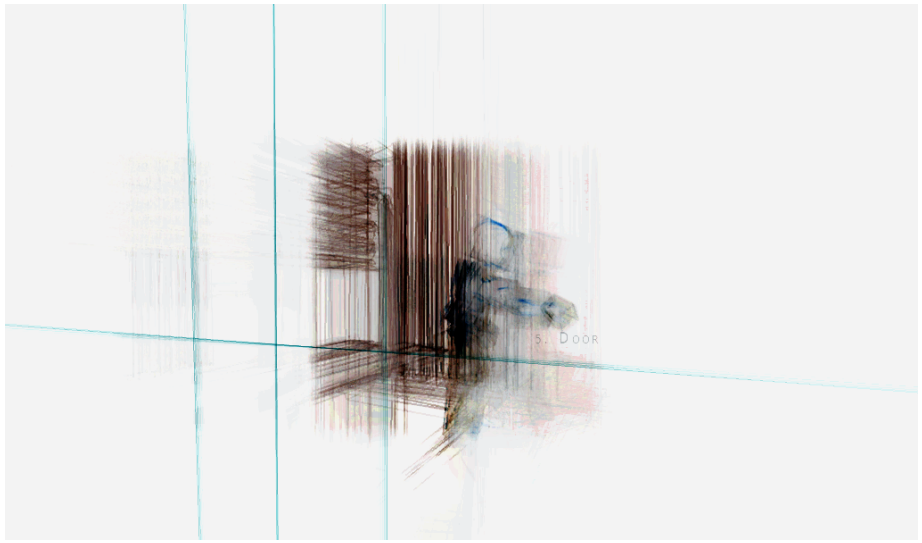


network from *The Music Creatures*

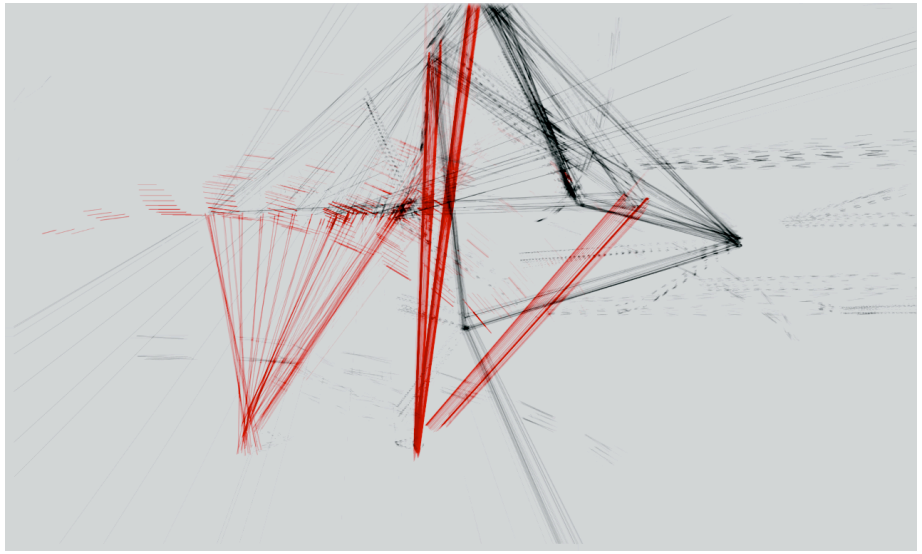
does not include human motion, *The Music Creatures*, with their long and multiply versioned development, are the work that is perhaps most responsible for refining my agent-based aesthetics. Further, the creatures in this work utilize a range of AI techniques to maintain a position of "dynamic disequilibrium" with the gallery space and each other, conveying a sense of effort, intention and ultimately transience and instability. This fragmentary and accumulative techniques and aesthetics is fundamental to my approach to interactive imagery in general and human motion in particular.

