

Marble Track Audio Manipulator (MTAM): A Tangible User Interface for Audio Composition

Alex Bean, Sabina Siddiqi, Anila Chowdhury, Billy Whited,
Orit Shaer, Robert J.K Jacob
Department of Computer Science
Tufts University
Medford, MA 02155, USA

ABSTRACT

We created a tangible user interface that allows children to create musical compositions through constructive play. Our Marble Track Audio Manipulator (MTAM) is an augmented marble tower construction kit where marbles represent sound clips and tracks represent different sound effects. To create musical compositions, children collaboratively build a marble tower and then play their compositions by dropping marbles into the tower. As marbles roll through the tower children can interact with the marbles and thus improvise and alter their musical compositions. By augmenting a popular toy, physically representing sound clips and effects as well as allowing improvisation, the MTAM system provides children with a creative, playful, and engaging encounter with music.

Author Keywords

Tangible User Interface, Children, Music, Augmented Construction Kit.

ACM Classification Keywords

H.1.2 [Models and Principles]: User/Machine Systems — human factors;

H.5.2 [User Interfaces]: Haptic I/O, H.5.5 [Sound and Music Computing]: Modeling

INTRODUCTION

During early childhood children learn about the world and express themselves primarily through play. Play and music are often related through activities such as music making, singing, and dancing. However, while many playful activities allow children to create music or repeat musical patterns only few allow children to compose music by manipulating pre existing sounds.

We introduce Marble Track Audio Manipulator, an augmented marble track construction kit that allows young children to collaboratively create musical compositions through constructive play. The MTAM system is based on a traditional marble track construction kit (see figure 1) that allows children to build a marble track tower, drop marbles into it, and watch the path the marbles take as they roll through the tower. Drawing upon the tangible interaction approach [7], we augmented such a kit so that marbles are

coupled with sound clips and colorful tracks represent sound effect. To create a composition and play it, children simply construct a tower and drop marbles into it. Children can also improvise and change their original composition while it is played.

By augmenting a popular toy (a Galt Super Marble Run), physically representing sound clips and effects as well as allowing improvisation, the MTAM system provides children with a creative, playful, and engaging encounter with music. Following, we further describe the design concept of the MTAM system and its implementation.

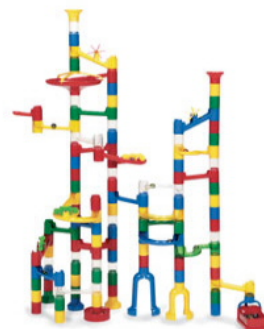


Figure 1, Galt America’s marble tower construction kit

RELATED WORK

Recent work in HCI research, demonstrated the usefulness of constructive tangible user interfaces in teaching children abstract concepts. Examples include a tangible programming language [3] and a tangible interface for simulating processes [8].

Similar concepts of creating music through construction of marble towers have been explored in both an early non-electronic marble-sequenced system for musical expression called *Musical Towers* [1], which was designed in the early 1950s by the Eames Office in Santa Monica and the recent Marble Track Music Sequencer [2]. While the Marble Track Music Sequencer focuses on the sequencing of sound clips our system focuses on manipulating audio by adding sound effects.

DESIGN CONCEPT

The MTAM system (see figure 2) consists of marbles and a set of tracks that can be assembled into a marble tower. Each marble represents a sound clip that is played in a loop from the moment the marble is dropped into the tower until it is removed. While rolling through the tower, when a marble passes through a colorful track, it triggers a sound effect that is then applied to the sound clip. Thus, by building a marble tower, users define a sequence of sound effects that are applied to any clip “sent through” the track tower. Furthermore, when a marble is rolling through the tower, users can stop the marble or delay it, for example by stacking their finger in a track, as well as drop additional marbles into the tower. Thus, users improvise on their original composition.

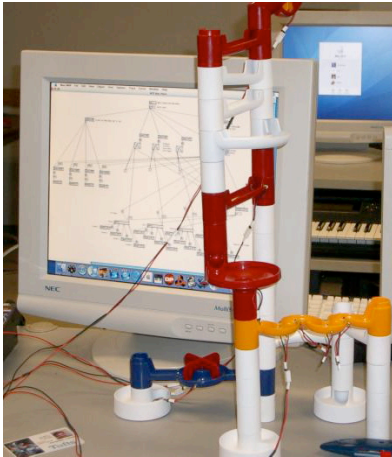


Figure 2, The MTAM system

Users can assign different sound clips to marbles by creating a play list. To create a play list a user “dips” a special marble in the sound pallet (see figure 9). Each area of the sound palette represents a different sound clip. After a play list is created, sound clips from the play list are associated with marbles based on the *order* in which marbles are sent into the tower.

