An Exploration on Mobile Interfaces with Adaptive Mapping Strategies in Pure Data

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Abstract

This paper presents initial Pure Data abstractions as a part of a toolkit system for the implementation of PESI research project. Research focuses on mobile interfaces in participatory interactive art context. Designing an easy to use/control interface for an mobile communication tool, allows participants to become more familiar with the collaboration process and experience a way of making music with a mobile device. A wide range of complexity of control-mapping layers and their integration in such a system, makes the design very challenging process. The implementations of control layer Pure Data abstractions in Maemo Nokia N900 device are described in this paper.

Keywords

Pure Data, mobile interfaces, adaptive mapping, interactive gestures, participative music.

1 Introduction

Mobile interfaces challenge the new interaction possibilities, applying alternative solutions to groups of users. Especially mobile phones aid the participatory augmentation in new media practices. They do not only make use of the technology but also emphasize the role of interactive gestures and its relationship to interaction in human actions [1, 2]. Designing an easy to use and easy to control interface for an mobile communication tool, allows participants to become more familiar with a participative music experience. There are, however, a number of challenges in combining multi-users with event-based interactions in the development of interactive mobile interfaces. A toolkit system, facilitating new forms of interaction and of enactive engagement of the multi-users are needed. In this context, the main emphasis of our current research, *The Notion of Participative and Enacting Sonic Interaction (PESI)*, is to develop computational models for musical interactions, extended with sensors and mobile devices for implementation in Pure Data environment.

In a wider scope, research aims to develop methods to analyze participant's control gestures, and use the intended results as a ground for defining next probability condition of the audio synthesis module to support, provoke or challenge the collaborative music experience. In its present phase, research focuses on adaptive modeling algorithms for exploration of alternative mapping strategies with mobile interfaces. This paper introduces one-to-many adaptive models for 2 dimensional control layers and their implementation as Pure Data abstractions in Maemo[1] Nokia N900 mobile device. Pure Data implementations also include abstractions that merge sensory input data of N900 mobile device with the toolkit system.

In the following sections, our main motivation is described in detail. The dynamic mapping strategies and interactive gestures on mobile devices are discussed further. The paper concludes with a presentation of the implementation and the future directions of our research.

2 Motivation

The importance of parameter mapping in digital musical instrument design is discussed earlier [3]. While one-to-one mapping has been one of the most focused control strategies, scholars also developed alternative control layers with more dynamic features [4]. In dynamic control mapping implementations, the system takes some input and produces a large number of output parameters. This process can be interpreted as a common goal for dynamic mapping layers in interactive systems.

[1] http://maemo.org/

Recent systems, such as *dynamic modulation system* [5], focus on real-time conditions integrating complex mapping with two dimensional control interface. Dynamic modulation system notes all control parameters as the sound modulators and applies the related mapping in one single matrix. This modulation matrix dynamically changes in real-time through performer's control action in gesture space. The system itself is an implementation of a previously developed mapping strategy [6], which is based on a structure where control parameters of synthesis algorithms associated with specific coordinates in two-dimensional space. Sounds are generated as a result of the original parameter sets which are weighted by their relative distance in the gesture space.

Another set of control layers, *dynamic independent layer system* [4] was developed with a slightly different approach, focusing on expressive forms in control of musical and visual structures. Their mapping strategy allows expressive control of a high dimensional parameter space using a low dimensional gestural controller. It seems entirely appropriate to state that performers should be freed from multiple control gestures in real-time performance situation. In our earlier study, we brought up this need for discussion within the framework of advanced control strategies in interactive performance systems [7]. We emphasized especially live-electronic performances where these systems could provide a dynamic mapping layer, formed and encoded by the event of other control layers. Similar type of need was also discussed in a trained, self-supervised machine learning framework [8].

All of these mapping strategies offer a promising expectations in terms of achieving sounds with a rich variety of structure; however, control gestures hierarchically and sequentially positioned before the mapping, as they [*bang*(and feed the system to flow the control data through the interconnected modules. While adaptive control strategies form the core part of the PESI research in its implementation phase, research gives equivalent weight on studying control gestures and their employed interaction with mobile interfaces in order to provide tools and techniques to facilitate related interactive gestures.

In current research, our main motivation is to explore adaptive mapping strategies designed as control modules in mobile interfaces and understand how their control gestures can be effectively built in mapping layers. Related gesture types are introduced in section 4.

