A Tool for Configuring Mappings for Musical Systems using Wireless Sensor Networks

Masters Thesis Proposal in Music Technology of Vijay Rudraraju

Overview

A digital musical instrument (DMI) is an interactive musical system that contains both a control mechanism and a sound-generating mechanism (Miranda & Wanderley, 2006). The relationship between input gestures picked up by individual sensors that make up the control mechanism and the sound-generation mechanism (usually an algorithm) is referred to as a mapping. It has been shown that the quality of the mapping is the determining factor in the quality of a DMI (Hunt, Wanderley, & Paradis, 2003).

When designing DMIs in collaborative projects involving engineers, performers, and composers with different skill sets it is important that those without programming expertise are able to experiment with mappings on their own (Malloch, Sinclair, & Wanderley, 2009). For this reason, the Digital Orchestra Tools (DOT) mapper was developed at the Input Devices and Music Interaction Lab (IDMIL) as part of the Digital Orchestra Project (Pestova et al., 2009) to provide a dedicated process for defining mappings using an intuitive graphical user interface (GUI).

The DOT mapper GUI auto-detects devices and their configurations in the network and then lists the control parameter names on the left side of the screen and sound-generating parameter names on the right side, allowing a user to define mappings between distributed devices by drawing lines between control parameters and sound-generation parameters.

This method works well for devices that are DMIs with relatively small collections of heterogenous sensors. However, in the case of musical systems involving many performers each wearing many sensors or environments with hundreds of similar sensors arranged throughout a large space, using text-reliant GUIs (or full-blown programming environments) to configure mappings becomes impractical. It becomes difficult to comprehend how small changes to a mapping affect the larger scale structure of the system when a mapping involves connections between hundreds of parameters (Norman, 1988).

The aim of my project is to create an alternative mapper interface specialized for configuring mappings over large numbers of distributed devices and sensors.

A large number of distributed wireless sensors that act as a single system is known in academic literature as a "wireless sensor network" (WSN). WSNs are an active field of research in a diverse array of research fields including defense, environmental monitoring, energy/heat systems, and structural engineering. However, these applications tend to use WSNs as monitoring mechanisms as opposed to control mechanisms and therefore do not have to contend with the problem of designing mappings (Yick, Mukherjee, & Ghosal, 2008). The development of novel GUIs to allow an artist to configure mappings for large WSNs efficiently is essential to their feasibility as real-time control mechanisms in interactive musical systems.

Background

There are an increasing number of interactive musical systems being created using WSNs. One such system that utilizes radio transmitters held by a large number of dancing participants to direct the music and lighting at a dance party is outlined in a paper by Mark Feldmeier and Joseph A. Paradiso (Feldmeier & Paradiso, 2007). The system mapping was programmed using

the Max programming environment, which likely limited their ability to experiment with more complex, flexible mappings and scenarios and collaborate with non-engineers who may not be Max programming experts.

One work that addresses a software infrastructure for using a sensor network in a creative context is SenseStage, a collaboration between McGill and Concordia Universities that provides a system for publishing data streams from sensors or other real-time data sources to a network so that data streams from multiple sources can be manipulated in a single system (Baalman et al., 2010). However, the crucial management of mapping the data streams to sound, visuals, or other outputs was outside the scope of the project.

Outside of the creative context, systems for managing distributed sensor networks are only beginning to be explored and even then, only in the context of commercial/industrial applications. The most relevant comprehensive examination of managing sensor networks that exert real-time control on other systems was undertaken recently by researchers at IBM, however similar to SenseStage, graphical interfaces for configuring and visualizing the network are outside the scope of their research (Chen, Choi, & Chou, 2010).

The hope is putting more thought into developing a dedicated process for creating mappings will lead to more sophisticated uses of WSNs in musical systems.

Proposed Research

The platform for my work is "libmapper", a C implementation of the DOT mapper back-end currently in development at the IDMIL. It performs all of the behind-the-scenes message routing, device discovery, and connection tracking that can then be reflected and managed using an external GUI (like the DOT mapper).

The WSN mapper built on top of libmapper will be implemented as an HTML5 application for the iOS mobile platform. Allowing the network mappings to be configured using a mobile device is useful for practical reasons because, by definition, most scenarios for using WSNs involve hardware that is spatially distributed. Being able to monitor and configure the network mappings while simultaneously being able to move about the environment to interact with the hardware is useful when debugging interactive musical systems.

The goal is to implement several visualization and interaction schemes based on graphical representations of devices, parameters, and mapping connections. Planned schemes include correlating device characteristics like spatial position, sensor capabilities, device type, etc. to graphical attributes like shape, size, coordinate system coordinates, etc. and projecting the high dimensional space of the sensor network onto different lower dimensional graphical spaces depending on the configuration task.

The usability of the system will be evaluated by creating test scenarios involving a virtual WSN composed of virtual devices and synthesizers and having individuals attempt to create a complex mapping and comprehend the larger scale structure of the virtual WSN.

Contributions

In addition to expanding the potential use cases of libmapper, I am contributing to Emerge, a joint project between McGill University, Concordia University, Moment Factory, and gsmprjct that attempts to expand on the work done during the SenseStage project and develop a new comprehensive system for creating artistic projects using wireless sensor/actuator networks.

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