

Tympan

Open-Source Audio Processing Platform Live Workshop!

2020-06-08

Session 1aPP

Agenda

- **Introduction to the ASA Challenge** 9:30am
- **Tympan Open-Source Audio Platform Overview** 9:35am
- **Tympan use examples** 9:50am
 - Chris Smalt: Sound level meter for complex noise
 - Chip Audette: Voice Shifting
 - Joshua Alexander: Electroacoustic measurements
 - Marc Brennan: Human studies with the Tympan
 - Joel Murphy: Howler Monkey Audio Recorder
- ***Break*** 11:05am
- **Q&A – pitch your ideas** 11:20am
- **Open-Source initiatives** 11:50am
- **Live tutorial** 12:00pm



Tympan

You Have a Great Audio Idea!

You try your idea
via post-processing

How do you try it
in real-time?

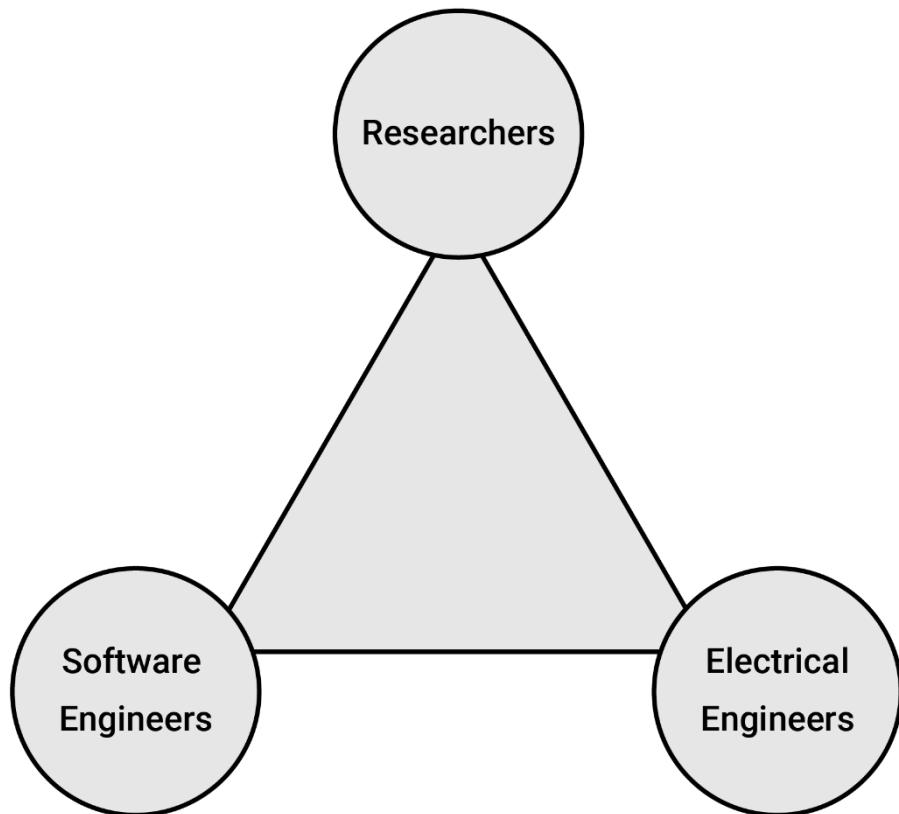


Tympan is a tool for you to move your idea off
your computer and out into the world.

How Do You Create a Real-Time Prototype?

