The Representation and Control of Time in Tangible User Interfaces (Summary of PhD Research)

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ABSTRACT
This paper summarises the author's PhD research on the representation and control of time in tangible user interfaces. The aim of the research is to create a theoretical framework that can aid the design of new temporal-media tangible interfaces.

Author Keywords
Tangible User Interfaces, Temporal Media, Interaction Design, Music, Digital Musical Instruments.

ACM Classification Keywords
H.5.2 User Interfaces: Theory and Methods

General Terms
Design, Theory

INTRODUCTION

The research question for the thesis arose from the experience of designing new tangible user interfaces (TUIs) for digital musical instruments. In some aspects TUIs provide an ideal method of interaction for music - they can be intuitive, accessible, multi-user and, most importantly, fun. In other aspects TUIs have some severe limitations that prohibit their use in a serious professional music capacity - namely scalability, flexibility and cost. The thesis aims to address these problems by creating a theoretical model of time in TUIs that can be used to aid the designer of new temporal-media TUIs.

BACKGROUND

Four research areas form the background to the thesis: tangible user interfaces, time understood through embodied interaction, interaction design and digital musical instruments. The Tangible User Interface paradigm, and the bringing together of 'bits and atoms' [2], forms the core of the research. In brief, tangible interfaces 'give physical form to digital information, employing physical artifacts both as *representations* and *controls* for computational media' [7]. A number of established theoretical models exist, and given that temporal-media TUIs are a subset of TUIs in general, these existing frameworks and theories provide a good starting point from which to formulate a new theory specifically addressing the design of temporal-media TUIs.

TEI 2010, January 24 - 27, 2010, Cambridge, Massachusetts, USA.
ACM 978-1-60558-841-4/10/01.

The particular form of temporal-media that has been chosen as a focus for the thesis is music, due to its nature both as a purely temporal medium, and also one with high levels of interaction involved in its creation. The approach taken in the thesis to understand how temporal-media is experienced is through the research of embodied interaction, particularly the work of Lakoff & Johnson on the understanding of time through metaphor [4].

The field of Interaction Design provides the methods and techniques used for exploring the temporal-TUI design space. Interaction design was chosen for its focus on the users experience in using an interface, as well as its physical sketching techniques that are well suited for exploring how users interact with the design over time.

Digital musical instrument research provides the context for the research, providing examples as well as functions for new temporal-TUIs. It was found that many TUIs using temporal media focused on music – examples include BlockJam [5], AudioPad [6] and ReacTable [3]. These instruments along with similar projects provided inspiration for the thesis, and considered as a group they form a rich design space worthy of further exploration.

ADAPTING THE MCRIT MODEL

As temporal-media TUIs are a subset of tangible user interfaces in general, it was decided to adapt an existing and proven TUI theoretical model. The Model, Control, Representation (intangible/tangible) (MCRit) [8] theory was chosen, as it logically divides a TUI into distinct components that can then be discussed in relation to temporal-media. Interaction designers tend towards using simpler theoretical models over those that are complex or prescriptive, and the MCRit model provides a level of analysis that encourages its use in practical design situations. The following sections describe the parts of the original MCRit model and how they have been adapted for interaction with temporal media.

Temporal-MCRit: Model

The model in the original MCRit theory is the computing system behind the control and the representation elements. Simply put, the goal of a TUI is to give the user the illusion of physically and directly manipulating the model, without experiencing the mediating layers of representation and control. In order to adapt the MCRit theory to specifically address temporal-TUIs, the question is asked 'how will a user understand the model?'. The proposed answer is that time is

understood through metaphor, so the most important factor in designing a model for a temporal-TUI is to address the metaphor used in the presentation of the model.

Temporal-MCRit: Control

The control element of the original MCRit theory describes the part of the TUI that the users manipulate. One of the aims of TUI research is to make the control element and the tangible representation elements as closely linked as possible, so that the illusion of interacting with a coherent and whole object is maintained. The problem with controlling a temporal system is that the thing needing to be physically controlled (time) is inherently not physical. The proposed method of controlling time is to either encapsulate time within an object (control through containment or embodiment) or to place a handle on time (control through a peripheral object).

Temporal-MCRit: Representation (intangible/tangible)

The representation element of the original MCRit model is split into both tangible and intangible elements. In a temporal-TUI it is proposed that the important aspect to consider is that time can only be represented through change. A perhaps obvious observation, but nonetheless important is that a static temporal-TUI would not be able to effectively represent temporal-media. An exception is the possible use of entropy as a means of statically representing times direction, but in general it is maintained that in a temporal-TUI the representation will incorporate some form of change, whether tangible (physical motion, modulation of form etc.), or intangible (motion of light, colour, sound etc).

THE BEATBEARING

The BeatBearing [1] tangible rhythm sequencer (see figure 1) has been used during the development of the adapted MCRit theory as a test-bed for the emerging concepts, and as a springboard from which concept designs can be developed. The BeatBearing is simple in operation, allowing the user to place ball bearings into holes on a 4x8 grid, constructing a rhythmical score played by a red line sweeping underneath the grid triggering sounds as it strikes the ball bearings. The simplicity of the design encourages the asking of 'what if…?' design questions, helping to populate the temporal-TUI design space with many possible design variations of the BeatBearing.

EVALUATION OF TEMPORAL-MCRIT

In order to evaluate the use of the temporal-MCRit theory as an aid to design, several variations of the BeatBearing have been developed, simulating possible design choices both with full knowledge and conversely with no knowledge of the temporal-MCRit theory. A user study has recently been completed; early analysis of the data indicates that application of the theory can result in temporal-media TUIs that are easier to understand and use.

FURTHER WORK & CONCLUSION

The next step in the PhD research is to use the temporal-MCRit model to generate a series of concept designs exploring the more detailed aspects of the theoretical model. The aim of the concept designs will be to validate the existing theory and to point out ways of both refining and expanding beyond the basic model. Currently, one design path for an advanced temporal-TUI is that of the 'Hierarchical-TUI', based upon the premise of nesting tangible elements (and time frames), allowing the construction of complex hierarchical structures. Early work on these concept design indicate that they may shed new light on many common design problems relevant to TUI design in general, including the scalability of data structures, saving/recalling workspaces and actuation of the tangibles.

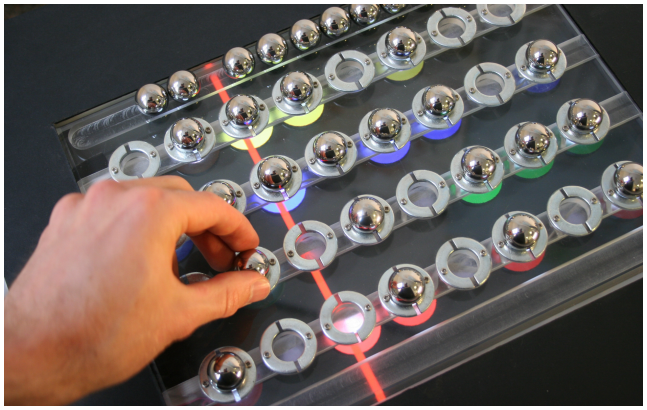

Figure 1. The BeatBearing Tangible Rhythm Sequencer

ACKNOWLEDGEMENTS

Thanks goes to Sile O'Modhrain and Roger Woods for PhD supervision.

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