Bathcratch: Touch and Sound-Based DJ Controller Implemented on a Bathtub

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Abstract. Bathcratch is a music entertainment system that converts a bathtub into a DJ controller, allowing an average person in a bathtub to play scratching music. The system detects the squeaks made by rubbing the bathtub and associates them with several preset scratching phrases. In addition, capacitive touch sensors embedded in the tub allow the selection of scratching phrases and background rhythm tracks. Here, we provide a system overview and explain the design, user interface, music controller implementation of this system along with the feedback received for it during a public exhibition.

Keywords: Interactive Music System, DJ Scratching, Rubbing Interface, Acoustic Sensing, Squeaking Sound Detection, Capacitive Touch Sensor, Bathtub, Daily Life.

1 Introduction

The sounds that a bathtub makes when rubbed, brushed, or struck would be familiar to most anyone. We propose using the bathtub as an interface for creating music. To explore this concept, we developed Bathcatch, a system that detects squeaks made when rubbing a bathtub as well as sounds made by other such actions and converts them into musical sounds (see Figure 1). By embedding sensors that can detect touch and sounds, the bathtub is essentially converted into the user interface (UI) for a DJ controller. We intend for this to be a new way to make everyday activities more fun.

In this paper, we present a system overview and describe the method of interaction processing of scratching sounds with rhythm tracks. In addition, we describe the feedback received from the public at an exhibition where the Bathcratch system was installed.

2 Related Work

Considerable research has been conducted on music systems and UIs for DJ controllers, including inputs for scratching. For example of experimental turntables,

A. Nijholt, T. Romão, and D. Reidsma (Eds.): ACE 2012, LNCS 7624, pp. 44–56, 2012.

Fig. 1. Using Bathcratch in a Bathroom[1]

the DJammer [1], MusicGlove [2] and Wearable DJ System [3] are wearable UIs which allow users Air-DJ and scratching. Mixxx [4] uses ARToolKit to implement an augmented reality turntable that can play various sounds. D'Groove [5] has a turntable with force feedback as well as a DJ mixer that allows users to practice the fundamental techniques of DJing. Hansen uses the Reactable as an UI for DJ scratching [6][7]. Fukuchi's system uses a capacitive multi-touch surface and allows multi-track scratching [8]. The other turntable controller including commercial products for scratching is described in detail in Hansen's doctoral thesis [9].

Moreover, some research has been conducted on utilizing acoustic sensing in a UI. Scratch Input [10] detects scratching sounds and the associated finger motions using a piezo microphone attached to a wall, table, etc. Stane [11] attempted the detection of vibrations when the surface of a small device with built-in piezo sensors is scratched. This device also used various input patterns that depended on the vibration length. Skinput [12] uses sounds and machine learning to implement a UI. This system uses the human body itself as the UI by recognizing finger taps through vibrations transmitted along the skin surface using a piezo film rolled around the upeer arm. Lopes's system [13] uses sounds of finger, knuckle, fingernail and punch touches, in order to expand the input language of surface interaction.

3 System Overview

As shown in the overview in Figure 2, a contact microphone (a piezo sensor) is attached on the inside of the bathtub edge at the point where the right hand of the user would be placed. The microphone senses squeaks made when the bathtub is rubbed as the solid vibrations in the body of the tub. The sounds are processed by a software

[1] `http://www.youtube.com/watch?v=kp_0rPx-RSY`

called the Squeaking Sound Detector, which handles the rubbing input. For the left hand, capacitive touch sensors are provided, which allow various other inputs to be given to Bathcratch. These embedded sensors represent one novel feature of the system: they are invisible and do not impede everyday cleaning of the bathtub. A video projector installed above the tub projects virtual buttons over the touch sensors on the left side and marks the input area on the right for the contact microphone. Another novelty is the flexibility of the interactive display and its compatibility with an ordinary household environment. The Scratch Music Controller generates scratching phrases according to the detected squeaks and also changes the scratching effects and rhythm tracks in accordance with the touch inputs, as shown in Figure 3.

