Department of Electrical & Computer Engineering
University of Central Florida

TherəMIDI & Expandomé

A midi-capable theremin and expandable easy-grid device

Group #1:
Anthony Adu[1]
Kenzo Mendoza[2]
Thomas Spalding[3]
Florence Trinh[4]

[1] amtee12@knights.ucf.edu
[2] kenzo_mendoza@knights.ucf.edu
[3] spalding@knights.ucf.edu
[4] ftrinh@knights.ucf.edu

A. PROJECT DESCRIPTION

1. PROJECT NAME

"ThereMIDI & Expandome"

2. PROJECT MEMBERS

Anthony Adu
Kenzo Mendoza
Thomas Spalding
Florence Trinh

3. PROJECT SPONSORS

At this time, we do not have any project sponsors. However, we are actively looking for sponsors. Prospects include Kickstarter, and asking our respective employers.

4. PROJECT INFORMATION CONTRIBUTORS

We do not currently have any named information contributors. As the project develops, we will include the names of any information contributors.

5. PROJECT NARRATIVE

Our proposed project consists of three device bodies, a theremin, pitch-to-MIDI converter, and an Expandome.

Theremin - Patented in 1928, the theremin was the first electronic musical instrument. Although now a classic example, it has always been the most drastic break from any traditional instrument before or since. The theremin is played by moving both hands in the air. The player's hands creates a 'hand capacitance' between the antenna and true ground through one's hand, acting as a plate, and the antenna as the other plate. Typically, the left hand controls the volume, and the right hand the pitch. The theremin requires an exquisite ear and complete control of one's motion, this brings us to our second device, a pitch-to-MIDI controller.

Pitch-to-MIDI Controller - This device takes an incoming audio signal and converts it to MIDI. The audio signal is analyzed by comparing its frequency to a lookup table of musical scale note pitches. The incoming audio signal can be directly pitch-matched in the outgoing MIDI data or used as a controller via data messages. By allowing the infinitely fluid theremin to be mapped to data messages, we will be able to directly see how in-tune the player is. This is useful as direct training feedback. It also allows the theremin to not only be an instrument but dually gives it the capability of a MIDI controller. In the latter faculty, it will be able to control any VST. In both capacities it will be able to be either an input source, or supplemental controller to our next device, the Expandome.

Expandome - The Expandome is a highly adaptable MIDI controller consisting, for the initial demonstration of feasibility, of one 8x8 and one 4x8 backlit push-button grid. Like the Chronome, it is another take on the Arduinome to further this easy-grid concept. The device itself is not an instrument, but a musical tool; it is ideally simplistic, yet complex, with the aim at creating a performance device that can elicit a virtuosic experience with ease. Upon pushing a button, the data is sent via shift registers to the microprocessor, and then optionally to a computer. Then this information, based on the current setting, will light up the button, play a track, set the tempo, directly produce a noise or if connected to a computer can control a VST. The Expandome will be capable of being a standalone device or be attached to another Expandome to create a larger grid.

Motivation - Examining the use of ephemeral interaction with technology, our senior design group decided to tie together the Theremin, a musical instrument that can be played without touch, to create a technological interaction that took physical bodies as input via the ephemeral, and provide a highly customizable interaction environment. To tie together this highly adaptable environment we lit upon Hochenbaum's Case Study on the Chronome[5], that notes to provide a virtuosic experience without the years of mastery, one must find a balance between the complexity of an instrument and ease of use. Having found this highly pertinent to our endeavor we decided to use this as the hub of interaction between the midi-capable theremin and any other midi-capable performance instrument. Additionally, to expand upon this customizability we set upon making the instruments modular, in that they can be placed together in many number of combinations to reflect one's personal mental organization. By creating the Expandanome we wanted to even further push the easy-grid instrument to the next level.
Our final goal is to create a virtuosic experience through high customizability, modularity, and simplicity. We shall accomplish this by understanding and developing the following devices: a theremin, a pitch-to-MIDI converter, at least two Expandome.