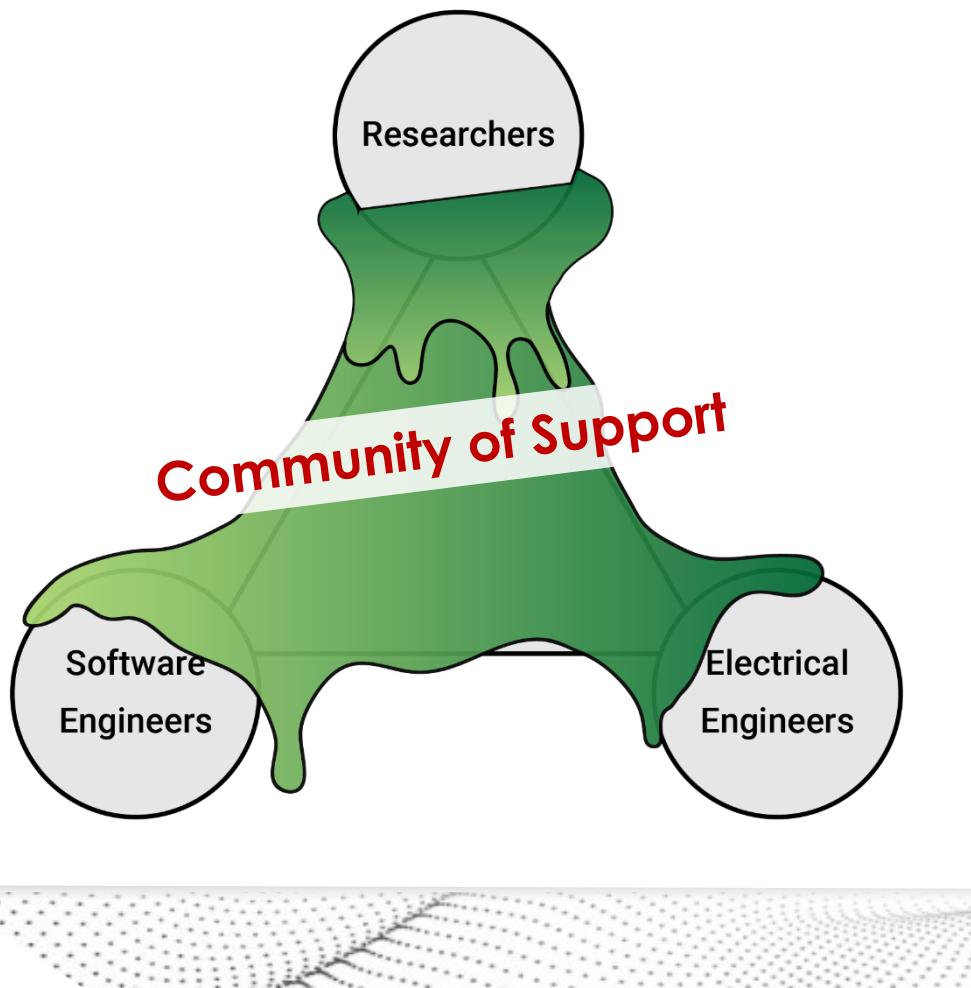
Traditionally, many skills are needed to make a real-time system

And the tools are often closed, making it difficult to collaborate or to reproduce results



How Do You Create a Real-Time Prototype?

Open-Source Tools lower the barrier to entry
and cultivate a community of support



Open-Source Forum

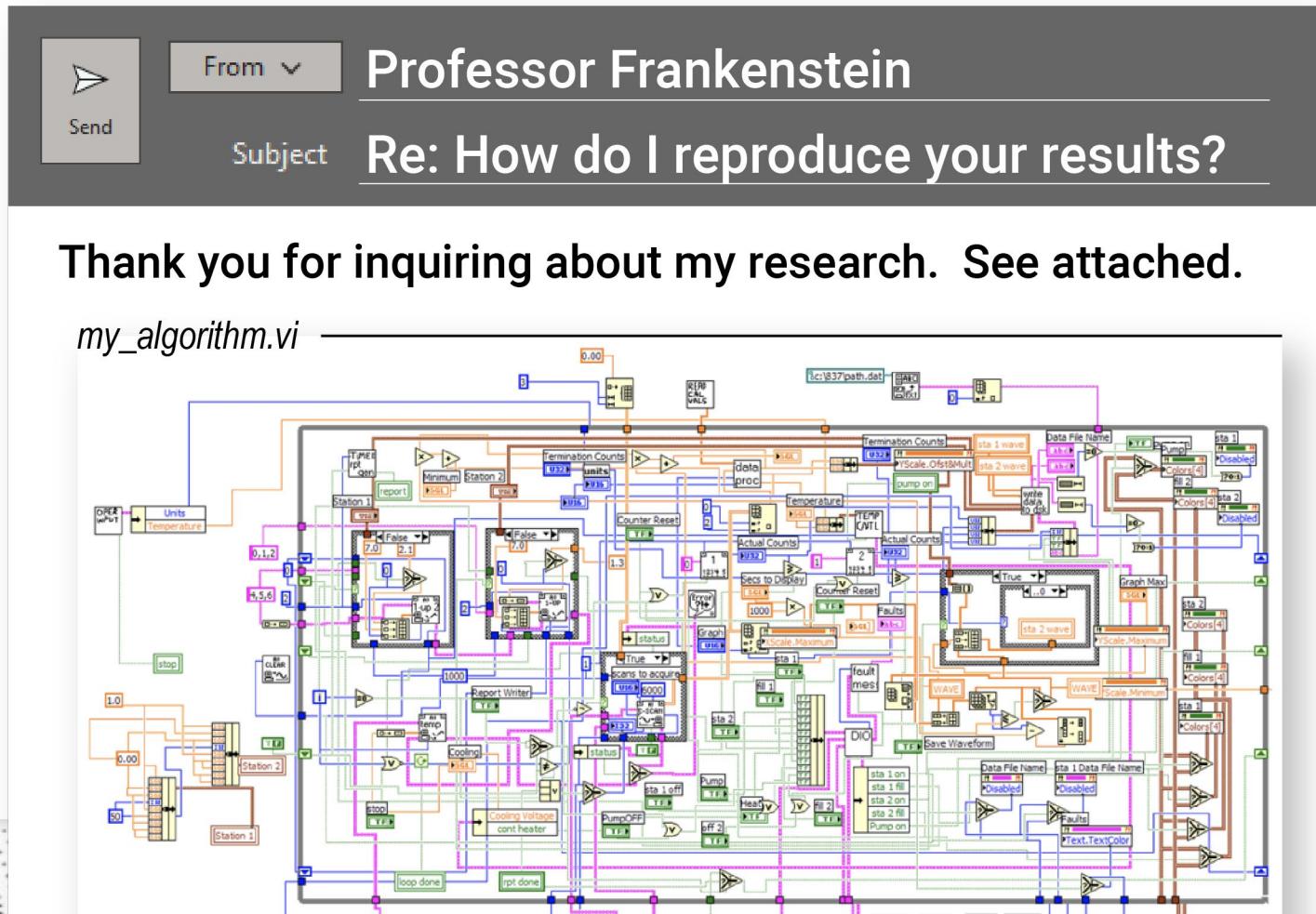
How do you create a real-time filter?