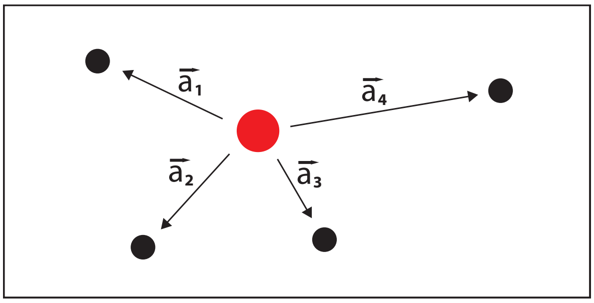

Figure 1: Touch position and 4-points

3 4-point Dynamic Adaptive Mapping

The Self-Supervising Machine [8] and *Dynamic Modulation Matrix* [5], in a broader scope show similarities with 4-point Adaptive Mapping Module developed in PESI research project. The former introduces a design of an automatic supervisor based on adaptive mapping network, and the latter takes into account the weighted sum of the relative distance of the original touch positions.

The idea with 4-point dynamic adaptive mapping strategy is to achieve challenging and complex mapping possibilities with applied simple rules. On mobile device touch-screen interface, touch with fingertip determines the appropriate gesture. In this two dimensional space, outline is set by the coordinates of the corner points, which are the position of 4 points on a touch screen surface. When a fingertip touches on the surface its position is calculated based on the corner 4 points. The position of the corner 4 points is fixed, therefore each time you apply the same touch gesture, touch position results in the same output. The structure of our dynamic adaptive mapping strategy is based on positioning 4-points on the same surface with a possibility to change their coordinate values based on certain events. As the change in direction of a touch position is tracked on the mobile surface, the distance of the same touch position to these new 4 points can be a source for creating alternative mappings to input. Touch position at N900 is tracked through Yves Degoyon's Pure Data object, [grid].

Once the 4-points are set in the abstraction (see Fig.1), the module continuously compares the vector position of the touch input with the vector position of each point and outputs the closest point

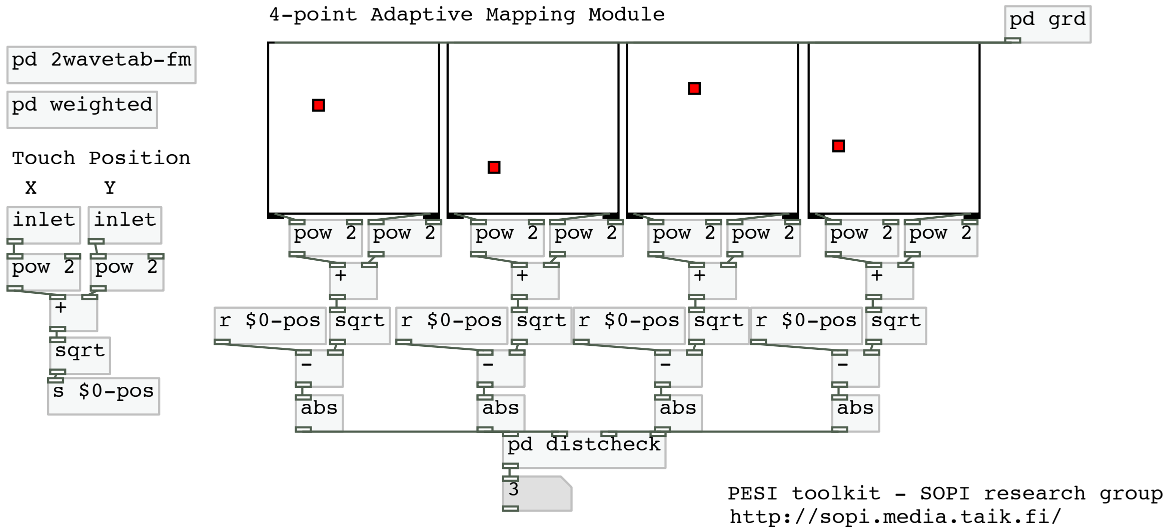

Figure 2: Pure Data abstraction for 4-point Adaptive Mapping Module.

id and the distance value. In this module, one gesture input is intended to be used to control or affect on more than one musical parameter. While employing this divergent mapping, one to many strategy [9] in our control module, we still wanted to keep the overall balance of the connected parameters. Therefore, mapping the weighted average of the 4-points distance to the related audio synthesis module brought up the intended musical results.

