

prosthetic extensions to dance

an interim manifesto

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Nearly every aspect of the arts has been touched or profoundly affected by the application of modern technology and media. Dance alone seems to have been spared the impact of ephemeralization, remaining a vaguely quaint form that has largely been marginalized. Perhaps this is due to the status of dance as the only truly mature four-dimensional form, rendering it resistant to simple notation.

Most works to date in the integration of multimedia with movement have focused primarily on placing the dancer into the role of controller of some other media, such as music or lighting. These pieces often use motion capture to create imagery of non-human dancers to interact with live performers.

The use of motion capture seems to be an especially misguided approach to dance. Any two dimensional portrayal of movement is ultimately an unsatisfactory substitute for a work that fills space, but beyond that, it shows a crass disregard for the ineffable element of performance. Whether in music, theater, or sport, audiences continue to crave a live execution of virtuosity, an experience that is wholly unique to a given performance.

**MOVEMENT SHOULD NOT BE CAPTURED
IT WANTS TO BE FREE**

It seems more appropriate to bring technology into the dancers vocabulary in ways that truly enhance the craft. To make artifacts that extend the dancers range of motion, memory, and stamina, as well as to challenge the most deeply held assumptions about dance. I hope to use these techniques to approach personal, political, and spiritual themes that challenge, entertain, and educate audiences. I specifically hope to create works that are accessible to a wide popular audience, rather than languishing in an academic or critical vacuum.

First Principles

Prosthetic extensions to dance

I wish to explore prosthetic extensions to dance, both in the physical and virtual sense. Dance prosthetics are nothing new - toe shoes are the most familiar example, allowing a dancer to extend his or her range beyond what is physically practical for a bare human body. However, I would like to work with further technological extensions to the human body to extend this range further.

Physical prosthetics may take forms such as mechanical footwear or even a full body armature, ultimately allowing for new forms of movement that may bear little resemblance to those traditionally associated with dance. Virtual prosthetics may extend the sensory and mental range of the performer, enhancing tactile and kinesthetic senses or memory. They may also allow the dancer to draw on stimuli during a performance, such as the attention state of the audience or data from external sources.

**MUST DANCE BE
THE WORK OF THE
UNAIDED HUMAN BODY?**

Dance and robotics

I start with the question as to whether a robotic dance is an oxymoron. Can we speak intelligently of a robot as a dancer, or is it a kinetic sculpture? The distinction is purely academic, and some work has been done in the area of robotic or mechanical dance, both in the commercial and fine art arenas.

I would like to explore further the possibilities of robots in dance, both on their own and in collaboration with humans, in the latter case known as cobots. I would hope to both extend the discourse and technology for robotic movement (e.g. developing techniques for multiple robots to synchronize in time and space) and for human movement, working with algorithmic dance forms similar to prior work with chance operations and structured improvisation.

**MUST DANCE BE
PERFORMED BY A HUMAN?**

Dance and gravity

In my recent explorations of dance, I have learned that the various styles of movement are often spoken of in their relationship to gravity. Jazz dance, for example, is often spoken of as being movement "into the floor," many Modern styles seem to center around cheating or accepting gravity, while Ballet seems obsessed with denying it altogether.

My work in this area is likely to be largely theoretical, though it may serve as a source of inspiration for my other work. I would like to explore how dance may evolve once it is performed without gravity or in different gravitational fields than that presently imposed by the earth. What sort of movement might be possible in the absence of gravity? Will dancers need prosthetics or props in order to control their movements? What sort of barre exercises would be needed to train in low or zero gravity? What sort of ballet movement would be possible on the moon, aside from a flashy entrechat soixante? What about higher or variable gravity fields? Perhaps, with the commercial expansion of space, it will be possible to realize such works in the next decade or two, though it would be interesting to make sketches, using computer graphics, to simulate such works.

DOES DANCE REQUIRE GRAVITY?

proposed works • methodology

I intend for the bulk of my research to be realized in the form of a series of performance works, typically (though not exclusively) driven by artifacts designed for the purpose. These objects and documentation of the performance will in themselves be suited for gallery display.

