## Abstract

This thesis examines the Internet as a space for playing collaborative, rhythmically synchronized music among artists who are in different physical locations. The Internet has revolutionized many aspects of life, but has yet to become a frequently-used venue for music performance. We take the position that in order for this to occur, we must develop a new class of musical instruments that are specifically designed for the web. In particular, they should compensate for the delay that exists in networked communication. We explore two different approaches to this problem. The first is a method for tempo synchronization across large distances. The second is a method for reducing delay by predicting notes before they are played, sending the note information across the Internet, and scheduling the note to be synthesized into audio at the same time in multiple locations.

Our method for tempo synchronization, the Global Metronome, delivers timing error comparable to or less than the industry standard method. However, our method can synchronize tempo between devices located anywhere on earth, while the industry standard method requires devices to be connected via a physical cable. Our approach depends on synchronized clocks. Therefore this thesis presents an inexpensive, portable and accurate time server device to grant users the ability to use the Global Metronome. This device, called PIGMI, is a software suite that runs on a popular single-board computing platform. The software is published as a freely-available, open source software project.

This thesis also presents a musical instrument that uses prediction to reduce network latency, called MalLo. We present a series of studies that explore the sensor requirements, viability, and usability of the system. We also use MalLo in concert performance and study musicians as they learn to use the instrument over 3 rehearsals and the concert.

The primary contributions of this work include (1) a method to synchronize tempo between devices that are separated by great distance; (2) a small, inexpensive timeserver that facilitates this approach; (3) a better understanding of the advantages and disadvantages of tempo synchronization via this approach; (4) a method for latency reduction via per-note prediction including simulations, a usability study, and a study of live performance exploring its viability. This work enables new methods of remote musical collaboration and moves us towards realizing the dream of a global community of collaborating musicians.