Does my mic need a blocking capacitor?

How do I change the sample rate in firmware?

How Do You Share Your Results?

Open-Source Tools allow you to collaborate
and build on prior research



An Open-Source Hearing Aid?

**What is out there already that we can build on?
What is missing? How do we pull it together?**



Mics and Speakers?

Electronics?

Software?

Enclosure?

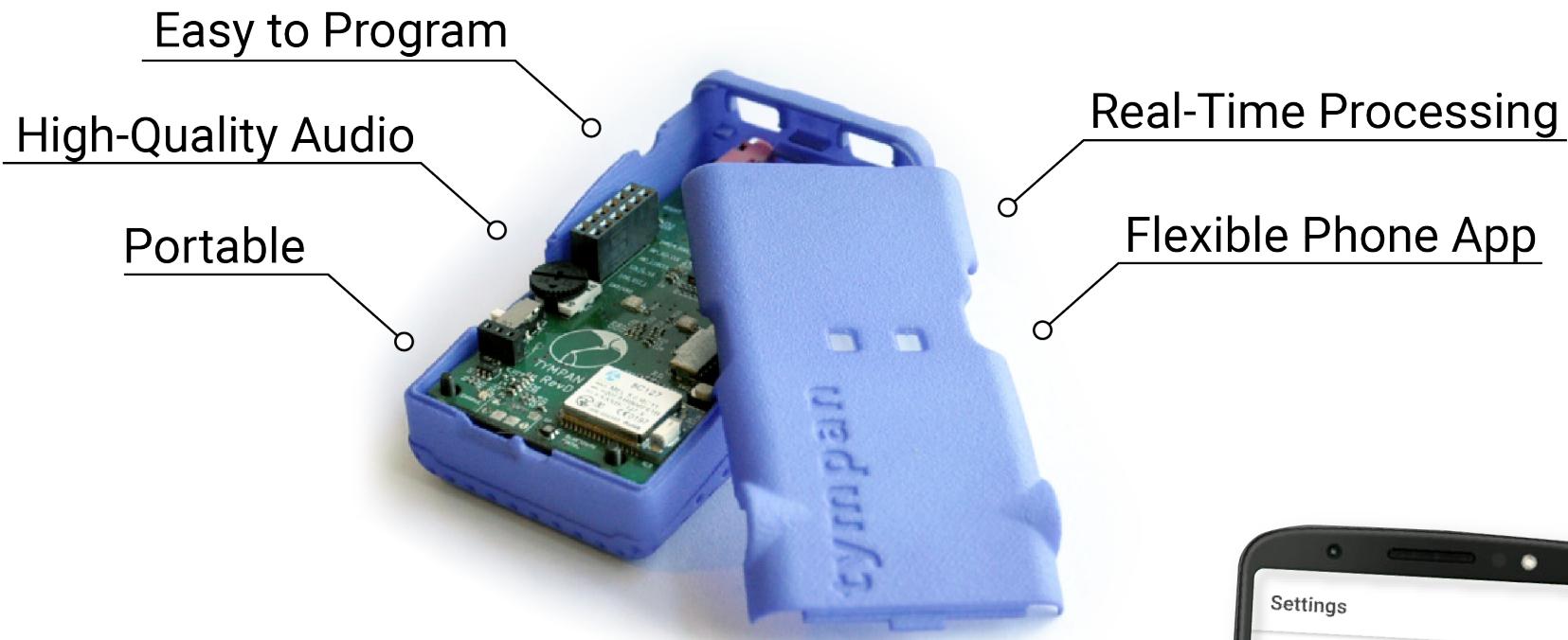
User Interface?

Community?