B. SPECIFICATIONS AND REQUIREMENTS

1. Theremin (1)

Input voltage of ±12v
Consumes 30mA of current
1 toggle switch - to turn on or off the device
2 coil antenna (pitch and volume)
4 potentiometers - controls the volume, pitch, brightness and waveform of the theremin
dimension of cabinet - 4” high x 1’ long x 6” wide
1 audio output jack
Resonant pitch antenna frequency of 285 kHz
Resonant volume antenna frequency of 450 kHz
Output frequencies ranging from 0 to 3 kHz

2. Pitch-to-MIDI Controller (1)

Dimension - not more than 6” wide x 4” long x 5” high
1 TTL to USB Serial Converter Range (to connect via computer)
2 Audio Jacks (1/4)--Audio in and out
2 MIDI sockets-- MIDI IN and MIDI OUT (no MIDI THRU)

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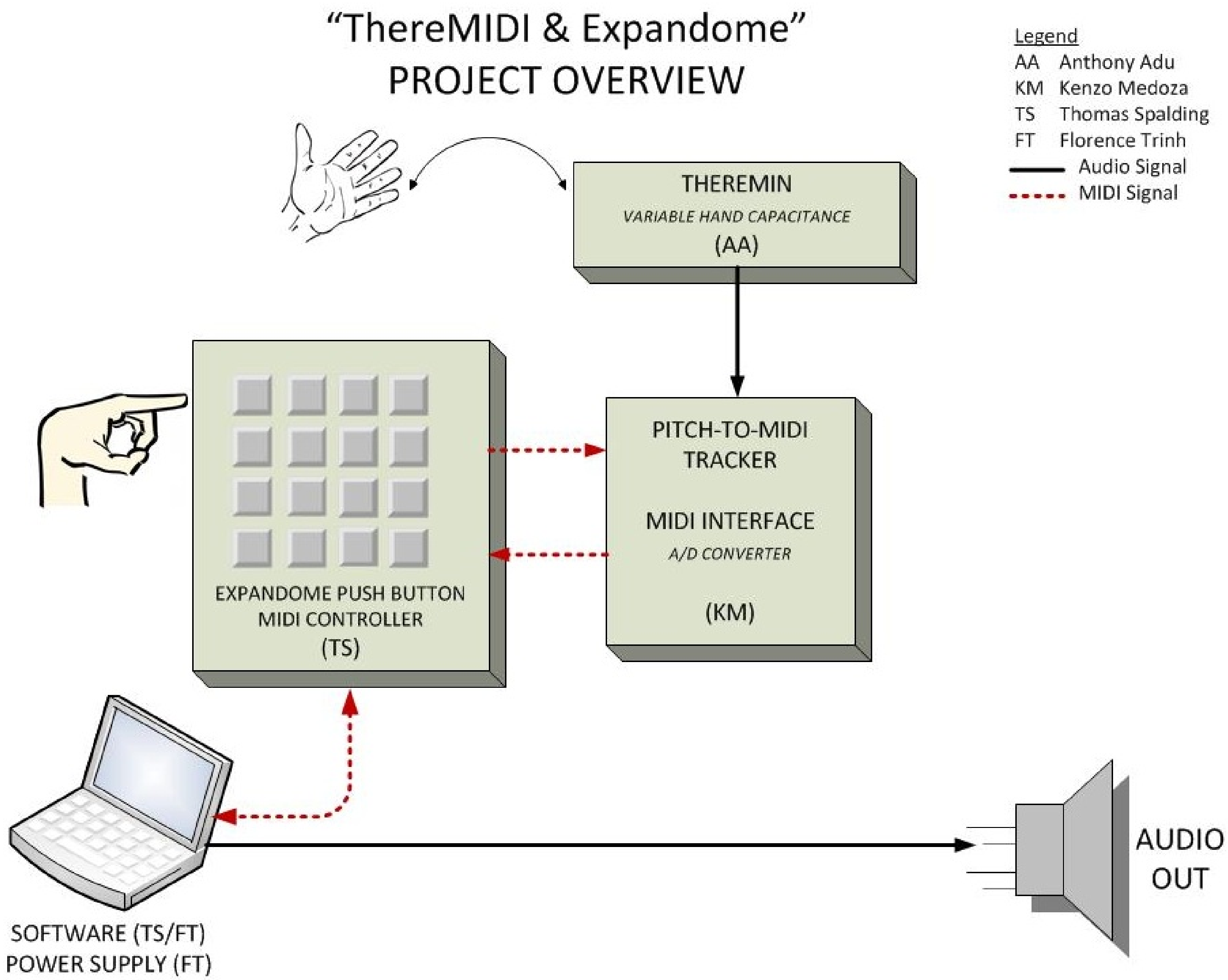
[5] **The Chronome: A Case Study in Designing New Continuously Expressive Musical Instruments** Vallis, O., Hochenbaum, J., Murphy, J., Kapur, A., Proceedings of the Australasian Computer Music Conference (ACMC). 2011. Auckland, New Zealand.

