TinyTune: A Collaborative Sensor Network Musical Instrument

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ABSTRACT

This paper demonstrates the implementation of TinyTune, a collaborative musical instrument using sensor motes. The system implementation is distributed across multiple nodes and supports the basic elements of a musical instrument, such as pitch and octave selection. The communication design for realizing a collaborative musical instrument and the available user configuration options are then presented. Other topics of discussion include: the underlying system architecture, covering the advantages of our design choices; and the extensibility of the concept, which discusses how the nodes are configured in multi-instrument environments.

1. INTRODUCTION

Musical instruments are generally thought of as an individual's pursuit. Each person has their own instrument, and brought together, they form a band. Collaborative playing, where both musicians play on the same instrument is a rare occurrence, although not unheard of [1]. A common example of such a situation is two players playing a duet on a piano. However in this configuration, both players individually play separate tunes, must be proficient in the musical interface (the piano), and must closely synchronize their performance. This demo abstract presents a new musical interface, called TinyTune, which enables cooperative (and potentially distributed) musical creation through the use of wireless sensor nodes. A good analogy of the collaborative music playing concept is two people driving a car, where one person steers and another operates the pedals. TinyTune provides this alternative to conventional music making by providing an easy to use collaborative instrument, which requires few skills to play. The two main challenges in building the instrument are scalability and minimizing delay. To provide scalability, we had to devise an architecture suitable for adaptation to larger networks while still maintaining operational simplicity. Ensuring robust communication between nodes which would not cause significant delays in the instrument's output is the second major challenge.

2. THE INSTRUMENT

The TinyTune system implements all the common elements of a musical instrument that a user normally controls, including note, note length, volume and octave. Through a web-portal, users can customise the instrument so that each node, equipped with a distance sensor, controls one or more of these elements. Once configured, a group of users can collaboratively play music through a simple distance based interface. Users manipulate the musical element, for instance the note, by moving their hand towards or away from the corresponding sensor node. The distance measurements are continuously streamed to a node with speaker for music playback.

2.1 System Architecture

The TinyTune collaborative instrument is composed of a web browser and multiple user nodes, as shown in Figure 1. The web browser runs on a PC, which is connected to a base station node, and provides access to web servers hosted by the user nodes. A user node is built around the CSIRO Fleck [2] mote and consists of an active IR distance sensor, a web server, and optionally a speaker and/or LED array. The distance sensor detects the user's hand proximity, which is used to control the sound, note length and octave of the speaker enabled node within the TinyTune instrument. The web interface, shown in Figure 2, allows configuration changes and remote monitoring of the node. Figures 1(a) and (b) show two different configurations of TinyTune that vary the musical element assignments among nodes.

The high-level design goal of TinyTune to provide the ability for distributed music creation not only includes distributed sensing, but also distributed actuation. The speakers that generate the audio output can be either located centrally or at each of the sensor nodes. The main purpose for the LED array is for note selection. It provides visual feedback as to which note is currently selected based on the distance sensor reading.

We have developed the instrument in TinyOS's BLIP stack. All user nodes are programmed with identical code which allows for in-situ configuration and extensibility. Dynamic web pages are hosted on each of the nodes in HTML5 with AJAX to reduce the volume of communication data. When configuring each node via the web interface, the node's functionality can be changed to one of: note selection, octave selection or note length. Additional functionality includes: playing a demo song on the selected node or giving a live reading of note, however the latter requires a slow tempo in order to hide the delay of TCP communication.