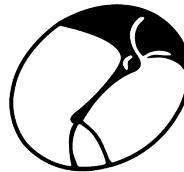


Tympan

Open-Source Audio Platform

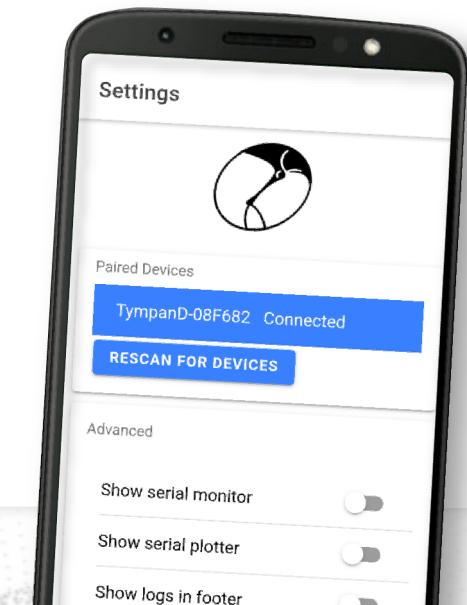


BTE Earpieces*

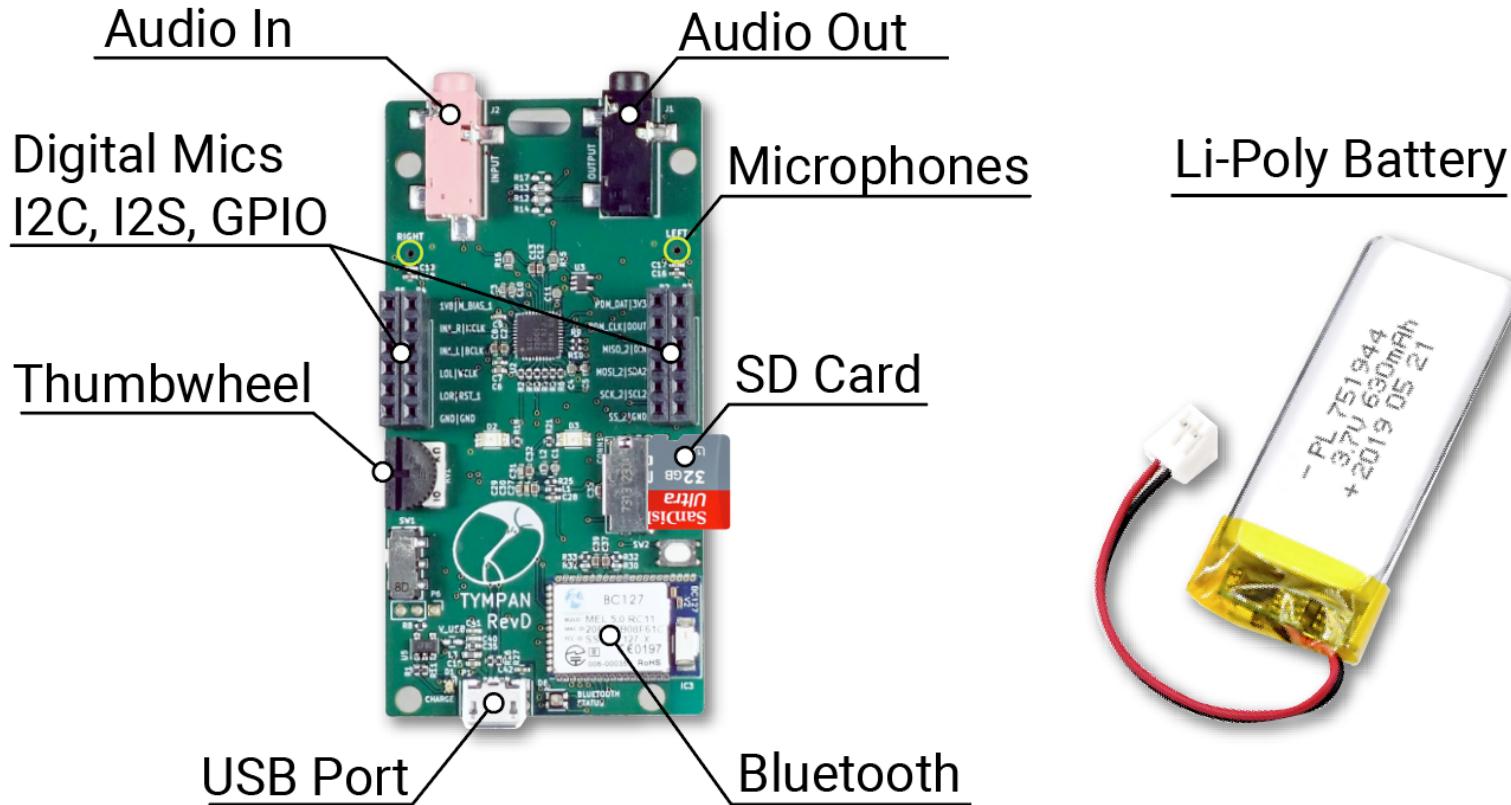


Tympan

*Based on a design by
Harinath Garudadri, UCSD



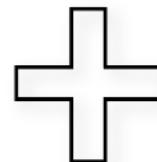
What's Under the Hood?