Venues have yet to be determined, though it is likely that many objects and performances will premiere at the annual Burning Man festival in northern Nevada. Specific themes will typically be driven by contemporary social and cultural dialogue, and are therefore also to be determined.

While the specific works may change significantly through my process of development, the following gives a general guideline and illustrates the progression from one idea to the next through various degrees of complexity.

2007: fashion

an exploration of robotics and movement in its simplest form; fashion, superficial and devoid of any particular function.

★Butterfly Jacket

a jacket covered with dozens of robotic butterflies, each driven by a piezoelectric crystal or electronically actuated nickel-titanium alloy. A gentle movement, either random or in choreographed waves, creates fashion from movement, and in a deeper sense, can bring dance into the everyday.

★Color Suit

I've had a great deal of fun recently with a rather plebeian costume piece acquired for less than £10 on eBay - an inflatable fat suit. This simple, loose-fitting costume inflates with an integrated fan driven by a belt-worn battery pack. Crowds love to see a trained dancer moving with this costume, creating a contrast of clumsy grace.

I wish to take this costume out of the realm of the silly into something rather more elegant. I plan to rebuild this suit using neutral white fabric, and add an undersuit of primary color LED's; in low light conditions, the entire body should glow with color, changing to suit the mood of the artist or the music.

2008: function

works here begin to influence performance and movement with their unique characteristics

★Footstick

Using principles of tensegrity as first envisioned by Buckminster Fuller and Kenneth Slenon we will construct a self-balancing post that can be carried by a dancer and used for support on any surface. The primary purpose of this exercise will be to lay the groundwork for the full body prostheses planned for 2010 and beyond, though in itself this will be useful for performances, particularly in outdoor and impromptu circumstances where it would be impractical to use another form of post.

★Works for Prepared Dancers

John Cage set the music world on its ear with his music for Syvilla Fort's 1938 dance "Bacchanale," by creating a "prepared" piano, whose strings were intertwined with objects to change the quality of sound. While Cage was not the first to experiment with such a piano, he has certainly received much of the credit.

It is interesting, particularly in light of Cage's long standing collaboration with Merce Cunningham and other choreographers, that none have taken the idea of a prepared instrument and applied it to movement performance. I wish to fill that void by creating works for "prepared dancers" - humans whose movement is limited or modified through physical modifications.

I anticipate that this theme will follow throughout much of my work, but the first and simplest pieces will involve dancers with one or more limbs encased in a plaster of paris cast, limiting their range of movement. It is my contention in general that an artist cannot create interesting work without limitations, and that these boundaries - the size of a canvas, the duration of a piece, the limits of physical materials - are crucial to the creative process.

These first works will certainly seem clumsy - by design - but will ultimately be followed up by more complex preparations involving robotic work element. One example might be a force-feedback device designed to transform the smooth muscle action of a human dancer into a staccato movement that would be otherwise impossible.

★Off the shelf

Various commercially manufactured robots may be well suited for use in a performance context, including the Aibo, Qrio and Asimo models, as well as task specific devices such as Roomba, Scoopa, White Box and various industrial machines.

2009: *autonomy*

The focus in this phase is on robotic performers capable of independent action, performing by themselves or otherwise without regard for their human creators, collaborators and audiences.

★BOXY

Boxy is a simple robotic platform, able to move on a stage guided by preprogrammed movement, or movement guided by its senses or a set of generated rules. Variations on the Boxy frame will function as performers for some of my works in subsequent years, both alone and partnered with humans.

In its first incarnation, BOXY will appear as a translucent cube, perhaps 30cm on a side, illuminated from within via colored LED's. While simple, BOXY will begin to broach the question as to what defines a dancer. Works set on the first generation of BOXY will tend to be slow and contemplative, tending towards the minimal and textural.

BOXY will progress as my body of work develops, both increasing in size and expressiveness, the latter accomplished with the use of flat video screens. In its final form, BOXY will form a rectangular parallelepiped of square cross section roughly 2m x 1m x 1m. Typically, these screens may display live or computer generated images of a human dancer, although abstract or other concrete forms may also appear.