1 LCD Display--Display the pitch and volume of the converted analog input sound to MIDI
1 Plywood for frame display
1 Toggle switch - to controller whether we want the controller to be on or off
5 LED’s - to display the accuracy of the analog pitch from theremin
Weight - no more than 2 lbs
1 SD Card Reader
Passive Mode - passes analog audio directly through device and requires almost none, to no power consumption.

3. **Expandome (1)**
8x8 or 4x8 Pushbutton display
1 SD Card Reader
1 TTL to USB Serial Converter Range (to connect via computer)
2 MIDI sockets-- MIDI IN and MIDI OUT (no MIDI THRU)
Runs on: ATMEL328 Standalone and may be supplemented with Windows for virtual instruments
Requires: USB A-to-B cable
Inputs/outputs: 20 including 6 PWM, 6 analog in
Language:Arduino Environment, C/C++
Power: 5V
Weight: Less than 2 lbs

C. BLOCK DIAGRAMS

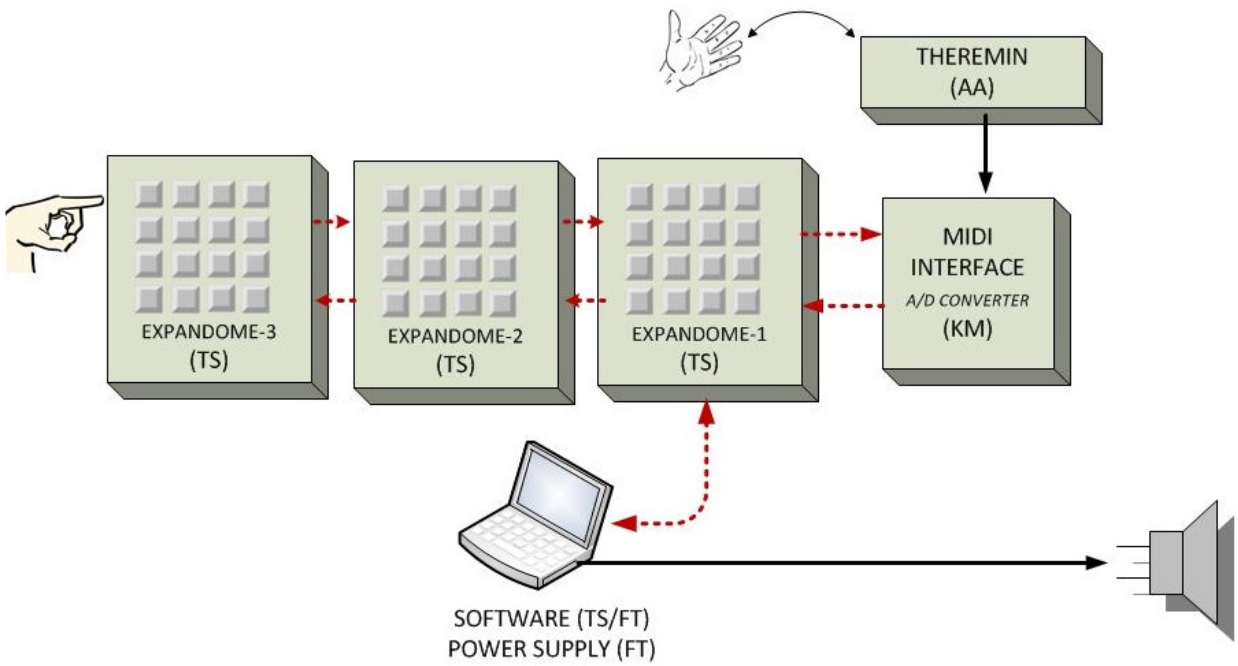


"ThereMIDI & Expandome"