I revisited the *Loops* installation last year, 2004, with *Loops Score*, a purely musical work to accompany *Loops*. While *Loops* began with Cunningham's performance of his solo for hands, *Loops Score* begins with a narration by Cunningham — reading from his diary, concerning his first visit to New York in 1937. The sound of this narration is recast by a battery of interacting agent processes onto a set of extended prepared pianos, using a high-resolution sample library provided by the John Cage Foundation. While *The Music Creatures* presented an extremely minimal, indeed visual, approach to music, *Loops Score* finds itself closer to the mainstream concerns of computer music. However, *Loops Score* retains the indirection of *The Music Creatures*, deferring the creation of new live music to an autonomous agent. This piece shares with *Loops* a technical focus on the strategies available to "score" such open works, and similar to *The Music Creatures*, *Loops Score* produces music that is at some times startlingly coupled to its source, and at others propelled and sustained by its own oddly inevitable logic. *Loops Score* premiered in 2004 at the Ars Electronica festival.

The final artworks I present in this thesis are my most recent involving choreography, two works entitled *22* and how long does the subject linger on the edge of the volume ... The first, *22*, was created in collaboration with choreographer / performer Bill T. Jones, the second, *how long...*, in collaboration with choreographer Trisha Brown. There are several technical accomplishments in these works, for they are live visual imagery for motion-captured dance performance;



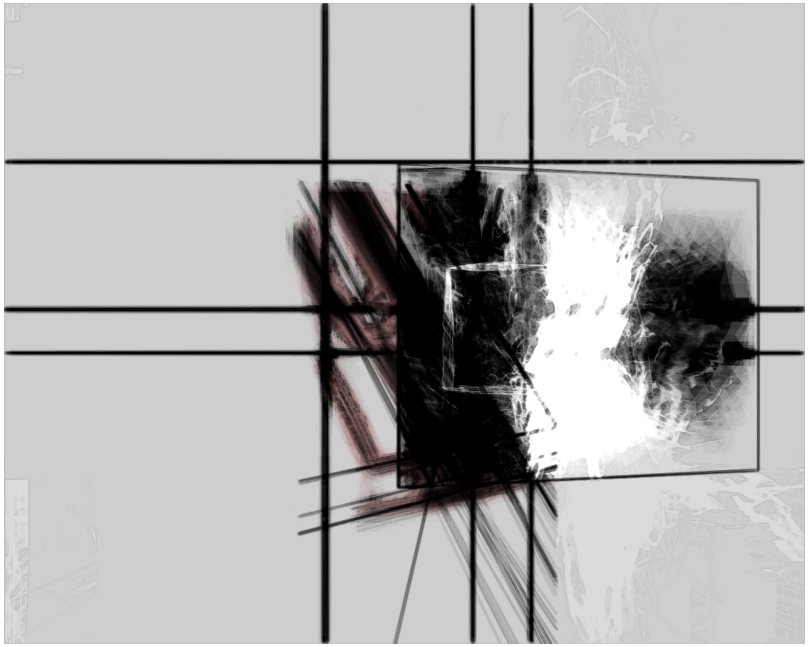
door from *22*



triangle from *how long...*

while *Loops* in 2001 used a carefully recorded, painstakingly hand-cleaned reconstruction of Cunningham's hands, these works in 2005 capture an entire proscenium stage in real-time. These works are some of the first to use this technology in front of an audience, and, to my knowledge, the first to do so on such a scale. Further, while the involvement of Cunningham began and ended with the capturing of his motion, these works were created truly in collaboration with the choreographers. I believe a number of technical and conceptual contributions in this thesis have are the consequence of the need both to keep pace with Brown and Jones in workshop and to meet the challenges of their choreographic practices. These works received their premiere in Arizona in April 2005; *how long...* showed the very next week live at the Lincoln Center for Performing Arts in New York, and the imagery has since received an award of distinction at Ars Electronica. The non-live "touring" version of *22* showed at the opening of the Walker Performing Arts Center in Minneapolis in June. Both are currently on tour.

