Bimba: Sensor Embedded Balls for Creative Sound Generation

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Abstract

Bimba is an exploration into designing playful interfaces which use embedded sensors to sonify object interactions. The system wirelessly collects data from sensors integrated into foam balls and generates a sound composition extracting the most relevant features of movement. We have designed and built a collection of sensor units, implemented a protocol to support a wireless real-time data network infrastructure, and proposed a sonification mapping for the generated output. The implementation of *Bimba* informs design possibilities for creative and expressive interfaces, with particular focus on those generating sound.

Introduction

Physicality has shown potential in facilitating the design of complex interactive systems. Fitzmaurice, Ishii and Buxton introduced the concept of graspable interfaces (1995) – physical objects that interface with computers for more meaningful human-computer interactions. Their work emphasizes the central role that physicality plays in the design of effective interactions. Further work (Ishii et al., 1997; Maynes-Aminzade, 2003) has investigated how users can leverage their acquired intuition about physical laws to better understand tangible systems.

In our design, we seek natural and meaningful relationships between physical properties and sounds. While there is not a definitive way to sonify physicality, we are proposing one approach with the aim of generating conversation around the potential of such environments.

The intersection between tangible interaction and sound generation has been explored before. Systems like the ReacTable (Jordà et al., 2007) are examples of physical manipulation of sound.

In the same vein, there exists a large collection of projects that embed sensors into instruments (Young, 2002; Overholt, 2005) or into wearables (Marrin and Picard, 1998; Paradiso et al., 2000) for the control of musical output or even enhancing stage performances.

The system we propose builds on concepts and mappings that we observed in these projects, but it is, at the same time, distinct in two main aspects. Firstly, our system proposes a duality between control and randomization, which makes it different from tangible musical interfaces that attempt to maximize control over the output. Secondly, it is designed to be embedded in everyday objects – as opposed to instruments, the performer herself, or her clothing.

There are two projects in particular that have deeply informed our work: Squeezables (Weinberg and Gan 2001) and Squidballs (Bregler et al., 2005). Squeezables are a collection of soft instruments that generate sound in an intimate way. Squidballs, on the other hand, involve a large audience in massive collaborative play. We wanted to create a system that works in both contexts, which is why we implemented *Bimba* to suit both intimate environments as well as shared spaces.

Expressiveness is an important factor in musical performance; it helps the artist to better communicate her music to the audience. At the same time, expressivity helps the audience to better appreciate the performance – establishing a connection between the performer's actions and the resulting sounds. We borrowed inspiration from projects that try to emphasize the emotional aspect of a performance when generating/affecting musical outcome such as (Marrin and Picard 1998). We believe that the physicality present in out system, combined with intuitive mappings, can help convey emotions and contribute to an interesting and informative visual – as well as auditory – experience.

As reflected in (André et al, 2009), serendipity can have a great impact on the creative process. We already commented on the affordances of object-based musical systems, but we also believe that such systems offer interesting possibilities for serendipitous exploration and sound randomization. Physical laws can help us design more accessible systems, but at the same time enable users to experiment with uncontrolled environments. In doing so, performers may even new inspiration in the surprising output that they generate. For example, a performer might achieve unique results by dropping one of these balls down a set of stairs or juggling with a trio of them.

Our investigation, *Bimba* – Catalan slang for ball –, builds upon research addressing the four characteristics described above: physicality, scale, expressiveness and serendipity. *Bimba* is a system for sonification of everyday objects with embedded sensors.

Technical Aspects of the System

Bimba consists of a set of small wireless power-autonomous electronic circuits. The current configuration of each circuit includes a microprocessor, a battery, a wireless communication chip and three inputs – namely, a three-axis accelerometer, an air pressure and temperature sensor, and a piezoelectric sensor.

The goal of this design was to create an integrated system that accommodates different physical objects collecting, processing and broadcasting a diversity of real-time sensor data. For the exploration discussed here, we incorporated the circuits into foam balls roughly 15cm in diameter

Figure 1. One of the balls of the *Bimba* system and a prototype of the sensor board.

