A Rapid Prototyping Toolkit for Touch Sensitive Objects using Active Acoustic Sensing

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ABSTRACT

We present a prototyping toolkit to create touch sensitive prototypes from everyday objects without special skills such as writing code or designing circuits. This toolkit consists of an acoustic based touch sensor module which captures resonant property of objects, and software modules including the one which recognizes how an object is touched by machine learning, and plugins for visual programming environments such as Scratch and Max/MSP. As a result, our toolkit enables users to easily configure response of touches with a wide variety of visual or audio response. We believe that our toolkit expands the creativity of non-specialist such as children and media artists.

Author Keywords

Sensors; acoustic classification; tangibles; machine learning; prototyping; support vector machine; piezo-electric sensor; OpenSound Control; visual programming.

ACM Classification Keywords

H.5.2 [Information interfaces and presentation]: User Interfaces - Graphical user interfaces; Input devices & strategies.

INTRODUCTION

Touch input is commonly used in many consumer products such as mobile devices or tablets. However making own touch sensitive prototypes is still challenging for people at large. This is because making touch sensitive prototypes usually requires special skills such as writing code and designing circuits.

Prototyping tools targeting touch sensitive prototypes have also been proposed. Most works construct touch sensitive prototypes by attaching conductive elements such as thumbtacks [2], vinyl cut copper foil [6] and printed conductive patterns [3, 4, 1]. In these works, the sensing capability depends on the number of electrical elements or patterns. Therefore, if users want to use more number of touch gestures, its hardware configuration become more complex. Moreover, the replacement of sensors is cumbersome.

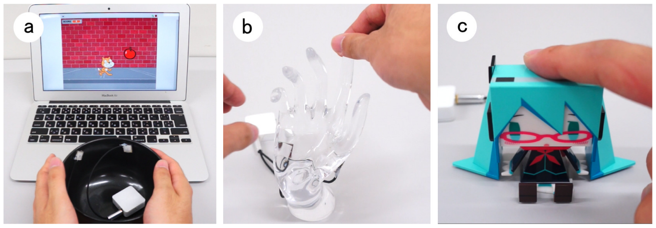

Figure 1. Examples of touch sensitive prototypes made by our toolkit: a) game controller from ceramic bowl, b) musical instrument from hand shaped acrylic object, c) music player from character figure.

In this paper, we present a rapid prototyping toolkit based on acoustic touch sensing technique that utilizes resonant property of everyday objects [5]. This approach requires only attaching a pair of piezo elements to an object; touch gestures to the object can be easily trained and/or modified by using machine learning. This enables users to create touch sensitive prototypes as shown in Figure 1 rapidly and flexibly even by non-specialists.

IMPLEMENTATION

Our toolkit consists of a sensor module and software modules.

Sensor module

We implemented an original sensor module (Figure 2) which extracts the resonant feature from objects. A microcontroller (NXP LPC11u24) controls a programmable wave generator (Analog Devices AD5930) to emit sinusoidal sweep signals from 20k Hz to 40k Hz in 5 msecs. This signal vibrates the piezo transducer and the vibration conducts the object. The vibration response is captured with a piezo microphone and its envelope is detected and amplified in the module. The microcontroller samples 150 points acoustic feature vector from the envelope and sends it to PC (Apple MacBook Air) via Bluetooth Serial Port Profile.

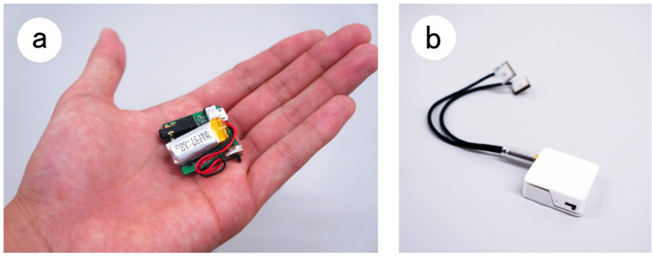

Figure 2. Our sensor module. a) The core whose size is 32 mm (W) x 32 mm (D) x 12 mm (H), b) the module with a case and cables.