Along the way there have been other works that I will appear less frequently in this thesis. Of most interest is probably the most recent of all my works, Imagery for *Jeux Deux*, which provides a number of example implementations, and often serves to demonstrate the applicability of my techniques to domains outside dance. Other works include *Lifelike* — live, but non-interactive imagery for the Merce Cunningham Dance Company commissioned and premiered by the Barbican Centre, London — and *Weather for an interactive window*, a small work for Joe Paradiso and the Responsive Environments Group's "tapper window" — a sensing piece of architectural glass. These too will appear in order to make arguments for breadth, or applicability. This thesis will also make extensive use, especially in the early chapters, of two collaborative pieces by the Synthetic Characters Group, of which I was a member: *Dobie* — an interactive, trainable dog; and *alphaWolf* — a multi-participant interactive simulation of wolf social behavior. *Dobie* is of considerable interest because he represents the high-water mark of the Synthetic Characters development of trainable charac-



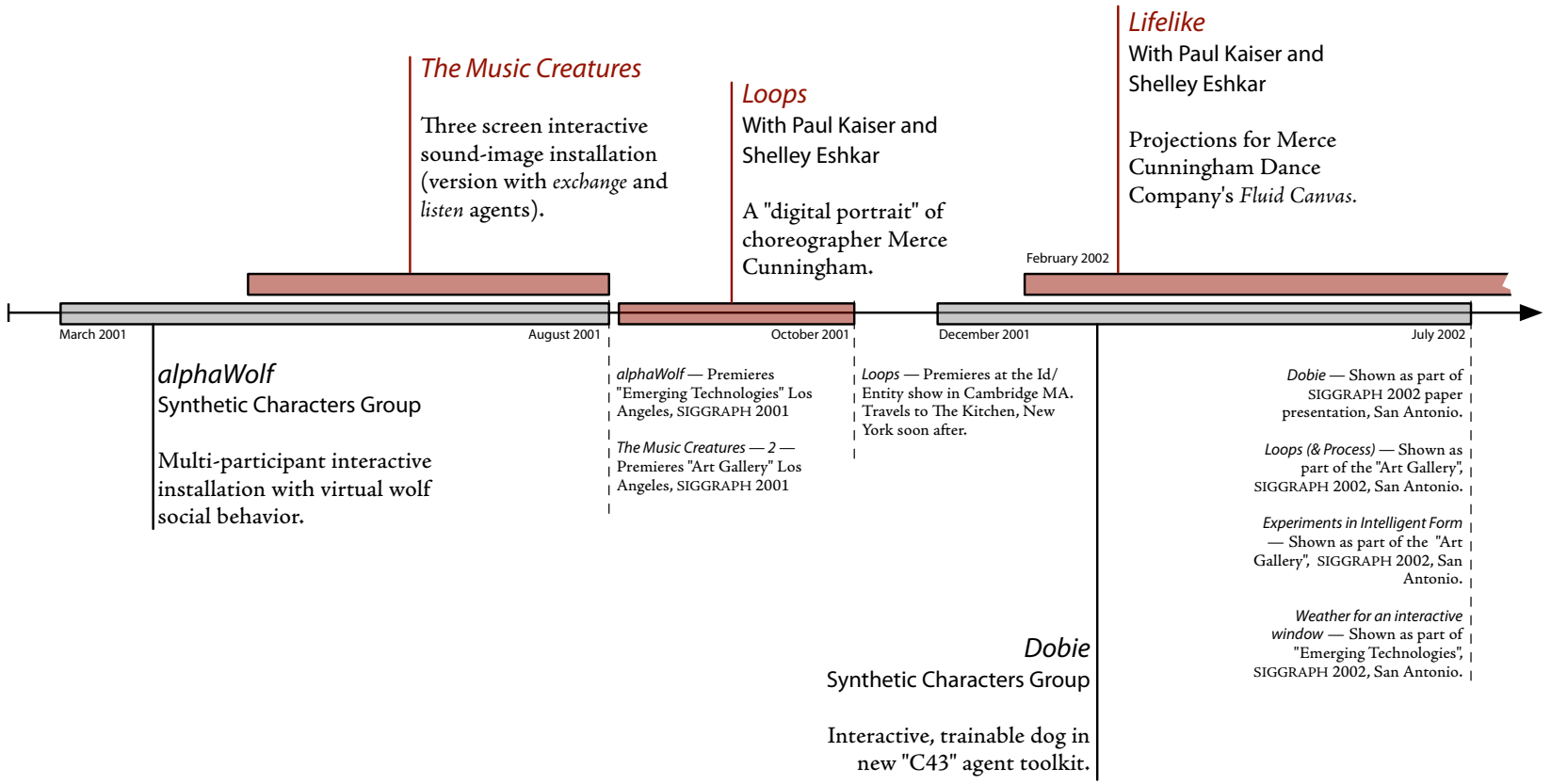