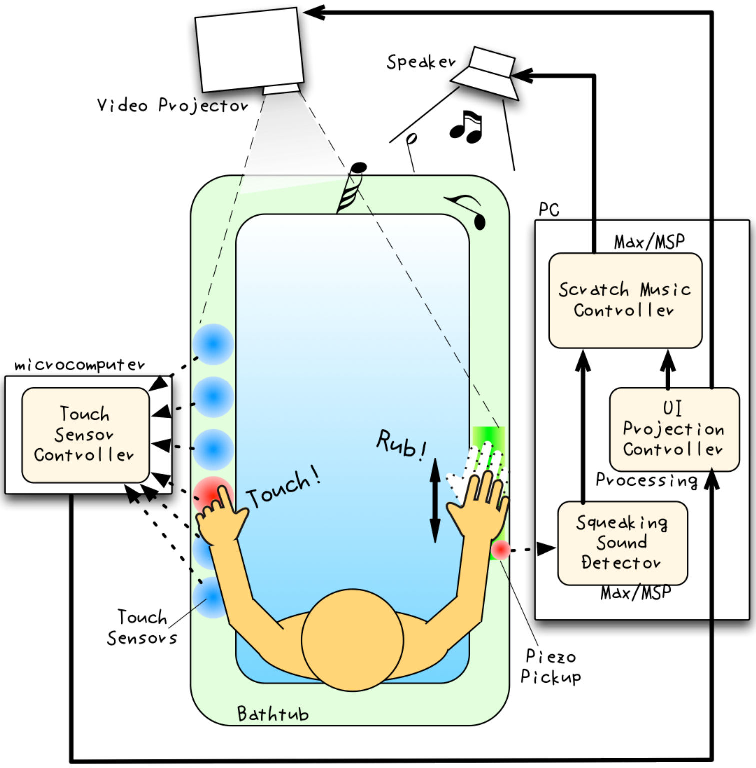

Fig. 2. Bathcratch system overview

4 Bathtub as Interaction Medium

4.1 Detecting Squeaks

This system must detect and differentiate between different squeaks and play associated scratch sounds. These squeaks have subtle differences depending on the

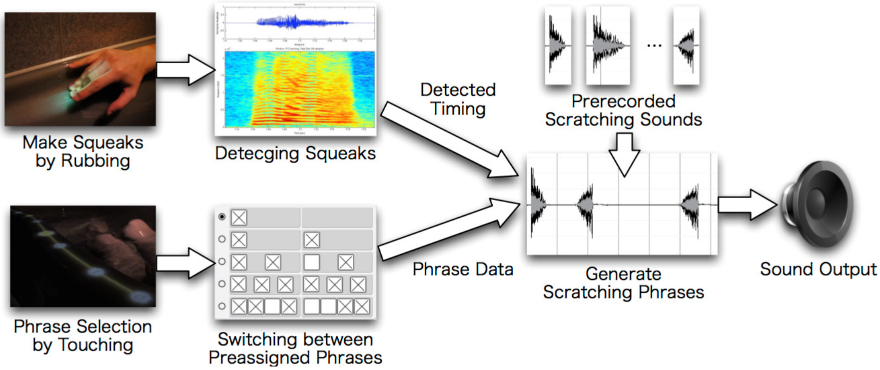

Fig. 3. Internal process of Bathcratch system

material of the bathtub and the way it is rubbed, for instance, with different finger angles, rubbing directions, and pressure values. However, these sounds have a fundamental frequency (F0) and specific harmonic structures, as shown in Figure 4. This spectrogram shows the harmonic structure and its continuous characteristic. We confirmed that the same characteristic exist for various bathtub squeaking sounds. The range of F0 is 100–600 Hz.

In addition to squeaks, taps and knocks on a bathtub also produce solid vibrations, although they do not have the same characteristics as squeaks; they have short durations and do not have a distinct harmonic component, as shown in Figure 5. The other sounds with harmonic components in a bathroom are human voices. However, we confirmed that a contact microphone attached to a bathtub filled with water will not detect a human voice. Thus, in order to isolate squeaks, the system must identify signals with a certain continuous harmonic structure and amplitude. However, the current system does not detect a continuous harmonic structure accurately. Hence, the external object sigmund~ in the Max/MSP software environment was used instead to estimate F0.