★BIKER

BIKER will, ultimately, be a solar powered fully autonomous bicycle. In an outdoor setting with limited obstacles, BIKER will be able to guide itself to a desired point, follow complex patterns, and synchronize with others of its kind in complex choreography both planned and generative. It is hoped that BIKER will come in the form of a kit whose specifications are published in an open source format and built upon an existing bicycle frame for under £100.

Ideally, BIKER will be able to store enough energy on a sunny summer day to cruise autonomously for the entire night, forming packs with others of its kind. BIKER cannot be ridden by a human, and resists efforts at utility - it will move joyfully according to its whims, not the needs of men.

★The Balance Stick

The balance stick is intended primarily as a sketch for future work with TWIGGY, initially exploring dynamic balancing techniques. In its initial form, the balance stick will appear as a staff, roughly 2m in length, with a bend 2/3 of the way from the bottom. The joint at the bend will be mobile, either with a hinge allowing it to change the angle of bend, or with a pivot allowing the shorter portion to swivel relative to the lower portion. This single degree of freedom should be sufficient for the first form of the Balance Stick to remain erect, balanced on its tip, for as long as its battery will permit or, with solar power, indefinitely.

The next iteration of the Balance Stick will have two small wheels at its lower end, allowing it to remain balanced in the manner of a Segway (a recurring theme throughout much of my planned work) I expect a tall stick to require a minimal amount of power to balance using small wheels, though I do not expect the sense of balance to be very strong. A light touch should make the Balance Stick begin to topple over, requiring several feet of travel to bring the wheels back under the center of gravity.

This version of the Balance Stick will make an excellent partner for a human performer, in a fashion similar to Fred Astaire dancing with a coat rack - except that the coat rack will dance back.

With solar panels providing power, the Balance Stick should be a compelling artifact in its own right - a seemingly magical object that stands sentry indefinitely, using the power of the sun to hold its place, like some sort of sessile proto-tree. Indeed, one could call the Balance Stick a robot tree... without the roots.

(note about self-balancing - it might seem that I am particularly interested in using this technique as it is the 'flavor of the month' in robots, due to the groundbreaking work of Dean Kamen. While I'm certainly fascinated for this reason, it draws more on the fact that much of classical ballet training is focused on balance, and that this technique does not appear to have been used much in the arts. Robots have learned to crawl; they must now stand).

2010: collaboration

I am most concerned in this phase with robots that work together with one another and humans in a performance context.

★TWIGGY

Twiggy represents the subsequent stages in the evolution of the Balance Stick.

In the first stage, the existing wheeled Balance Stick will be allowed to, shall we say, spread its wings. Rather than being limited to use its wheels exclusively for static balance, Twiggy will be able to roll and to

turn following a choreographed path or one generated based on sensory input or other algorithmic methods. In this stage, Twiggy may also be fitted with a simple persistence of vision display, allowing it to leave a trail of text or imagery behind it in darkened areas.

In the second stage, I hope to replace the wheels with a motorized ball, similar to a ball-point pen or trackball. Such a ball has been built as a form of force feedback device, but does not appear to have ever been used for mobility. This will allow for full holonomic movement, and will also make Twiggy more aesthetically appealing.

During this work, Twiggy will also gain the ability to track other Twiggy's or human partners. Twiggy will ideally be deployed in groups programmed to dance and move together, forming patterns and painting their colors in the air.

Imagine: the artist walks into the space containing a finely crafted box, 100cm x 50cm x 10cm. The box is hinged, and contains a dozen small Twiggys, as well as a supply of butane for topping off the fuel cell power supplies of each robot, speakers for music playback, and signaling devices allowing the Twiggy's to orient themselves relative to the box. The box is opened and allowed to stand upon its edge, forming a V to make it stable. Upon pressing a button on top of the box, music begins to play and the Twiggys emerge from the box and begin their performance, like a music box dancer. When the song ends, the Twiggys all return to their places for refueling, and the box may be closed. The entire performance can be sold to a collector or a museum, or even mass produced with a library of performances, if there is sufficient demand.

2011: integration

In this period, robots become wearable and integrated with human performers, with no clear lines between the two.

