

# Video Interaction for Swarm Art

Jeffrey E. Boyd  
Dept. of Computer Science  
University of Calgary  
Calgary, AB, Canada  
boyd@cpsc.ucalgary.ca

Gerald Hushlak  
Dept. of Art  
University of Calgary  
Calgary, AB, Canada  
hushlak@ucalgary.ca

Christian Jacob  
Dept. of Computer Science  
University of Calgary  
Calgary, AB, Canada  
jacob@cpsc.ucalgary.ca

## ABSTRACT

We describe motion swarm widgets for video interaction with art installations and video games. This mechanism for interaction is a byproduct of an ongoing collaboration among the authors involving both arts and science. The inspiration started with a desire to build installations with en masse audience interaction, and evolved towards an interaction mechanism that is robust in crowded and complex environments.

## Categories and Subject Descriptors

J.5 [Computer Applications: Arts and Humanities]: Fine Arts; H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems—*Animations, video*; H.5.2 [Information Interfaces and Presentation]: User Interfaces—*Input devices and strategies*; I.4.8 [Image Processing and Computer Vision]: Scene Analysis—*Motion, tracking*

## General Terms

Algorithms, Design, Experimentation, Human Factors

## Keywords

Audience interaction, interaction through video, motion analysis, swarm art

## 1. INTRODUCTION

For several years, we have engaged in a collaboration between an artist and two computer scientists. We have produced several installations and published descriptions of our work [3]. Beyond these immediate and tangible results, our collaboration has provided inspiration for the research of each partner individually. This document describes some of the installations that have come out of our collaboration, and how our collaboration has led one partner to explore new directions in video interaction with audiences.

## 2. SWARM ART INSTALLATIONS

The installations we have produced share three common elements, each reflecting one partner's interests: swarm simulation, video interaction, and visual art. Swarm simulation provides patterns of motion that are apparently random, but when viewed as a whole exhibit a visual coherence [5]. The result is motion that is interesting to watch, but never repetitive. One parameter of the swarm simulation defines a center, or home for the swarm, akin to a flock of birds that moves freely through the air, but always staying close to a favorite tree.

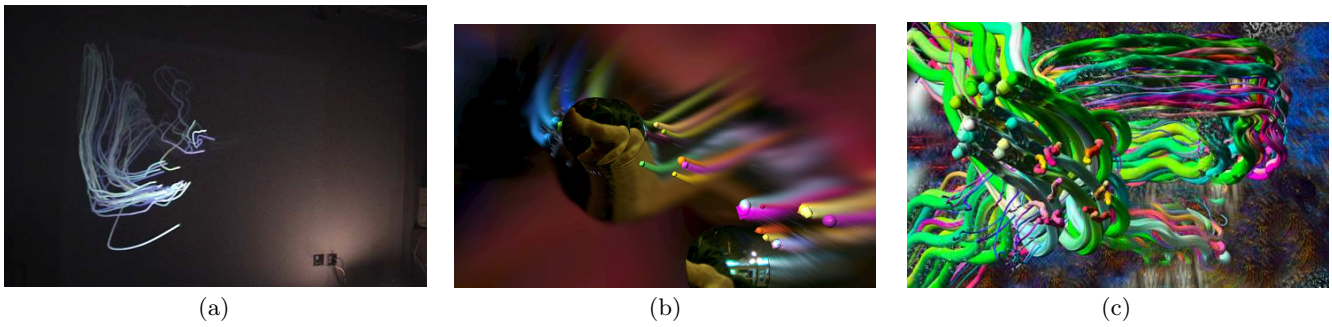
Viewers of the Swarm Art interact with the swarm simulation through their motion. Using a variety of mechanisms, we convert the motion to a set of coordinates, and those coordinates in turn define the swarm center. As the observers move, the swarm center moves, and the swarm appears to follow the motion of the observers. Although the observers cannot control the swarm directly, they modulate the motion of the swarm by affecting the position of the swarm center.

Although observing a simulated swarm and playing with it through visual interaction can be interesting at first, it lacks the visual depth required to sustain interest. The swarm and video interaction become art when we render the swarm to achieve a visual richness that is not inherent in the simulation. Swarm parameters, mechanisms for interaction, and variations in artistic rendering create a palette that is likely to be interesting for some time.