USE SCENARIOS

The following use scenario drove the design of the MTAM system. The users of MTAM are mainly young children ages 4-12. They use the system collaboratively in a classroom or at home. At home, children may collaborate with a parent to construct a marble tower and observe what effects are applied to sound clips that are sent through the tower. In the classroom children may collaborate to create a play list and then build a tower that recreate an effect sequence played by the teacher. By building a marble tower and sending marbles through it, children experiment with sounds and create musical compositions in a playful, constructive and engaging manner.

DESIGN CONSIDERATIONS AND DESIGN PROCESS

The current prototype of MTAM (see figure 1) consists of an augmented off the shelf marble tower construction kit, a set of metal marbles, and a sound palette. This prototype is

the result of an iterative design process that included developing a series of prototypes and rapidly modeling the system. We constructed a number of low fidelity prototypes using cardboard and clay (see figure 3).

To rapidly model the structure and behavior of the MTAM system we used TUIML[5], Tangible User Interface Modeling Language. TUIML views the structure of a tangible user interface as a collection of tokens (physical objects that represent physical information) and constraints (physical objects that constrain the behavior of tokens) [6]. In the MTAM system, marbles are viewed as tokens because they represent different sound clips. The tracks are viewed as constraints because their physical properties constrain the behavior of the marbles – causing them to role in a certain way and take a specific path. We used TUIML models to refine the mapping of physical relations to token and constraint relationships as well as to identify and address boundary cases (for example a marble tower that consists of a single track). Following, we describe how we mapped physical properties to audio functions.



Figure 3, A low fidelity prototype (clay)

Musical Metaphors: Mapping Physical Properties to Audio Functions

In order to make MTAM intuitive for use by young children and help them visualize sound effects, MTAM physically represents sound effects using different track types. Here we describe how different track types are mapped to represent different sound effects based on their physical properties.

Delay

We represent delay using a curvy track. The time that it takes for a marble to pass each curve is used for timing the delay (i.e., determining the length of the effect’s intervals). The number of curves represents the number of the effect’s intervals.

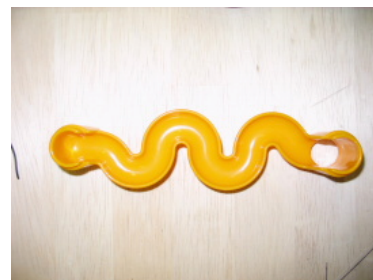


Figure 4: Curvy track represents the delay effect

Effect: Distortion

We represent distortion using a wheel track. The speed of the wheel is mapped to the amount of distortion applied to a sound. The faster the wheel spins, the larger the distortion.

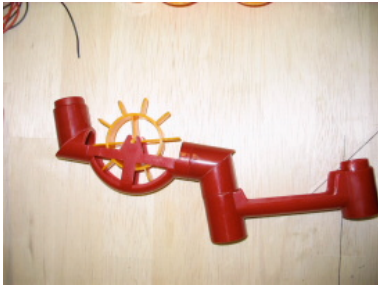


Figure 5: Wheel track represents the distortion effect

Effect: Reverb

We represent the reverb effect using a funnel track. The time that takes for a marble to drop through the funnel represents the reverb time (how long the reverb lasts).



Figure 6: Funnel to implement reverb effect

Effect: Filters – low-pass, high-pass

We represent filters using a random fork track. The random path the marble takes is used to determine which type of filter is applied – high-pass or low-pass.

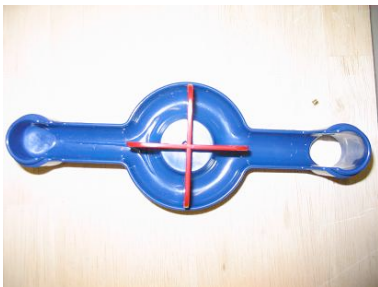


Figure 7: Fork to implement filter effect

No Effect

The straight or simple white tracks do not represent any effects. Rather, they are used for increasing the time a current pattern of effects is played without any new effects being added.



Figure 8: The sound palette is represented using a paint palette. A golden marble is used for creating a play list.