3.1 Weighted Average Abstraction

The standard definition of the function is called weighted average, commonly used for performing an average operation assigning a weight for all the relevant items involved in the average. 4-point Adaptive Mapping Module (see Fig.2) computes the average of four distance values (touch input distance to 4-points) using the vector positions of the 4-points. All the variables are nonnegative and they add up to one. In order to normalize the result, variables are divided by the sum of the distance values:

$$\bar{x} = \frac{w_1x_1 + w_2x_2 + w_3x_3... + w_nx_n}{w_1 + w_2 + w_3... + w_n} \qquad (1)$$

The closest point to the touch position has a large weight on the distance of the other points. In a regular average calculation each value is not taking into account just as being a value; a big value affects the data gets more weight, comparing to the other relevant items in the data. Figure 3 shows the weighted average abstraction. In order to set the closest distance as the biggest value in this weighted average calculation, we subtract the distance by the maximum vector position on that specific touch-screen interface and take the absolute value of the result. Currently, weighted average values are mapped to the frequency parameters of four wavetable fm synthesis modules, which are identical with their patch structure.

4 Interactive Gestures on Mobile Interface

While we have been focusing on touch as one of the appropriate gestures, the research considers the functional movements of musicians [10] and recreate abstracted sound-action relationships for novice participants with commonly-used mobile devices. The nature of mobile devices brings forth a form of interaction with graspable interfaces, where interaction can employ semaphoric hand gestures; dynamic hand or arm movements [11, 12]. Focusing on semaphoric gestures led the design strategies in PESI to be developed further to allow eyes-free style interactions, enabling participants to focus more attention on their mobility and interaction with other participants instead of having continuous visual interaction with their mobile devices [13,14]. Therefore, the sound-action strategy in PESI is focusing on main action as tilt to change state. Participant's tilt to change state of their action determines the similar control features of musical instruments in PESI system.

In an earlier study, before the actual design phase of the audio synthesis modules, we decided to inquire about preliminary expectations for the sonic characteristic of a graspable, mobile device. We conducted a series of experiments with 14 participants already presented our results [15] Furthermore, we had a chance to implement our findings during the PESI research design process.

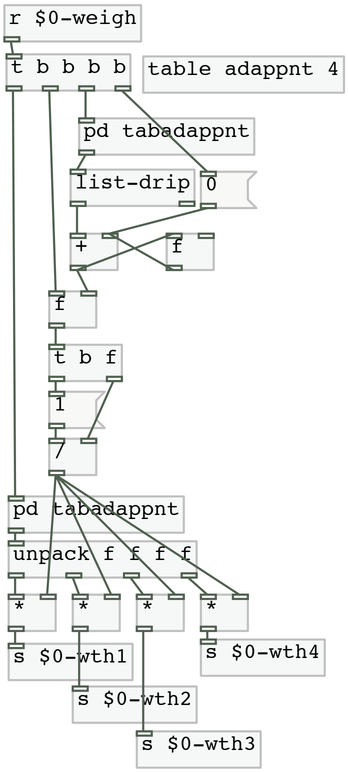

Figure 3: 4-points weighted average abstraction.

Sound-action expectations with mobile devices already began to provide certain gesture types to be linked with certain features for the sonic behavior of mobile devices. Shaking, pointing to a direction, circular movement, lifting up, dropping down, squeezing, rolling, scratching were the most common expressive gestures observed in our previous study [15].

4.1 Sensory Input - N900

In relation to these expressive gestures, the gesture data is strongly linked to the sensory input modules of the mobile devices. In order to receive, control and stream sensor data, we implemented Pure Data abstractions for Maemo N900 device. Currently, we can get the touch position, accelerometer, ambient light sensor data and control vibration level, color range of LED display together with the brightness of six backlight LEDs.

