# The BeatBearing: a Tangible Rhythm Sequencer

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## ABSTRACT
The BeatBearing is a novel musical instrument that allows users to manipulate rhythmic patterns through the placement of ball bearings on a grid. The BeatBearing has been developed as an explorative design case for investigating how the theory of embodied interaction can inform the design of new digital musical instruments.

## Keywords
Embodied interaction. Tangible user interfaces. Enactive interfaces. Explorative Design.

## 1. INTRODUCTION
This paper and the accompanying interactive demonstration address the theme of this years conference 'building bridges' as the BeatBearing was specifically designed as a tool to investigate the bridge between design studies (in particular the theory of embodied interaction) and design exploration. This research question is placed in the context of Fallman's 'interaction design triangle' [6] of design studies, exploration, and practice.

The BeatBearing has been designed to function as a tangible means of programming rhythm sequences, allowing 'hands-on' manipulation of the beat. This follows in the footsteps of many other drum sequencers such as the Roland-808. The BeatBearing also continues in the tradition of musical tabletop based tangible user interfaces such as the AudioPad [9] and ReacTable [8]. The BeatBearing differs from these by way of the simplicity of its design, the use of discrete, rather than continuous points of interaction, and the use of physical constraints built into the work surface.

## 2. THEORY
The BeatBearing has been developed as an ongoing project investigating how interaction design can be used in the development of new digital musical instruments. The particular theoretical focus or 'flavour' of interaction design practice that we focus on is that of embodied interaction [4] with emphasis both on the use of enactive interfaces for musical instruments [1][5] and tangible user interfaces [7]. This pair was chosen for their complementary nature, with enactive interfaces primarily concentrating on the embodiment of the user and tangible user interfaces on the embodiment of the interface.

Tangible user interfaces "give physical form to digital information, employing physical artifacts both as *representations* and *controls* for computational media" [10]. As a tangible user interface the BeatBearing aims to exploit a users natural ability at spatially reading and manipulating physical objects, and the design aim is to guide the users motion through the use of physical constraint and affordances. Advantages of this tangible method over the more conventional software approach include: multiple points of interaction; encouragement of multiple users; visual feedback is available to an audience, both from the instrument and the users gestures; the performer receives haptic feedback from the interface; and physical constraints can be used to assist the performer.

Enactive interfaces involve the exchange of enactive knowledge, a type of knowledge that involves 'knowing by doing' as opposed to symbolic of iconic knowledge. The potential benefit of an enactive interface is access to the embodied knowledge of the user, which allows previously learnt bodily skills to be applied in the interaction. Currently the BeatBearing is designed to not actively encourage enactive interaction. This has been deliberate, in order to investigate how to take a 'standard' tangible interface and modify the design to encourage enactive learning, thus creating a 'tangible enactive-interface' [3].

## 3. DESIGN
The BeatBearing has been designed with the use of various interaction design practices, including early physical 3D-sketching and prototype development, informal user-testing at regular stages in the design process, and demonstration videos [2] allowing feedback from a wide range of potential users.

Particular considerations taken into account in the design of the BeatBearing include: multimodal feedback, so users can see, hear and feel the instrument; easily modifiable hardware and software to allow for rapid prototyping; relative low cost compared to other tangible interfaces; multi-point interaction and multi-user capabilities; simplicity and robustness.

One particular design principle that has influenced the development of the BeatBearing is the concept of 'containment'. This principle aims to create interfaces that appear (though are not necessarily constructed) in a self-contained manner. This is in opposition to interfaces that are 'split-up', where a user is presented with a separate physical control surface, a screen, and an audio source all in different physical locations. The aim of containment is to encourage interacting with the device in a Heideggerian 'ready-to-hand' manner, and increase the possibility of the user experiencing 'flow'.

## 4. CONSTRUCTION
The BeatBearing has been deliberately designed to be both relatively low-cost, simple, robust and easily reconfigurable. As such the original BeatBearing was designed around the use of a flat-screen CRT computer monitor that was placed horizontally so that its screen acts as a tabletop. The use of a CRT screen that can be found cheaply (or even free as they are being replaced by LCD

monitors) is in contrast to the prevailing use of projectors in the construction of tangible user interfaces. In keeping with the use of the CRT screen, a suitably low-cost, simple and robust input method was used in the form of closing a switch circuit with a metal ball bearing.

The BeatBearing uses an Arduino board for interfacing with the computer. This allows cross-platform support, and easy development potential. The BeatBearing application is written partly in Processing (visuals) and partly in MaxMSP (sequencing). Again, this allows for high-level cross-platform development, and also for quick prototyping. The MaxMSP application sends out MIDI data that can be used to play samples either in another program, for instance Ableton Live, or even in a hardware synthesiser or sampler.

**Figure 1. The BeatBearing in use.**

Two different methods have been used to create the switch that the ball bearing closes. The initial prototype used two bars of thick wire as contacts. The second version (fig.1) uses metal washers that have been split in half. Although this works satisfactorily, the washers obstructed a great deal of the screen space, and also required more effort to manufacture and design for. The current solution is to etch copper tracks onto a transparent substrate of polycarbonate to create a transparent printed circuit board. This approach provides good design flexibility and is comparatively easy and inexpensive to manufacture.

## 5. PLAYING THE BEATBEARING

This section gives an account of what a user will encounter when playing the BeatBearing. A red line sweeps across the screen from left to right, disappearing off of the right hand side and appearing back on the left. When no balls have been place on the grid, no sound is made. A dark grey circle is shown on the screen directly underneath each hole, reinforcing that this is the site of interaction. When a user places a ball on the grid the dark grey circle directly under the ball turns white, indicating that the ball is now ‘on’. As the red line sweeps past the ball, a larger coloured halo is triggered around the ball. Each row has a different colour, which indicates a different sound: kick drum, snare, high-hat, and cowbell.

Examples of behaviours encouraged by the BeatBearing include: building up a rhythm note by note, randomising the rhythm by ‘smearing’ the balls across the surface, and two handed rapid placement of the balls.

## 6. FUTURE WORK

The main aim of the BeatBearing is to act not as a finished instrument, but as an explorative design that will act as a springboard from which to ask questions about the nature of embodied interaction and interaction design within the development of new digital musical instruments. As such this section is important in showing the BeatBearing’s worth as an explorative design. Future work on the BeatBearing includes:

- Use of ‘plug and play’ surfaces. Rather than using the same transparent tabletop interface for many different interactions, it is envisaged that a different tabletop can be selected for different applications and simply slotted into the main screen. Each surface would have different physical affordances that would encourage a particular task.
- Handing over the interface to another designer to allow them to develop an application on it. The aim is to compare the resulting design with one guided by the theories of embodied interaction.
- Exploring methods of using physical constraints in placing the balls. For example, can the balls be pre-arranged on a separate grid, so that they can be placed in one go on the active surface, thus creating a form of ‘physical memory’?

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