mirror from *Imagery for Jeux Deux*

ters in the toolkit that forms the basis for my subsequent work; *alphaWolf* because it represents the large, complex, multi-programmer collaboration at around the same time.

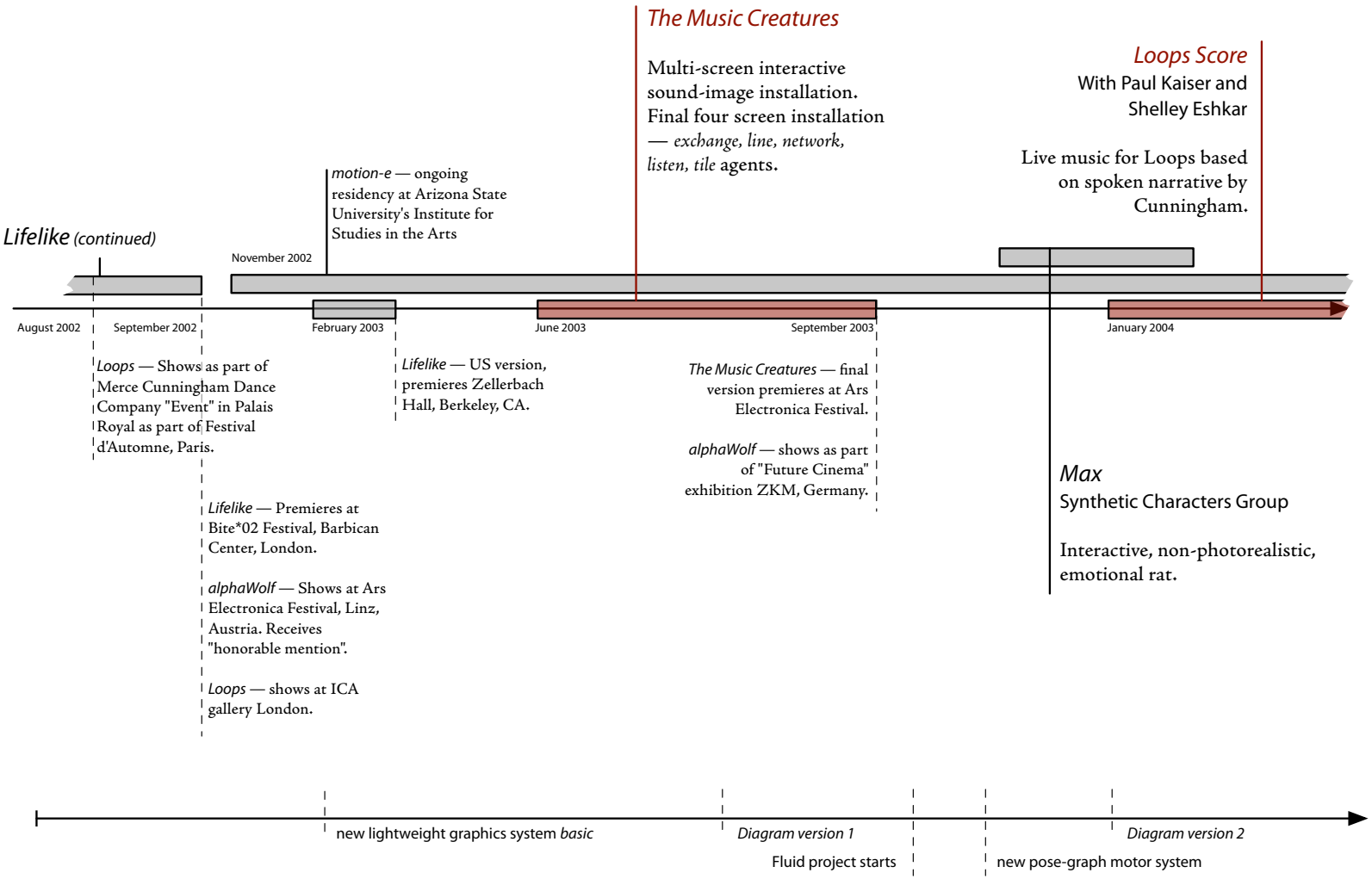
Chapter 1 will contextualize this thesis, locating it between the three areas it is in contact with — choreography, artificial intelligence and computer graphics — and will outline the main arguments both technical and conceptual that will appear in the remainder of the document. The next chapter will lay the groundwork for our agent framework, and survey the particular starting point for the agents constructed for this thesis. It will indicate how the agent-based might fit into an art practice, and what kinds of work AI architectures need to meet the requirements of a practicing artist. Following this chapter will come an overview of my first artwork concerning human motion —*Loops* — that critically develops a response to what I believe to be artificial life's "anti-methodologies" of emergence. Proceeding chronologically, I then present the sound-image installation *The Music Creatures*. This installation, while not drawing upon human movement, helps define several aspects of my agent-based aesthetics and sharpen some of the strategies that it offers in dealing with the uncertainties of interaction. I then pause in chapter 5 to discuss two general frameworks for constructing the perception systems for agents in complex worlds, that will be of specific use in the dance theater works. It is this chapter that contains the most focused technical rebuke of"mapping" a diffuse and dangerous concept I believe to be widespread use in interactive art. Chapter 6 introduces *Loops Score*, and more importantly collects the extensions to the agent framework, based on the lessons learnt in making *The Music Creatures* and *Loops*, into a new agent toolkit: the Diagram framework. This framework is designed to offer new forms of authorial involvement in the creation and maintenance of agents. Chapter 7 presents *how long...* and *22*, both pieces for interactive dance theater. *22* provides my most focused attempt to reform computer graphics'"non-photoreal" with new rendering techniques, while *how long...* represents my most sustained effort to create a collaboration between digital visual