4.2 Detecting Touch Positions on Bathtub

The next input for this system is through touch positions on the edge of the bathtub, which allow switching between various functions while playing. We use capacitive touch sensors installed on the edge of the bathtub near where the user's left hand would be, as shown in Figure 6.

Usually, capacitive sensors respond to contact with water and are therefore used to measure water levels in tanks. Hence, recent multi-touch input devices tend to be incompatible with wet environments. However, the basic function of a capacitive sensor is to react to the presence of dielectric objects. Since water and the human

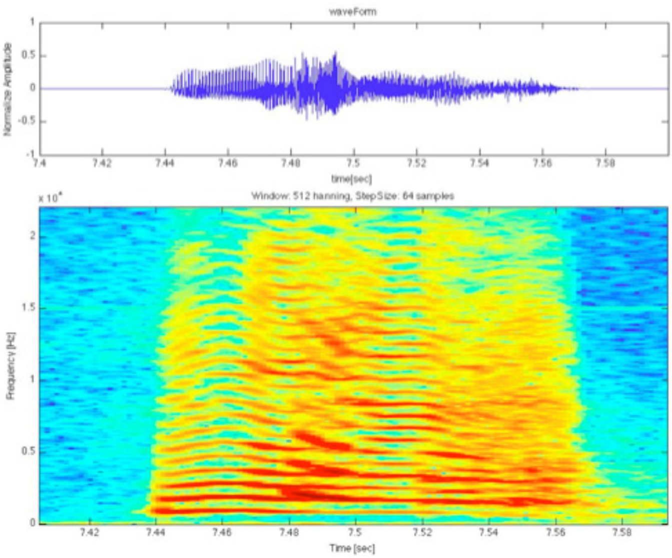

Fig. 4. Spectrogram of a bathtub squeak

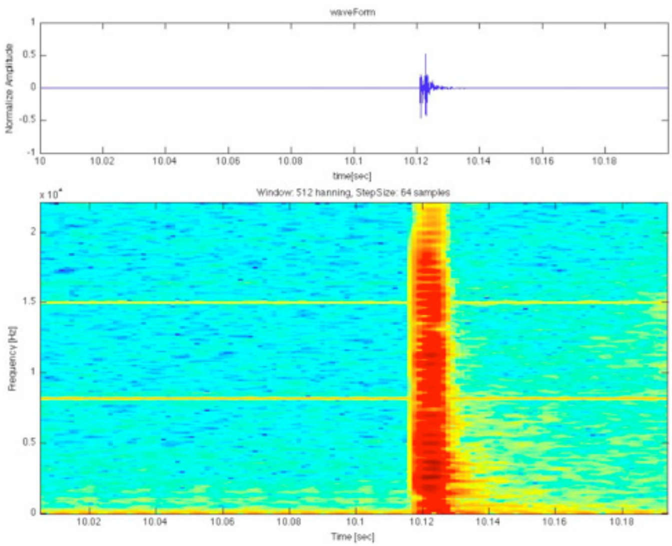

Fig. 5. Spectrogram of a bathtub knock

body have different relative permittivities, a capacitive sensor can indeed be used to detect human touch even when wet. Bathcratch uses the functionality to detct only human touches to change rhythm tracks and scratching sounds.