Figure 1 shows some images from some of our installations. We have progressed from some interesting, but visually simple installations, to installations that are more visually profound.

## 3. AUDIENCE INTERACTION

We explored the possibility of displaying Swarm Art to a large audience using, for example, the large screen displays commonly found in sports arenas and stadia. This immediately raised a question: how can an audience interact with a display en masse? We were predisposed to consider video interaction both as a matter of habit, and because the equipment is simple and cheap. Our solution, motion swarms, was inspired by a combination of the swarm aspect of our work, and by previous research in appearance-based computer vision [4].



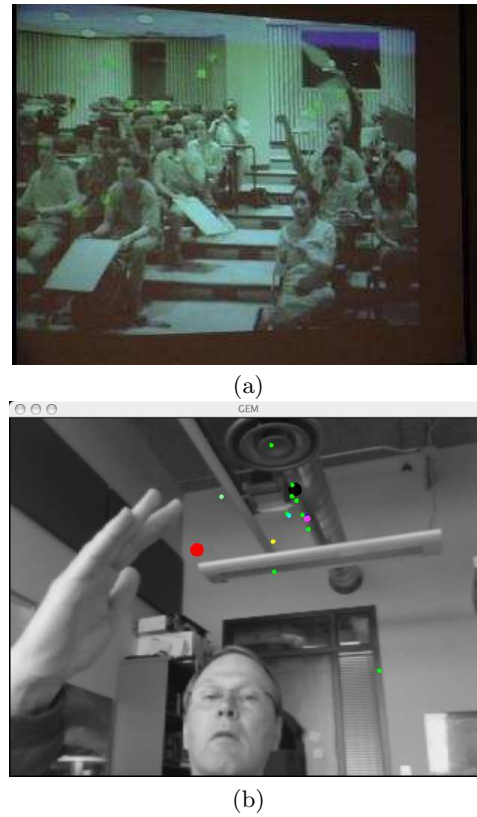
**Figure 1: Examples of Swarm Art installations:** (a) our first installation with simple rendering and interaction (2002), (b) an image from SurveillanceArt.com at the Vancouver Island Art Symposium, (2006), and (c) an image create by SwarmPainter.com (2008).

A camera and video system capture the motion of an audience to produce a motion image, an image that is bright where there is motion and dark elsewhere. This motion image can be built using motion history images [2], a combination of adaptive background subtraction and distance transforms, or optical flow. We then treat the motion image as a force field, e.g., a gravitational or electrical field. A software simulation of a particle moving subject to the forces in the field gives us a set of coordinates that moves in response to motion. If we use these coordinates to be the center of a swarm, then the audience moves the particle with their motion, which in turn modulates the motion of the swarm. The solution was particularly attractive because measuring a motion field is a relatively easy computer vision task and can be done with few constraints placed on the environment, and the audience needs no special props or equipment. There is no requirement for tracking or gesture recognition, both of which can be extremely difficult in a complex environment such as in an arena. Figure 2(a) shows an image of a test audience interacting with several particles to generate sounds while 2(b) shows a single person interacting with a swarm on a laptop computer by the same mechanism.

#### 4. THE NEXT STEP: GESTURE-FREE WIDGETS

Interaction with Swarm Art is not very demanding. If an observer moves, and the swarm display (sort of) moves with them, then that is usually sufficient. Simple video processing suffices to build an interface that is close enough for jazz (and for Swarm Art).

Can we modify the concept of motion swarm interaction to facilitate a more precise form of interaction? Our most recent work answers this question affirmatively. We realized early on with audience interaction that it is necessary to constrain the motion of the particles. This is necessary to do things like keep the particles in view, keep them near a specific part of the audience, and limit the speed of the particles. We extend these constraints to build widgets that are typically used to build graphical user interfaces (GUIs). For example, we can constrain the particle to move in a short, wide region, resulting in a particle motion that is primarily horizontal. An observer can move the particle as they might have for the audience-swarm interaction, but now



**Figure 2: Examples of motion swarm interaction:** (a) an audience interacting with several motion swarm particles to play music, and (b) one of the authors interacting with a swarm on his laptop computer by pushing the red particle.

the particle movement operates like a GUI slider widget. Figure 3(a) shows such a slider in the upper-right corner. The blue rectangle indicates the bounding box for particle motion while the red square indicates the horizontal position of the particle within the box. The user manipulates the slider by pushing it with their motion.