The accelerometer data at N900 is sysfs file information, which is a virtual file system provided by Linux 2.6 [16]. Sysfs exports sensor and driver data that can be used by all mobile device applications. The three coordinates of accelerometer sensor is written in *coord* text file provided on one line and separated by white space [16]. The values are in mG (milli G). 1000 = 1 G. The path to access this file is: */sys/class/i2c-adapter/i2c-3/3-001d/coord*. Pure Data abstraction in Figure 4, simply reads coord text file in Maemo through the [shell] object and sends accelerometer values as a packed, concatenated list. The raw data is further used to calculate related accelerometer features; magnitude, pitch and roll angle values. Certain position of the mobile device can be set as an offset position with these abstractions. Besides the accelerometer data, ambient light sensor data is accessed by reading another sysfs file; */sys/class/i2c-adapter/i2c-2/2-0029/lux*. In a similar way, these Pure Data abstractions can access the vibration module and vibrate the device for certain moment (see Fig.5). Together with the vibration module, full color range RGB LED display can be controlled (see Fig.6) and as a result, haptic and visual feedback modalities are integrated in PESI toolkit application.

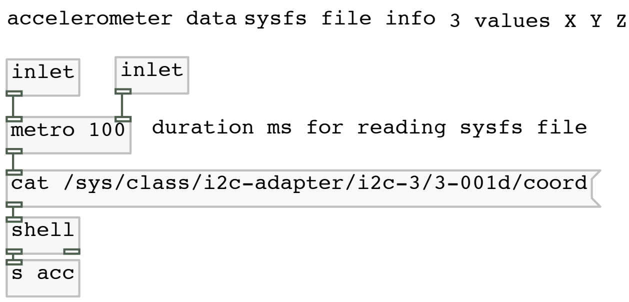

Figure 4: Pure Data abstraction for receiving N900 accelerometer data.

Reading a system file continuously in order to get sensor data, slows down the interaction between mapping and the synthesis modules. Manipulating certain audio related tasks through dynamically changing sensory data results in problems in maintaining functional, usable and stable Pure Data runtime. However, being able to compile and run a complete Pure Data version in Maemo N900 makes it possible to prototype our research implementations.

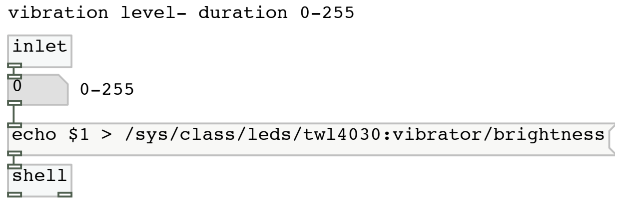

Figure 5: Pure Data abstraction for controlling N900 vibration module.

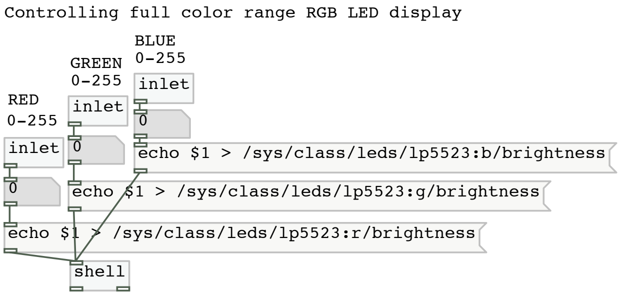

Figure 6: Pure Data abstraction for controlling RGB color range of the N900 LED dispay.

5 Conclusion

We have presented our 4-point adaptive mapping strategies in 2 dimensional touch screen interfaces. Simply changing the coordinates of these four points while applying the same touch gesture can result in a variety of outcomes. This mapping strategy has the possibility of adapting itself to the changing conditions while staying in a controlled environment throughout its weighted sum module. 4-point adaptive mapping strategy is developed for only touch gesture input on 2 dimensional interfaces. Moreover, other types of control-data in PESI system and the conditions of interaction among the participants can be cumulated in a centralized network. Throughout the analysis of this data, an adaptive system can continuously monitor certain events during a participatory music making process and affect on the audio synthesis module to support, provoke challenge the collaborative music experience. It is one of our research objectives to investigate alternative adaptive systems and their possible integration in our interactive system.

Mobile devices provide a variety of possibilities to investigate the sound and action relation besides the touch gesture. Interactive gestures can maintain the eyes-free style interaction in the participatory music experience. The Pure Data abstractions presented in this paper make it easy to access the sensory input data in N900 mobile phones and process sensor data in the actual device or stream it to other devices. These abstractions are helpful in understanding the expressive gestures that participants can make using mobile devices as tools for creating and experiencing music in a collaborative and participatory context.

The recent strategic changes in Nokia have resulted in a decision to stop the development of the Maemo and the more recent MeeGo operating systems. It is in our intention to integrate the PESI toolkit with other possible mobile operating systems, Android being a likely candidate.

6 Acknowledgements

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