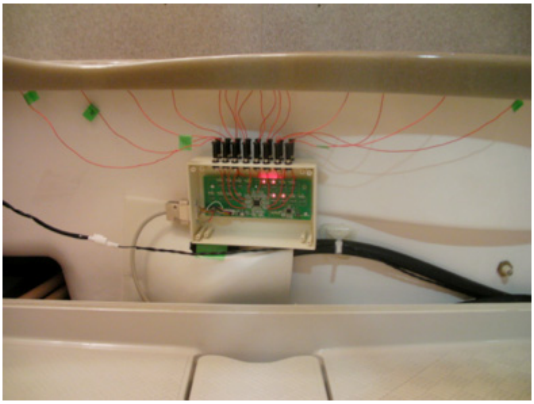

Fig. 6. Bathtub equipped with capacitive touch sensors

4.3 Projection Display

The embedded contact microphone and touch sensors are invisible and there no changes are made to the surface of the bathtub, as mentioned above. Instead, a video projector installed above the tub projects virtual interactive objects over the touch sensors and indicates a designated rubbing area near the microphone (see Figure 1). Note that the contact microphone (piezo sensor) can be installed anywhere on the bathtub edge as the solid vibrations are conducted quite well through the bathtub. The designated rubbing area is only intended as a visual aid to prompt the user to rub the bathtub.

5 Scratching Music Controller

5.1 Overview of Scratching Phrase Generation

The Squeaking Sound Detector and Scratching Music Controller were implemented as a Max/MSP patch, as shown in Figure 7. The checkboxes at the top are toggle switches to control the entire Bathcratch system in order to play specific rhythm tracks and to change the pitch of the scratching sounds. The faders control the volume of each scratching phrase and the master output. The checkboxes in the middle can be used to make scratching phrases, as described in the next section. To the right of these checkboxes is an option to set the tempo for the rhythm tracks and scratching phrases. The current Bathcratch system does not generate scratching sounds synchronized with the actual rubbing motion, but generates phrases synchronized with the tempo of the selected rhythm track. This is because of the latency in detecting squeaking sounds and the difficulty for users to rub and make squeaking sounds in synch with the rhythm track. Therefore, we designed the interaction of Bathcratch such that rubbing actions (making squeaking sounds) are first used to prearrange a set of scratching phrases, which can be switched by using the touch controls. Thus, any user can intuitively create DJ scratching sounds with relative ease. Note that we plan to implement synchronized, real-time scratching for experts in the next version of Bathcratch.

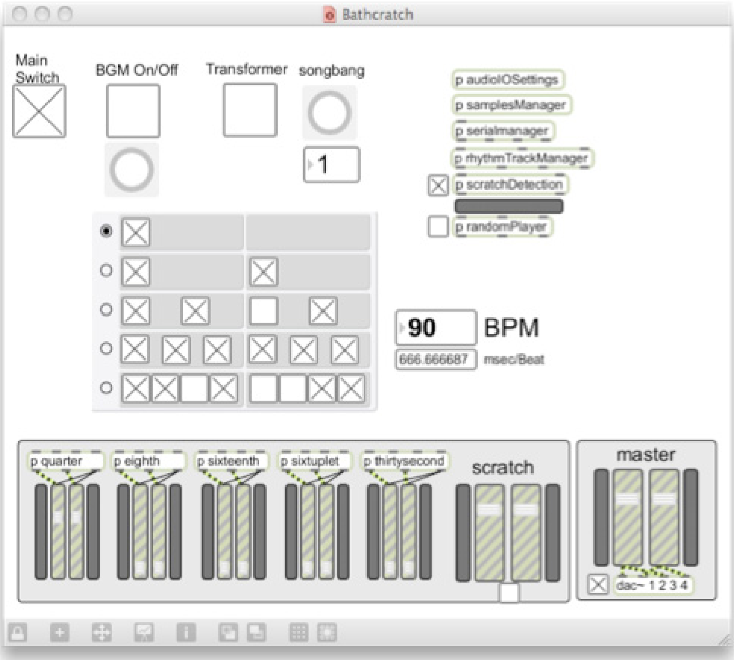

Fig. 7. Max/MSP patch for Bathcratch

5.2 Switching between Scratching Phrases

Five scratching phrases can be arranged freely based on half notes, quarter notes, eighth notes, sixteenth notes, and triplet notes. These phrases are prearranged with checkbox groups in the middle area of the patch shown in Figure 7, and icons representing each phrase are projected on the top of the touch sensors. Users can switch between the five scratching phrases by touching the projected objects. The five phrases are always played in the tempo of the current rhythm track, and Bathcratch outputs only the phrase selected by controlling faders for each phrase. Therefore, even if a user rubs vigorously and quickly, the output phrase is not changed. Furthermore, when a user selects another phrase before the current phrase has completed, a smooth transition is made using cross-fading effects.