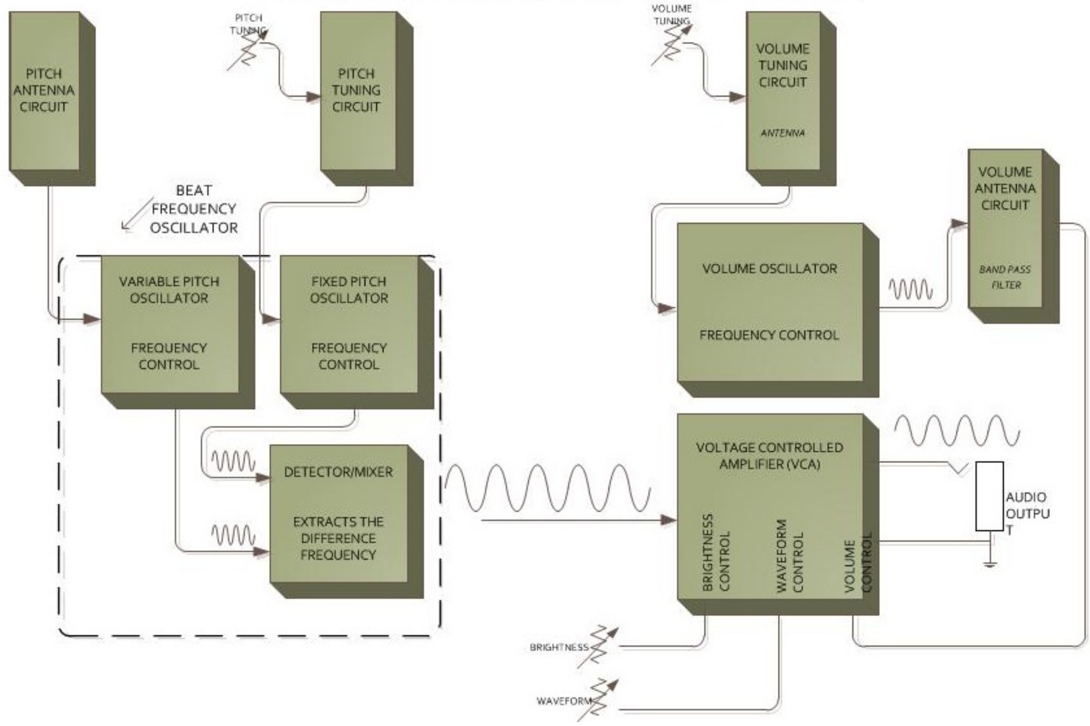
Project Features: MIDI Capable Theremin and the Ability to Connect and Control Multiple Expandome

Legend

AA Anthony Adu
KM Kenzo Medoza
TS Thomas Spalding
FT Florence Trinh
Audio Signal
MIDI Signal



ELECTRONIC MUSICAL THEREMIN



D. BUDGET

PROJECT COST ESTIMATE

Project Title: ThereMIDI & Expandome   Date: 5/30/2012

Group: GROUP 1

ITEM	DESCRIPTION	QTY	UNIT	UNIT COST	LINE TOTAL
1	Theremin	1	each	$ 150.00	$ 150.00
2	Arduinome	2	each	$ 200.00	$ 400.00
3	MIDI Interface	1	each	$ 100.00	$ 100.00
4	Power Supply	1	each	$ 50.00	$ 50.00
5	Software (Open)	1	each	$ -	$ -
6	Enclosure	4	each	$ 25.00	$ 100.00
	TOTAL ESTIMATE				**$ 800.00**

**All of the electronic components and materials necessary to build the devices listed above must be researched and acquired.*

E. PROJECT MILESTONES

	WEEK 1	WEEK 2	WEEK 3	WEEK 4
MAY			Form Design Team and Research Project Ideas	Submit Project Proposal and obtain approval.
JUNE	Divide and assign responsibilities for research report sections and format. *(Goal: Write a minimum of 6 pages per week each)*	Discuss and define hardware design and power requirements, define methods connection and signal processing (Report: 6x4 =24pgs)	Discuss and define software requirements, data structure and implementation. Order design parts and build prototype modules. (Report: 12x4 =48pgs)	Define material, component, and equipment listing and sources. Build and test circuits for research of signal processing. (Report: 18x4 =72pgs)
JULY	Document simulation output, photograph prototypes, flow charts signal/data. Component diagrams specs. (Report: 24x4 =96pgs)	Test software on research prototype. Program and test function. (Report: 30x4 =120pgs)	All members submit reporting sections. Draft report for review.	Finalize report details, corrections, and format.
AUGUST	Submit Final Senior Design I Paper (Report: 30x4=120 pages)	Order/acquire materials for final build (PCB, enclosure, power supply, controller, audio out speaker)	Order/acquire materials for final build. Build box/enclosure. Review DSII Report requirements and format, assign members to sections.	Finalize simulations, research prototype models. Begin building components per design.
SEPTEMBER	Build Theremin and test.	Build Pitch to MIDI Interface, connect to Theremin. Test output.	Build Arduino Board, connect to PC and MIDI Tracker, program and test.	Connect all components for initial test. Review DSII Report Status and format.
OCTOBER	Program and test. Cut material for final model enclosure.	Build enclosure for final prototype model. Program and test.	Complete construction of all components and enclosure.	Program and test. Work on report.
NOVEMBER	Program and test. Work on report	Program and test. Work on report.	All members submit reporting sections. Draft report for review.	
DECEMBER	Project is 100% complete. Presentation.	Graduate!!!		