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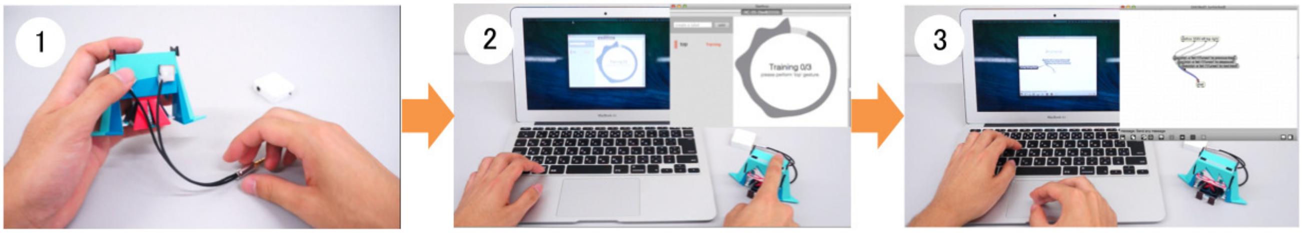

Figure 3. Workflow using our toolkit: 1) attaching the sensor module, 2) training touch gestures, 3) configuring response (using Max/MSP in this case).

Software modules

We implemented a recognition software and plugins for Scratch and Max/MSP as software modules. The recognition software classifies touch gestures using Support Vector Machine. The 150 points feature vector from the sensor module is sent to the classifier 30 frames per second. The recognition software communicates with the plugins for Scratch and Max/MSP via HTTP and OpenSound Control (OSC) respectively, and sends the recognition result to them. For Scratch, the plugin behaves as a condition block which returns true or false on the recognition result. For Max/MSP, the plugin behaves as a Max object which emits a bang corresponding to the recognition result. The user can set the label names as the arguments in the Max object; the Max object has outlets each of which corresponds to each label. When the plugin receives a recognition result, the Max object sends a bang from the outlet corresponding to the recognition result.

WORKFLOW

Figure 3 shows the workflow using our toolkit. Our toolkit can be used in three steps: 1) attaching the sensor module, 2) training touch gestures, and 3) configuring response. Note that any of these steps do not require any special skills such as writing code or designing circuits. Thus, our toolkit is readily accessible to everyone for prototyping touch sensitive objects.

1. Attaching the sensor module

First, a user attaches a sensor module to an object that the user wants to make touch sensitive, making the both of two piezo elements adhere to the object using double-sided tapes. One limitation is that the objects that can be made touch sensitive using this toolkit are limited to hard and handheld sized ones as [5] describes.

2. Training touch gestures

Second, the user trains touch gestures using our recognition software. When the software starts, it automatically trains “no touch” gesture. After “no touch” gesture is trained, the user can begin to define a new touch gesture with entering a label (i.e., the name of the gesture being defined) into the text box on the software. At the moment, the training of the touch gesture will start. During the training, the user preforms the touch gesture several times (e.g., five times); the software always compares the current feature vector with the feature vector of “no touch” gesture. If the difference between them exceeds a certain threshold, the software recognizes it as the object is touched in a certain manner and trains the system with the current label. After the training is finished, the software starts the recognition of touch gestures.

3. Configuring response

Last, the user configures the response of the touch by external software such as Scratch and Max/MSP. For example, by connecting the Max object’s outlet to a shell object through a message object which controls iTunes (e.g., *osascript -e ’tell application \”iTunes\” to play’*), the user can make a physical music player. For experts who have a programming skill, the result from the recognition software can be sent as OSC messages to their program. Therefore other environments such as Processing and Arduino also can be used to configure the response with more rich expressions.

FUTURE WORK

Currently, this toolkit is used by a few people who are interested in interactive arts for trial use; we are gathering their feedback about its usability. In future work, we plan to conduct a workshop targeting children or media artists. In the workshop, we will evaluate the usability and explore how people’s creativity can be expanded by the toolkit.

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