5.3 Sound Sources and Effects for Scratching

Currently, this system plays prerecorded scratching sounds for each note in the scratching phrases. It is possible to assign a single sound source and slightly change each note in the phrase and to change the playback speed of the assigned source to create individual effects. By using these functions, the same sound source can be used in a phrase, although each note played is not the same. This reduces the number of sound files and materials necessary and makes it easy to create a phrase with a few sound sources. Even if only one sound file is assigned to all notes of all phrases, a wide repertoire of phrases can be realized by randomly changing playback speeds. Although individual assignments are performed before playing with this system, the randomizing mode can be controlled in real time using the touch inputs. This method of sound assignment and generating effects makes the phrases seem more natural and nonmechanical. In addition, actual DJs employ a variety of techniques on real turntables and faders, for instance, chirp scratch, forward/backward scratch, and transformer scratch. These functions of Bathcratch can be considered as simplified and modified functions that are carried out using actual turntables and faders.

5.4 Rhythm Tracks

We prepared a range of background rhythm tracks, for instance, OldSchool, Dubstep, JazzyHipHop, and Electronica, for the scratching performances. Users can select a rhythm track by sliding the track selection area over the touch sensors. However, the rhythm track manager always plays all tracks in parallel and only turns up the volume of the selected rhythm track while muting the others.

6 Demonstrations and Exhibit

The initial version of Bathcratch with a simple UI can seen on YouTube (Figure 1). The installation version of Bathcratch (Figure 8) with an improved UI (Figure 9) was exhibited at the 2010 Asia Digital Art Awards at the Fukuoka Asian Art Museum in Fukuoka, Japan, from March 17 to 29, 2011[2]. It was also been exhibited at the National Museum of Emerging Science and Innovation (Miraikan) in Tokyo on October 10, 2011. The UI was changed for this version since it was played on the sides of the bathtub (see Figures 10 and 11).

[2] http://www.youtube.com/watch?v=g-Z0visXQwo

Fig. 8. Bathcratch installation

Fig. 9. User-interface of Bathcratch installation

Fig. 10. Exhibition at the Fukuoka Asian Art Museum in Fukuoka, Japan

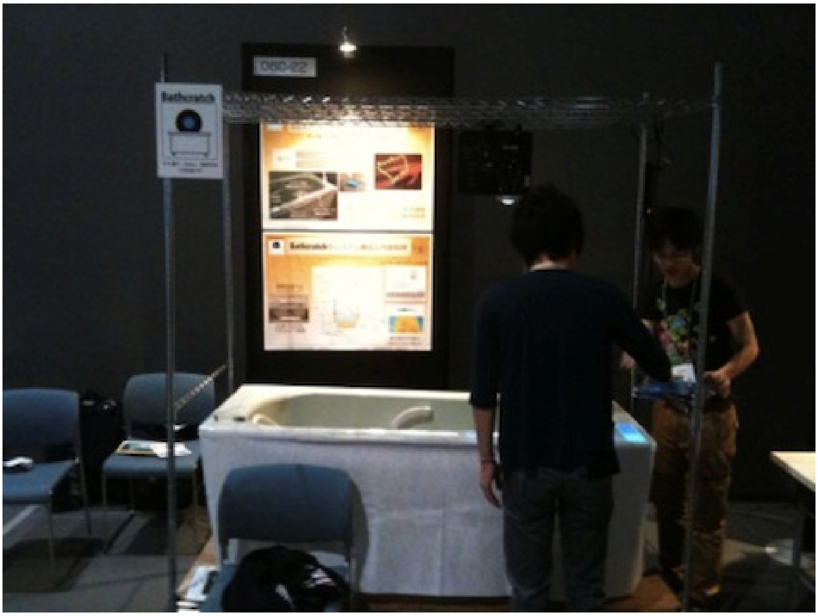

Fig. 11. Demonstration at the National Museum of Emerging Science and Innovation (Miraikan) in Tokyo, Japan

The UI of the installation version presents a movable gradation square for rubbing on the right edge, as seen when standing to the side of the bathtub. The buttons used to select scratching phrases are along the left side of the square rubbing area. Each button represents a musical note, for instance, a quarter note, an eighth note, a sixteenth note, and Etcetera, which represents a fundamental note of a scratching phrase. Users can select and change phrases by touching these buttons. Moreover, on the left side, there are effect buttons to change the pitch of phrase notes as well as a sliding selector and a mute button for the rhythm tracks. Each icon of the sliding selector represents the characteristics of the associated rhythm tracks in terms of color and icon design[3].