F. GLOSSARY

MIDI - Musical Instrument Digital Interface (MIDI) is commonly used by musicians who want to blend or combine the sounds of several different instruments together on one track without the expense of hiring a musician to play each instrument. Originally, MIDI, developed by major synthesizers manufactures in 1983, was used as a protocol to allow one synth to play another remotely. Consequently, the developers realized that with the right hardware, a "computer" could record and playback data at the sametime. Its ramification lead to new possibilities, including a single person can compose multi-music by themselves.

MIDI is a digital signal consisting of an extensive set of "musical commands" which electronic instruments can use to control each other. MIDI **events**, or series of MIDI commands, are simply binary data that indicates the following:

musical notation
pitch
velocity (how hard the key is pressed down)
control signals for parameters (volume, vibrato, panning cues)
ON and OFF Event (when the key is pressed down and up, respectively)

Figure 1 demonstrates MIDI events in a MIDI track within a MIDI sequencer

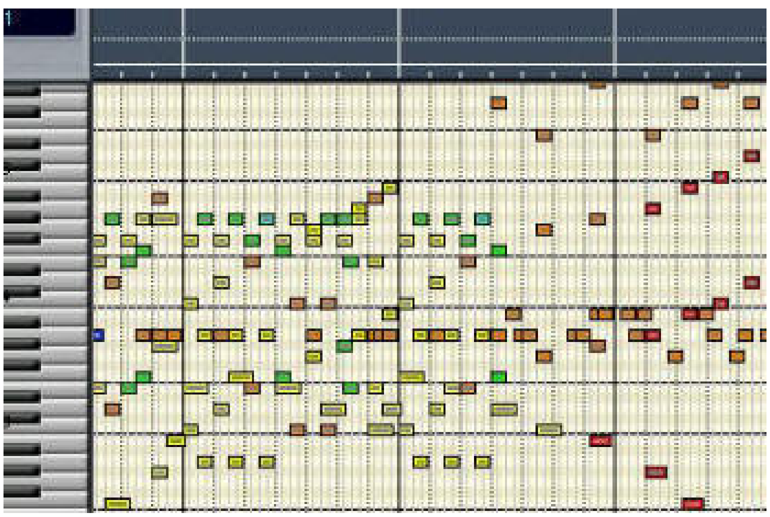


Figure 1

MIDI Sequencer - is an application software that handles MIDI events, along a timing grid. Typically, the MIDI sequencer is the core of manipulating and coordinating MIDI--it can record, playback, edit MIDI information. Furthermore, the sequencer ultimately decides what exactly the MIDI information can be used for. Since MIDI is simply an electronic command, it can be used to assign to play notes from a sound modules (either hardware or software), or assign short-cut commands in the software or other possible commands.

VST - Virtual Studio Technology (VST), licensed by Steinberg, is a software sound module that interfaces with MIDI devices. When the MIDI sequencer assigns a MIDI event to a VST channel, the MIDI will communicate with the VST and command to play an audio playback, based on the MIDI's binary data (musical notation, pitch, etc). Unlike using a hardware sound module, VST offers plug-ins VST (Virtual Studio Technology Instruments, or **VSTi**), which widely opens limitless parameters and sound sources. For instance, if the MIDI sequencer assigns a MIDI event to a violin VSTi, the MIDI will tell the VSTi to play accordingly to its binary data and consequently, it will simulate a traditional violin recording (the quality of sound thereupon depends on the quality of VSTi).

G. ACRONYMS

LED	Light Emitting Diode
MIDI	Musical Instrument Digital Interface
SD	Secure Digital
USB	Universal Serial Bus
VST	Virtual Studio Technology
VSTi	Virtual Studio Technology Instruments