Tympan

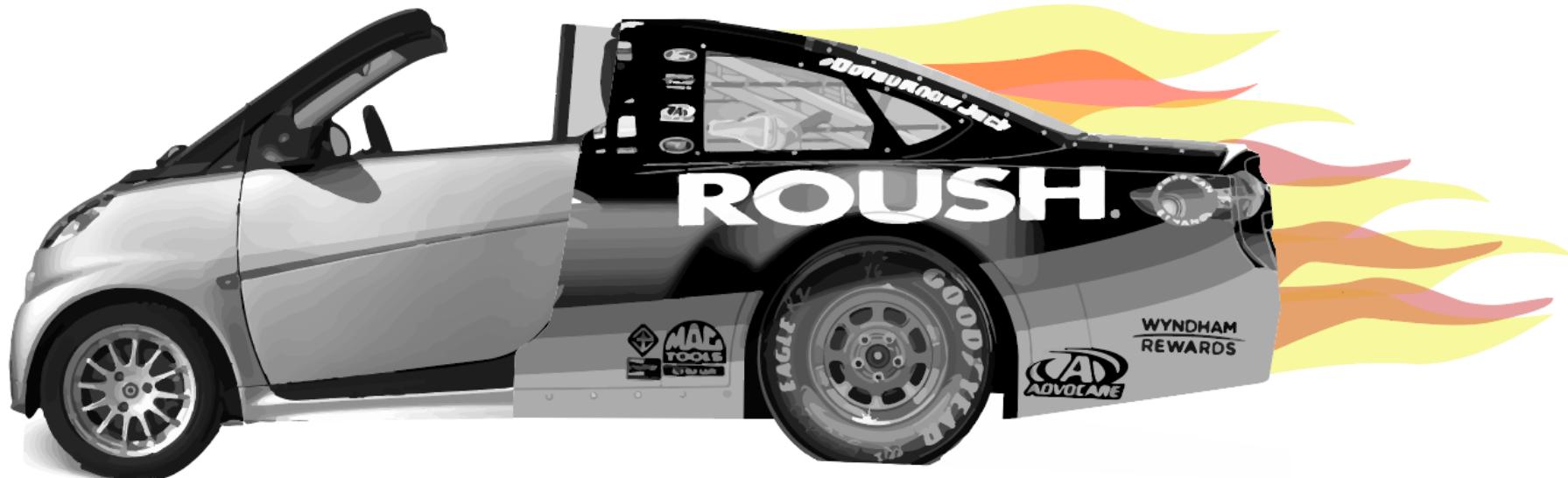
Built on the Teensy

Simple Interface



Powerful Backend

Teensy®

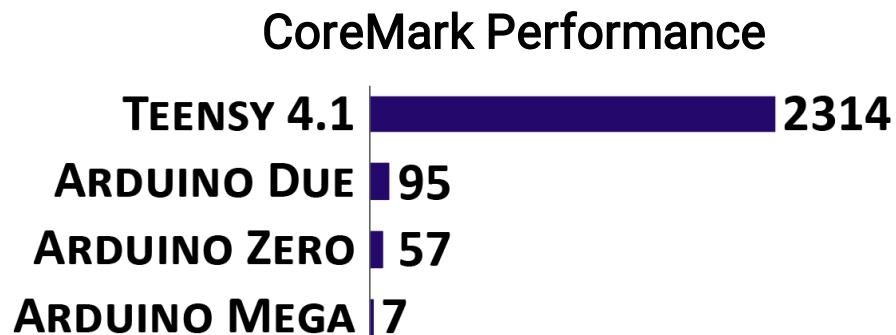


Tympan

Built on the Teensy

Teensy is programmed using a simple Arduino interface, but is powered by a much faster processor (600MHz)

- All hardware is preconfigured using an open-source library
- Access to a large community of enthusiasts!



Ref: <https://github.com/PaulStoffregen/CoreMark>



Tympan

Programming the Tympan

Tympan adds an extensive Audio Library with canned examples

- Basic Gain Amplifier
- Treble Boost
- Record to SD Card
- Custom Phone App
- Sound Level Meter
- Multiband Compression
- Frequency Shifting
- ...and more!!!