We provided a wet sponge along with the setup to allow users to wet their fingertips and create squeaks when rubbing the bathtub. It was placed near the square area designated for rubbing.

A few drawbacks were noticed during this exhibition. One involves setting the input gain for the piezo sensor when there is no water in the bathtub. Turning a rhythm track up at high input gain causes misdetection of F0 because of interference with the notes from the rhythm track. This phenomenon does not occur when there is water in the bathtub. Therefore, we think that water acts as an attenuator that blocks surrounding sounds. Another problem is that some users could not understand the difference between the rubbing UI and the touch UI. Most of them did not rub but slid their fingertips lightly on the rubbing area despite the fact that they needed to make squeaks. Fortunately, the exhibition staff explained the operation of Bathcratch and showed users how to use it. This indicates that we need to improve the UI to more clearly indicate that a rubbing motion that produces squeaks is necessary.

7 Discussion

In Japan, there is a unique bathing culture. A lot of people feel bathrooms as amenity spaces with staying. The half-body bathing is typical of it. Hense, general bath modules in Japan have a feature to expand various functionalities with optional equipments. For instance, ceiling speakers for listening to music, ceiling illuminations with spotlights for room effects, a mist sauna apparatus for beauty and fine skins. People read books and listen to music while in half-body bathing or bathing with mist sauna.

The important point of Bathcratch is to make bathing in daily life more and/or inexperienced fun. This system needs audio equipment for output sounds, capacitive touch sensors, a contact microphone, a video projector and a PC for measurement and control of this system. Most bathtub in Japan mentioned above has a removable side panel. Optional equipments, for instance, whirpool and heart rate monitor, can be installed inside a bathtub from the side. Figure 6 shows a bathtub removed a side panel, installed capacitive touch sensor unit and red lines as sensor electrodes. A contact microphone can be also installed in this space. The installation of these

[3] `http://www.youtube.com/watch?v=5F5utOrVlcI`

equipments are already available to existing bathtub. Only a video projector is not ease to install in above a ceiling. However, pico-projectors have a remarkable development at the present. We think a waterproofed type of pico-projector, which is ease to install beneath a ceiling, will be released sooner. Therefore, we also think Bathcratch will be released as a practical entertainment system.

8 Conclusion and Future Work

In this paper, we described Bathcratch, which allows anyone to create DJ scratching sounds by rubbing a bathtub. This system utilizes the squeaks produced by rubbing smooth surfaces—a bathtub in this case. The paper also describes the UIs used for rubbing and touch inputs, which were implemented with a projector, along with the systems for detecting squeaks and controlling the scratching music. Bathcratch was presented at several exhibitions, where it was awarded some prizes.

Squeaks produced by rubbing smooth surfaces are quite common in everyday life, for instance, when polishing mirrors, windows, bathtubs, and dishes. Therefore, this system can appropriate a casual action in daily life as a means of entertainment. People can control various devices via rubbing motions and squeaks. Moreover, the input functionalities of this system can be increased by including rubbing length and timing as additional parameters.

As a future work, we plan to simplify this system and analyze squeaking sounds accurately in terms of the timing. We will also analyze the feasibility of including various other aspects of rubbing motion as additional input parameters for a general UI, for instance, the number of rubbing fingers, rubbing direction, and the intensity. Finally, we would like to improve Bathcratch's entertainment functionality, including the music controller, and further explore the concept of entertainment with common objects found in a typical home.

Acknowledgments. This research was partially supported by a grant from Hayao Nakayama Foundation.

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