★Tail

Of all the affordances lost in our progression to the top of the food chain, the tail is certainly the most missed. I would like to construct a tail, building on present research in tentacle robots, to give a dancer the advantages enjoyed by simians and cats with their tails; balance and gesture.

the Tail would be worn at the dancer's center of gravity. Gestural movement might be controlled by gloves in the manner of the N-Fingers interaction method (Lehikoinen et al 2001). When put into 'balance' mode, a six axis accelerometer would compute the correct tail position to provide sufficient torque to dynamically assist a dancer with balance.

The Tail might be programmed for a particular performance to watch for finger and movement gestures and perform other functions, such as drawing inwards to increase the speed of a turn, or adding lift to a jump.

Much research will be required, particularly in algorithms, and the Tail may have to be rather heavy to provide sufficient torque to balance a human. The Tail may find industrial spinoffs in applications requiring people to maintain balance over a long period of time, e.g. construction work.

★Leggy

A bipedal platform ridden by a human performer.

2012: the future

★Full Body Prosthesis

The final and most complex planned artifact is a full body performance prosthesis. Ten meters tall, the device is half-worn and half-ridden. The performer is strapped into the device, pinioned at the closest point to his center of gravity, with straps and sensors around each limb segment. With screens at eye level and buttons within easy reach of the hands, the suit will provide power and balance assist to movement. Ultimately, this may be sheathed in translucent screen with video projection, or even video fabric once this is available.

★Tosser

An additional idea that may not be practical within this time frame. The Tosser is a pair of robotic arms on the scale of an indoor stage - perhaps 10m-20m long each at full extension. The Tosser has sufficient strength and control to lift a dancer via a bracket worn on the back, and gently throw the performer from one arm to another. It would be agile enough to grab a human in mid-leap, toss them across a stage, catch them in the other arm, and set them gently in a new position with no damage or discomfort. One day, the Tosser might be able to juggle people.

Parallel I: 2008-2012: gravity

In parallel with the robotic work, I wish to proceed with developing movement techniques and styles suitable for zero- and low-gravity environments. My present practice is largely concerned with discovering movement that conserves and redirects momentum, drawing as little energy from friction and gravity as possible.

Short parabolic flights affording a few minutes of zero gravity are regularly scheduled as of this writing, starting at well under £2000 per person. With appropriate funding, I would like to bring a group of dancers into this environment to explore movement and the use of devices such as compressed air for controlled performance movement without gravity.

I expect by 2015 at the latest it will be practical, albeit expensive, to lift a small dance troupe into low earth orbit for sufficient time to mount a proper performance.

Parallel II: 2009-2010: Augmented Movement Training

Time and resources permitting, I may also explore the use of technology in dance training. Ideas include

- augmented reality mirror for use in a dance studio, pointing out specific trouble areas to both the student and teacher*
- head-worn displays for performance memory prosthesis*
- a force feedback suit, allowing a dance instructor to touch her students remotely or as a group*

about stephan.com .

I come to your program with a background in theater, computer graphics, art, wearable computing, gaming and electronic media. My earliest training in theater was as a child and teen actor. As an undergraduate, I focused on computer graphics, and then received an MFA from the Electronic Visualization Laboratory in Chicago. While there, I began my association with (art)n Laboratory, receiving four patents on my work with autostereographic imagery, and creating works from the late 80's through the late 90's that hang in museums and private collections around the world, notably including a permanent sculptural installation at the Smithsonian Institution. Following that, I worked a few years in the private sector for Nokia, researching wearable computing and gaming as applied to mobile multimedia, and received ten more patents for my research in this arena.

All through this, I have had a passion for dance, studying intermittently from the early 1980's onward. In the broader sense, I am interested in performance art; I had originally planned a performance piece for my MFA, but never realized that work, and set it aside. I had never had the time to devote myself fully to dance until 2002, when I enrolled at Santa Monica College as a dance major. In two years of focused study, I greatly extended my technique and understanding of dance, and finally realized my goal of creating my first performance art pieces.

At present, I am working as Chief Information Officer for MobileGates in La Palma, California. My current work includes creating software for mobile technology, and will primarily revolve around location based applications. I hope to leverage some of this work into my performance practice.

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