Easy



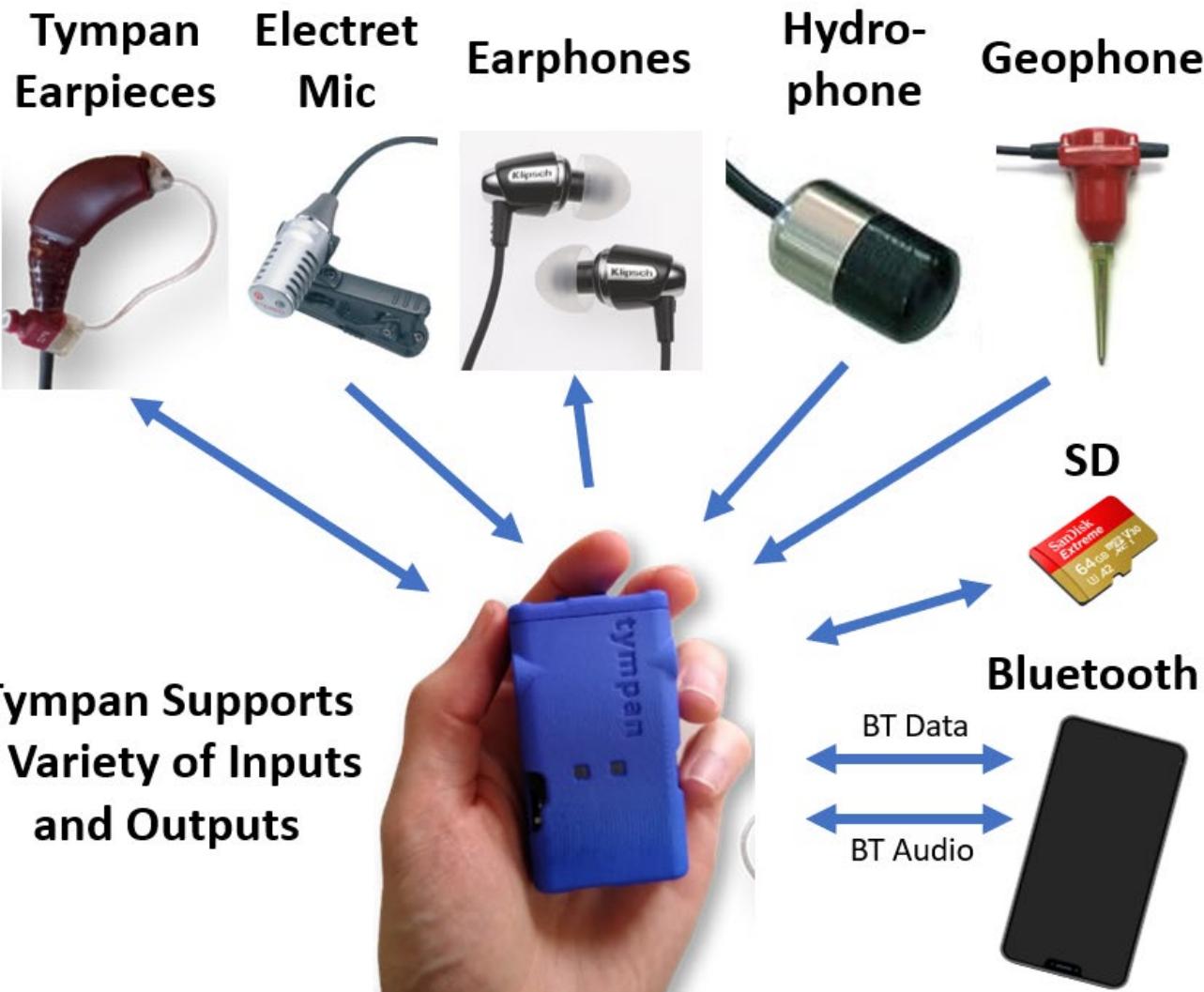
Advanced

Demo after the Break



Tympan