Figure 3 shows a series of interaction widgets we have developed using this technique. Widget types include

- sliders (Figure 3(a), upper right),
- buttons (Figure 3(a), upper left),
- menus built from a combination of sliders and buttons (Figure 3(a), selected menu item shown on bottom as 'A' through 'E'),
- dials (Figure 3(b)), and
- item selection by placing a particle on a colored box (Figure 3(c)).

With the exception of the dial, all of these widgets are simple particles with a set of constraints added to get the desired behavior. Implementation of the dial requires that the particle motion be constrained to lie on a circle. Theoretically, this could be done using a particle anchored to the dial center with a stiff spring of nominal length equal to the dial radius. However, details of the physics simulation of such a stiff spring meant that it was easier to implement the dial rotational motion as a special case.

## 5. INTERACTION FOR GAMES

In a pilot study on the usability of the motion swarm widgets, younger participants suggested that the widgets would be fun if applied to a video game. While we have yet to implement a *good* video game, a replication of the classic (1972) game of Pong [1] is easy to implement and adapt for motion swarm widgets. Figure 4 shows the result. A *START* button on the upper right of the display initiates game play. The human player controls the *paddle* at the top of the screen via a motion swarm slider. The computer *paddle* is at the bottom of the screen. Vertical play worked better than horizontal play because of the nature of motion swarms: it is easier for people to control the motion across the top of the display without producing confounding motion than to control up-and-down motion along the side of the display.

## 6. REFERENCES

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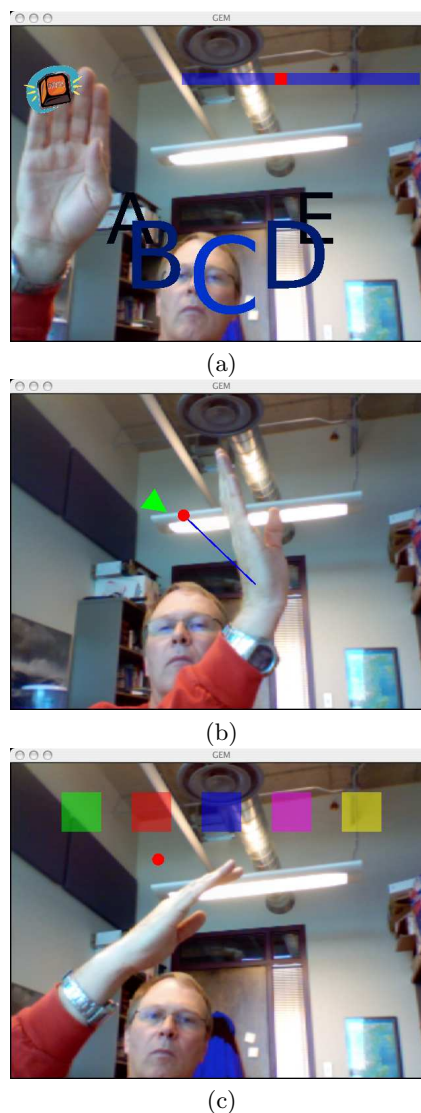


Figure 3: Examples of motion swarm widgets: (a) a slider (upper right) and a button (upper left) combine to select menu items (bottom), (b) a rotational dial, and (c) item selection by placing particle on a colored box.

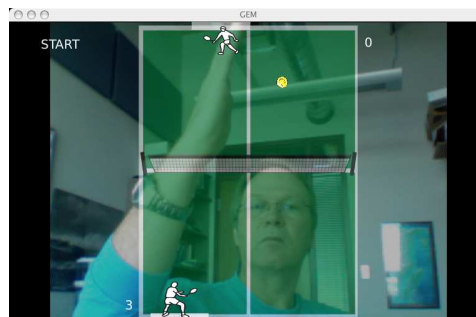


Figure 4: Screen capture of Pong game in progress. A slider across the top of the screen controls the human player paddle position. A button in the upper left corner, (labeled *START*) initiates game play.