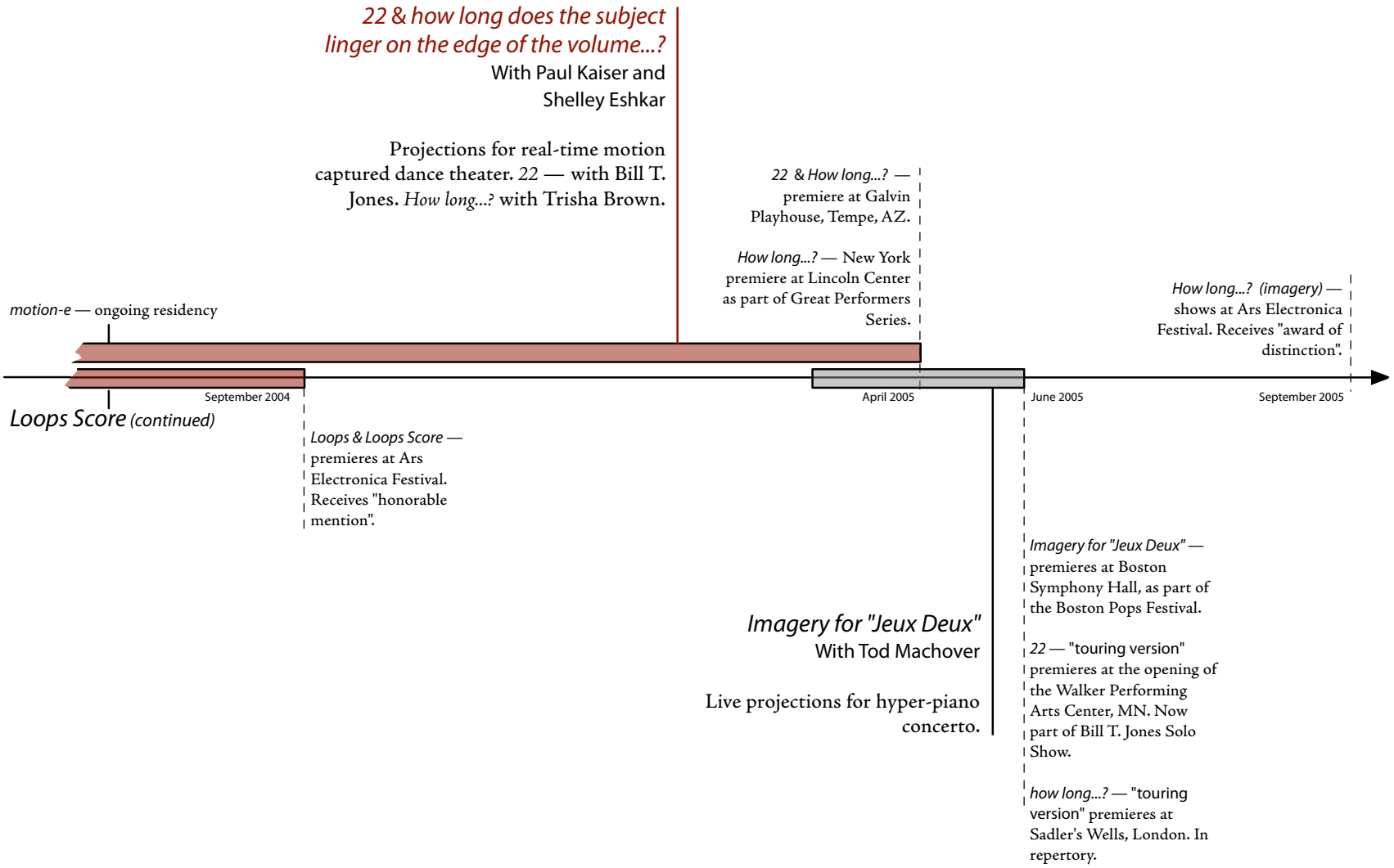
imagery and choreography in a live setting. Chapter 8 concludes the main body of this thesis with a description of a parallel thread — the custom graphical environment that allowed my agent-based approach to meet the realities of collaboration, rehearsal and improvisatory choreographic practice.

summer 2001 — summer 2002



summer 2002 — winter 2004




22 & how long does the subject linger on the edge of the volume...?
With Paul Kaiser and Shelley Eshkar
Projections for real-time motion captured dance theater. 22 — with Bill T. Jones. How long...? with Trisha Brown.
22 & How long...? — premiere at Galvin Playhouse, Tempe, AZ.
How long...? — New York premiere at Lincoln Center as part of Great Performers Series.
How long...? (imagery) — shows at Ars Electronica Festival. Receives "award of distinction".
motion-e — ongoing residency
September 2004
April 2005
June 2005
September 2005
Loops Score (continued)
Loops & Loops Score — premieres at Ars Electronica Festival. Receives "honorable mention".
Imagery for "Jeux Deux"
With Tod Machover
Live projections for hyper-piano concerto.
Imagery for "Jeux Deux" — premieres at Boston Symphony Hall, as part of the Boston Pops Festival.
22 — "touring version" premieres at the opening of the Walker Performing Arts Center, MN. Now part of Bill T. Jones Solo Show.
how long...? — "touring version" premieres at Sadler's Wells, London. In repertory.