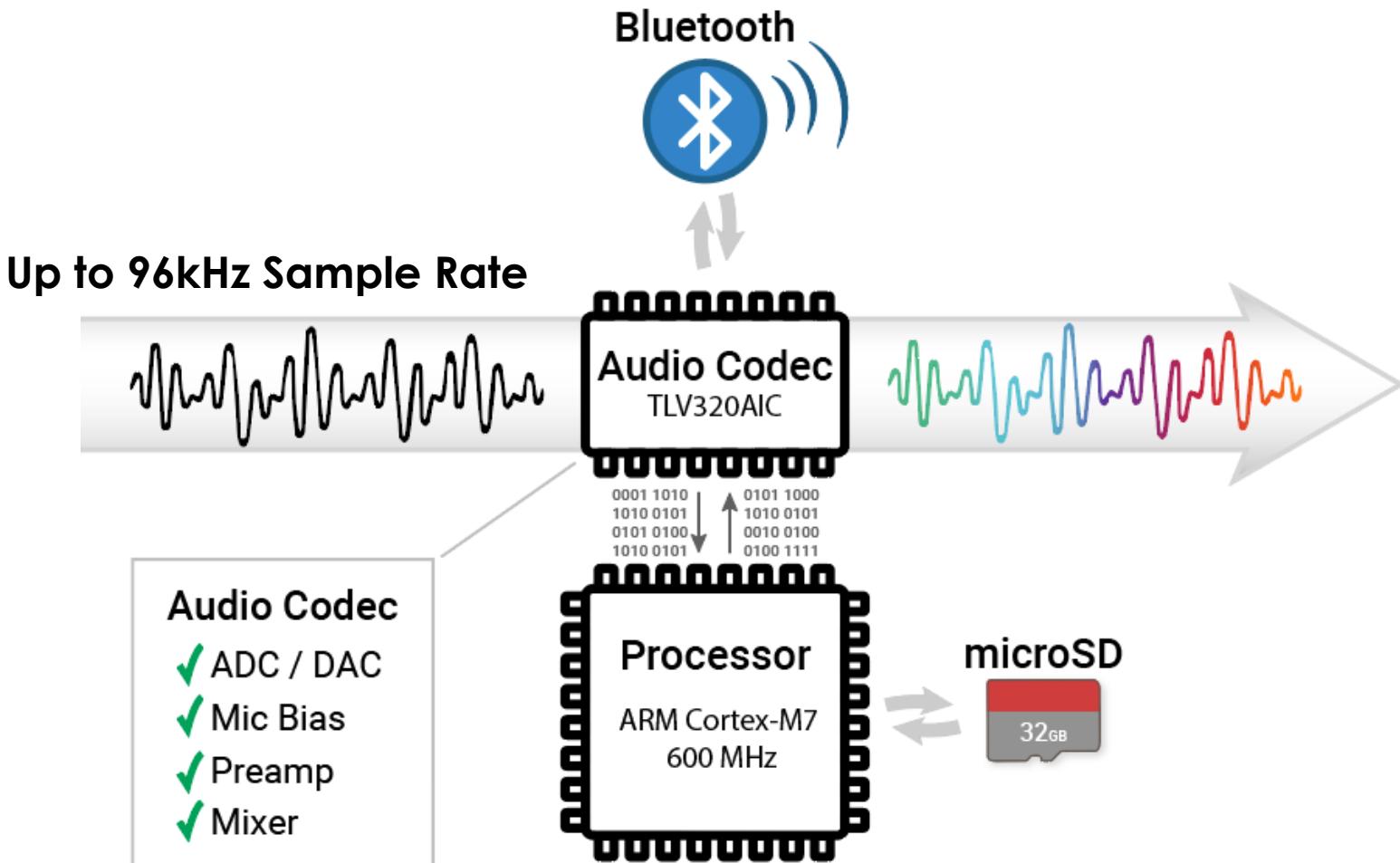
Many Inputs, Many Outputs



Tympan

How to Get Audio to the Processor?