We developed a communication protocol to process multiple packets of data coming from sensors distributed across different objects. Having built each of the boards with an integrated wireless communication module, we created a star topology network. That is, all communications are centralized in a controller node. This controller node then generates sound with the information received. This kind of network enables us not only to generate music from each individual sensor, but also to establish sound relationships between all of the devices connected.

Physicality: Rules, Object Properties and Mappings

In a system such as the one we are describing, it is important to have clear constraints which guide the creative process. The laws of physics, which are universally applicable to the objects that surround us, provide common ground for creation. The specific characteristics of each object add the necessary variability to the system; depending on its shape, weight, composition, and size, an object interacts with the environment differently.

To achieve an appropriate balance between variability and predictability, it is necessary to relate physical rules to compositional rules in a meaningful way. For this reason, mappings are an essential component of a successful system. The system discussed here senses three different parameters: acceleration, altitude and impact. By no means are these the only interesting parameters to consider; for future iterations of the system, we will design a customizable circuit that enables addition and replacement of the sensors included.

For each of the sensors used in the current version of the system, we propose a set of mappings. These are described in the following sections.

Acceleration. The system reads the aggregated acceleration of the balls. This parameter is strongly related to the sense of motion and momentum. Because movement implies continuous variability, this parameter is especially suitable for controlling the base frequency of the background tone.

Altitude. The relative height is particularly well suited to representing the primary sound's pitch because it is intuitively associated with a range from low to high.

Impact. Bouncing motion is clearly associated with percussion. In our design, the system triggers a MIDI drum kit sound each time a ball senses contact with another object or surface.

Design Criteria and Goals

The system design was intended to explore four concepts tied to our research interests: relating serendipity and inspiration, supporting different creative styles, building immersive environments, and enabling collaboration. We believe that these four pillars lay the foundation for creative flow.

Serendipitous approach to creativity. As we alluded to in the introduction, designing for serendipity is as important as designing for controlled environments. By taking advantage of environments familiar to the user, *Bimba* supports playful exploration in a relaxed and intuitive way. Ideally, this would minimize distraction so that the creative experience may also be an immersive one.

Supporting different styles of use. Designing tools for creation means providing resources in an unencumbered manner so that users can challenge conventions of the system in new and interesting ways. Research has shown the importance of appealing to different creative styles to push the boundaries of creativity (Resnick and Silverman 2005). For this reason, *Bimba* aims to support a broad range of approaches to sound generation.

Design that impacts the ecology. Successful designs affect the ecologies that they inhabit. Since our system is deeply connected to the environment – by means of the laws of physics – we expect users to modify spaces to stage their own "worlds of music".

From intimate use to massive collaboration. *Bimba* is designed to support the full range between small-scale, intimate interactions and massive collaborations. As previously described, the system can be easily used for personal exploration of sound landscapes. However, because the proposed design is distributed, there are also many instances in which it can be used collaboratively.

Discussion and Future Work

We talked about the importance of mappings for performers to connect with an interface. Enabling users to create or modify their own mappings may strengthen the bond between the performer and the sound object.

The current system supports input from multiple objects, but it does not yet propose mappings reliant upon inputs distributed across a collection of objects. Improving these distributed mappings may encourage higher levels of collaboration.

Additionally, if *Bimba* had an awareness of the material composition of the objects, then the mappings could reflect this. Zoran's Chameleon Guitar (2009) is an inspiring example of using resonance filters to represent different material arrangements.

Another future line of research lies in creating a set of modular sensor boards. Such a modular system would enable performers to capture the most important aspects of each object. For example, the physical characteristics of a bouncing ball can be well represented by sensing motion, altitude and impact – but this may not be the case when the interface object is instead a glass bottle.

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Conclusion

Bimba serves as a preliminary investigation into turning everyday objects into musical interfaces through the use of embedded sensing.
This paper reflects on the benefits of capitalizing on object affordances to creative sound generation. By grounding our exploration in four main design considerations – serendipitous approach to creativity, supporting different styles of use, designing for impacting the ecology, and cross-social scenario – we hope to stimulate future dialogue around them.

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