IMPLEMENTATION

To make the MTAM system practical for use by children at home and in a classroom we designed it to be inexpensive, robust and portable. To implement our design, we looked for a sensing technology that is capable of detecting the location of a marble within the tower, detecting the location of the golden marble within the sound palette and using a large number of cheap and replaceable marbles. Thus, we decided to use an I-PAC controller that maps hardware events into keyboard events. Following we describe our implementation in detail.

System Architecture

The MTAM system consists of twenty tracks, three metal marbles, a golden marble and a sound palette with six areas. Each area of the sound palette as well as each of the colorful tracks (that represent sound effect) is connected to an I-PAC input pin. The I-PAC controller is connected to a desktop computer.

Hardware

The I-PAC (Interface for PC to Arcade Controls) controller translates hardware events such as the pushing of a button, or closing of a switch, into keystrokes. It has twenty-eight programmable inputs. When a marble enters a certain track, it triggers a switch-closing event that is sent through the I-PAC to the PC as a keystroke. Each track represents a different keystroke, and hence the location of a marble within a tower can be detected. In order to create such switch-closing event, we connected two ends of a circuit to the sides of each track (see figure 9), so that when a metal marble is passing through a track it completes the circuit (and hence closes a switch), each such circuit is wired to an I-PAC input pin. A MAX program listens to the keystroke events sent by the I-PAC.



Figure 9: Track Circuits

Software

Max, an extremely flexible graphical programming environment for calculation and manipulation, was used to create a patch for interpreting incoming signals. Our Max patch listens to the keystroke events sent by the I-PAC, determines in which track the marble is, and which effect should be applied to the sound clip associated with the marble. In order to determine which sound clip is associated with the marble we keep track of the order in which marbles reach each track. The first marble will be associated with the first sound clip on the play list, the second marble to the second sound clip and so on. The sound clip starts playing in a loop as soon as the marble completes the circuit of the first track and a stop playing once the marble is removed from the base of the tower. The effects are additive. That is, they pile up on top of each other rather than turn off when the marble leaves each track. Thus, they are routed sequentially so that, for example, an echo is distorted or a filter reverberates.

We use Reason, a popular music synthesizing software that emulates a rack of hardware synthesizers, samplers, and mixers, to produce and manipulate sounds. The Max patch transmits MIDI Note On/Off signals to control which sounds to play and the effects are engaged using MIDI Control Change signals. For each marble, we condense the event into six basic commands: START, DIST, REVERB, DELAY, FILTER, and END. Max waits for the start signal and begins looping a sample. The next four commands represent each of the four effects. Max is able to listen to which effect comes in which order and turn them on in real-time.

Reason listens for MIDI, and once Max triggers an event, it is instantly heard by Reason, and the actual processing begins. The Reason patch (or "rack") contains one sampler with all sounds loaded in. To make sure that each sound can be heard moving through each effect, each sound has its own independent signal path to a "block" of effects. In order to allow for the 24 possible re-combinations of four effects, each effect block is made up of four *Combinators* creating a 4x4 matrix. By telling Max to engage one effect from each "row," the system can make any routing that the user can create.

FUTURE WORK

Evaluation Plan

We hypothesize that MTAM makes an intuitive and engaging tool for creating musical compositions by young children. We intend to evaluate its usability and expressiveness with actual users and apply the results in future prototypes. Our plan is to evaluate MTAM in both formal and informal learning environments (i.e. in the classroom and a science museum). In terms of usability we are interested to find out whether children can easily and collaboratively construct a tower that represent a musical composition, play the composition and improvise on it. We are also interested in investigating the usability of the sound palette feature. In terms of expressiveness we are

interesting in measuring the variety and complexity of children's compositions. How many different effects occur within a given time-span and whether effects are grouped into patterns.

Next Steps

We would like to refine the concept of the sound palette and investigate other ways to assign sound clips to marbles. We are also looking forward to improve the MTAM system based on user studies' results.

CONCLUSION

We introduced a tangible user interface that allows children to create musical compositions through constructive play. MTAM is based on a traditional marble track construction kit toy. It facilitates collaborative hands-on exploration by allowing users to create musical compositions, play them and improvise on them by constructing marble towers and dropping marbles into the tower. To make musical composition more intuitive, the system help children visualize sound effects and musical compositions by physically representing these abstract concepts. Thus, the MTAM system provides children with a creative, playful, and engaging encounter with music.

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