In terms of hardware, generic active infrared distance sensors are used for hand proximity detection. The absolute distance is not critical in this application so a cost effective sensor with a range of approximately 1m was chosen. The full range of motion of the users hand is linearised and as-

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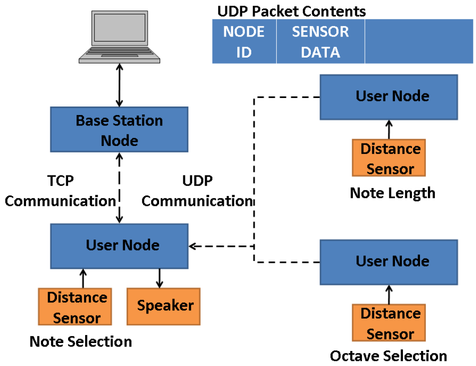
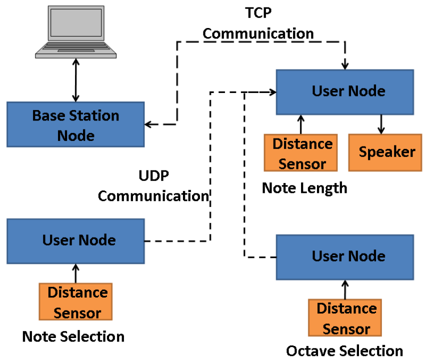


(a) Example configuration of an instrument: Audio node, which includes distance sensor and speaker, controls note selection



(b) Alternately configured instrument: Audio node, which includes distance sensor and speaker, controls note length

Figure 1: Two possible configurations of TinyTune

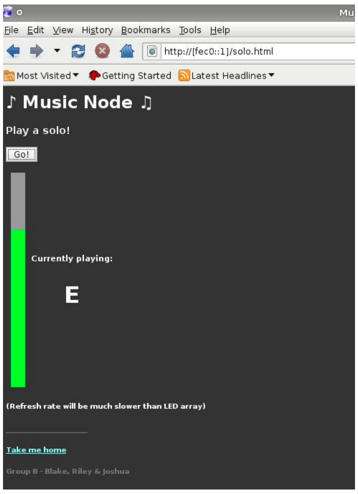


Figure 2: Screen shot of our simple web interface

signed to a musical note. Each node has an audible output via a piezo speaker. The piezo speaker is ideal for this application as it uses very low power and is easily driven from the microcontroller's PWM output.

2.2 Design Issues

Timely communication is a key design factor for TinyTune. As timing is a crucial building block of musical theory, provision of a high enough transfer rate is the top priority to ensure notes are played on time. Another slightly less crucial requirement is reliability. If too many packets are missed, the music playback becomes choppy. Because reliability and transfer rate involve an inherent trade-off here, we select UDP transmission at a high baud rate in order to minimize the delay. The system still has an upper bound on the maximum supported music tempo, which is dictated by the delay of sending, receiving, and decoding packets while capturing new sensor inputs. Other information transmitted from each node includes node id, which is used in instrument configuration to select which nodes perform what tasks. For instance, a single node can be configured to control the note length and octave selection. This would ensure all notes are of the same length and on the same octave within the instrument. Alternatively, the configuration can specify that one node controls octave and another node controls note length. While several nodes can be configured to control various elements of the same instrument, our architecture also supports the composition of several instruments as groups of nodes.

3. DEMONSTRATION OVERVIEW

The demonstration will consist of a base node connected to a PC for configuring the sensor network from a web browser. Multiple sensor nodes will enable users to collaboratively play musical sounds. In particular, users can control aspects of the instrument's sound and configuration by manipulating the distance sensors and modifying the node configuration via PC. The demonstration is designed to show the achieved effectiveness of a WSN performing as a collaborative instrument, with system robustness, delay and human cooperation being the key design factors. Visitors are encouraged to interact with the sensor nodes to create unique pieces of music.

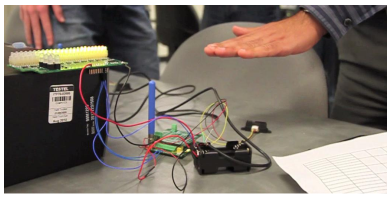


Figure 3: Photo of the demo in action

4. REFERENCES

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[2] P Sikka, P Corke, L Overs, P Valencia, and T Wark. Fleck - a platform for real-world outdoor sensor networks. In *3rd International Conference on Intelligent Sensors, Sensor Networks and Information*, pages 709–714. 2007.