# Mime-Inspired Behaviors in Minimal Social Robots

**Eric Deng**
University of Southern California
Los Angeles, CA 90007, USA
denge@usc.edu

**Maja J. Matarić**
University of Southern California
Los Angeles, CA 90007, USA
mataric@usc.edu



## Introduction

Humans intuitively understand nonverbal gestures; robots that can effectively use such nonverbal communication have the opportunity to improve the quality of social human-robot interactions by eliciting more trust [9], improving learning [1], and creating more engaging conversations [3]. We are interested in exploring expressiveness in minimal social and socially assistive robots. Toward that end, we explore the use of the robot's physical embodiment as a natural communication channel. In this work, we describe how the central concepts of mime can be used to develop robot behavior controllers that enable minimal robots to convey information about non-present physical objects.

## The Building Blocks of Mime

Mime is an art form that uses the human body to act out stories without the use of speech or sound [12]. Mime artists tell rich stories by using a variety of nonverbal cues. A classical mime act demonstrates being stuck in a box; the artist gestures all around his body as if touching a glass box that surrounds him. The performance involves acting relative to imaginary physical constraints, such as the glass box, and being physically as well as emotionally expressive, such as showing anxiety from being stuck.

## Behavior Control for Robot Mime

We are interested in exploring how a swarms of simple spherical robots (Spheros) can be controlled for various social interactions including play and basic conversation. Spheros are low degree-of-freedom (DoF) robots that can be controlled by combining external sensing from a centrally-mounted, top-down RGB camera with a centralized controller for the swarm as a whole [11]. Using basic theory from the art of mime we now have an approach to defining physical spaces and objects using minimal robots.

*Space-matter manipulation* is the main underlying mime technique for generating matter and demonstrating how matter behaves [8]. Using this technique, mimes define detailed object features such as mass, volume, and shape [8]. Mimes show the behavior of objects in physical space by applying force to those imaginary objects and then responding in physically-appropriate ways. To define the shape and volume of objects, mimes shape their hands to fit the physical properties of those objects. This includes changing the curvature of the palm of the hand and leaning the body to show the effects of balancing.

We aim to achieve similarly evocative effects of communicating shape, size and physical properties through formation control in robot swarms.

Spheros, like other non-verbal robots, use their bodies to convey intent. We break down the motion of Spheros into position, velocity, acceleration, and jerk, the derivative of acceleration. To apply mime space-matter manipulation techniques to a swarm of Spheros, we use position, acceleration, and jerk; position defines the volume in which objects exist, and the combination of acceleration and jerk is used to indicate physical properties of objects upon impact, specifically hardness and elasticity [13].

*Miming Shape and Volume*

Simple robots and swarms can "simulate" iconic gestures [6] to describe non-present physical objects to human interaction partners [4]. To develop systems that accurately manipulate the *positions* of nodes in a swarm of robots, we can centralized control methods for pattern formation in multi-robot systems. For example, a target assignment strategy for formation building [10] allows for obstacle avoidance that can be used in defining the outline of described objects by assigning individual trajectories for each robot in the swarm [2].

*Miming Physical Properties*

To demonstrate mechanical properties of the mimed objects, such as distinguishing between boxes of varying compressability, we adjust the *acceleration* and *jerk* of each robot's motion upon impact with the mimed object. Acceleration is effective at conveying how the bounds of an object react to applied forces. For example, in compressing an object, the acceleration of the robot is demonstrative of how the shape deforms to a compressing force. Jerk is effective in showing the elasticity of objects, or how objects react to initial impact [13]. Acceleration and jerk of each robot in the swarm can be adjusted dynamically [14].

## Evaluating Mimed Behaviors

As with the classic Heider-Simmel Illusion, wherein users inferred and interpreted complex social dynamics from a short video displaying the motion of basic shapes around a central box shape [7], observers are likely to interpret potentially complex behaviors, intents, and emotions from a properly designed movement of a swarm of simple robots. The simplicity of programming these robot platforms allows for rapid data collections from users that would lead to more analytical modeling [5]. Our goal is to first select a set of basic "gestures" for testing the premise of mime-inspired swarm control with Spheros, and then use the results toward the design of data-driven models for mime-inspired behaviors more generally.

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