Audio Codec digitizes the audio stream for processing

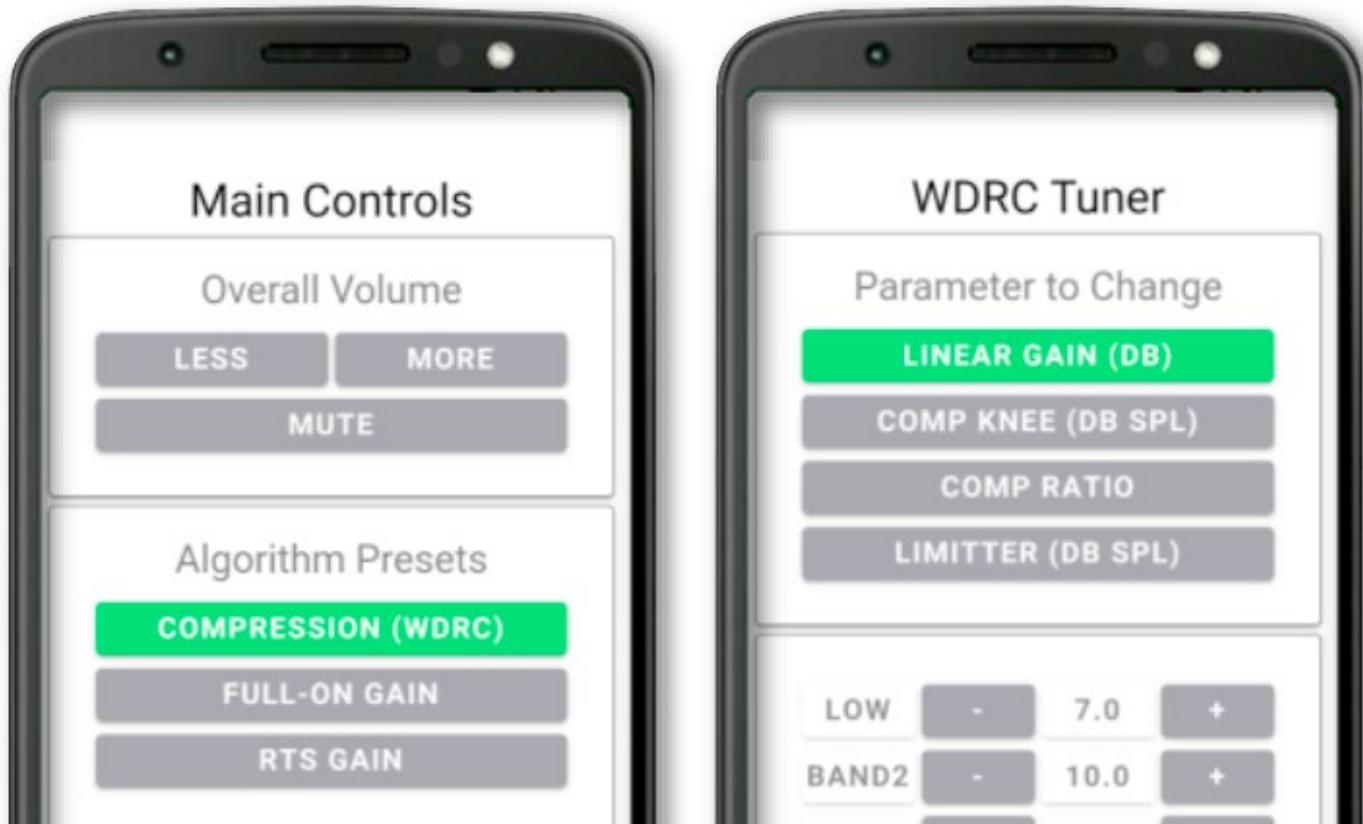


Bluetooth Phone App

Full App for Configuring a Hearing Aid

- Wide Dynamic Range Compression (WDRC)
- Feedback Cancellation
- Mic Directionality

Adjust Settings on the Fly!



Bluetooth Phone App

- Custom Layout is set with a few lines of Arduino code
 - You don't need to be an app developer!

1. Add a “Page” → `page_h = myGUI.addPage("MyFirstPage");`

```
145 //Add first page to GUI
146 page_h = myGUI.addPage("MyFirstPage");
147 //Add a card under the first page
148 card_h = page_h->addCard("Change Loudness");
149 //Add a "--" digital gain button
150 card_h-> addButton("--", "K", "minusButton", 4);
```



How Does the Tympan Work as a Hearing Aid?

Electroacoustic Study



Joshua Alexander
Associate Professor
Purdue University

Human Behavioral Study

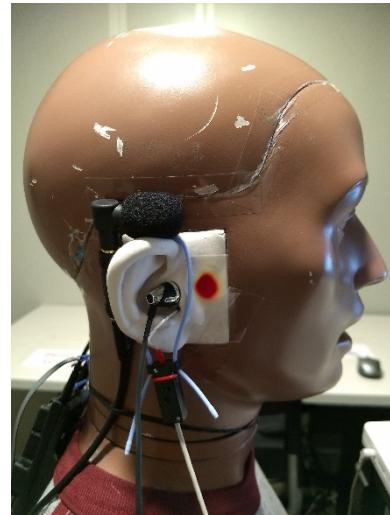


Marc Brennan
Assistant Professor
Univ. of Nebraska-Lincoln

Hearing Aid Verification



KEMAR Manikin



Human Studies



What Else Could a Tympan Be?

Mixed-Noise Sound Level Meter



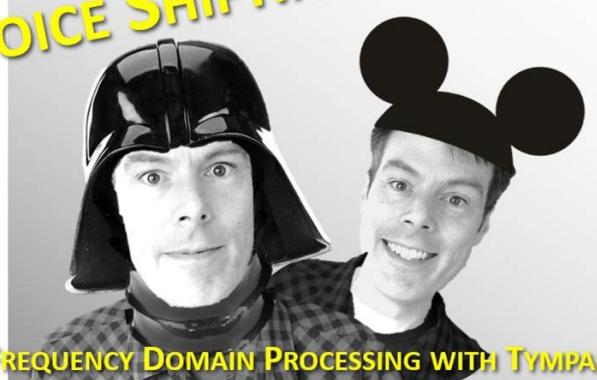
Christopher Small
Technical Staff
MIT Lincoln Laboratory



- Custom BT Phone App
- Audio Triggered Recordings
- Custom Tympan Shield



VOICE SHIFTING



FREQUENCY DOMAIN PROCESSING WITH TYMPAN

Chip Audette
Engineer & Tympan Mastermind
Creare

Howler Monkey Recordings



Joel Murphy
Solutions Prototyping
& Design
www.tympan.org

Q&A after each talk
Feel free to use the chat



Tympan

Break for 15min

Meet back at 11:20am (EST)

- **Learn about the Tympan ASA Challenge**
 - <https://tinyurl.com/Tympan-ASA>
- **Workshop Your Ideas**
- **Open-Source Community**
- **Live Tutorial on Getting Started**

Feel free to ask questions via chat



Tympan-ASA Challenge

We want put the Tympan in as many hands as possible

Awarding the Top 10 Applicants **Free Tympan Hardware!**

- Submit a proposal by June 20
- Present at the next ASA Conference in December (2021)

A few examples of what is possible:

- Speech: Analyze speech in real time to improve understanding in noisy environments
- Noise: Build a custom sound level meter
- Voice: Record larynx activity using an accelerometer
- Sensors: Use the Tympan as a stethoscope

See Link For More Info

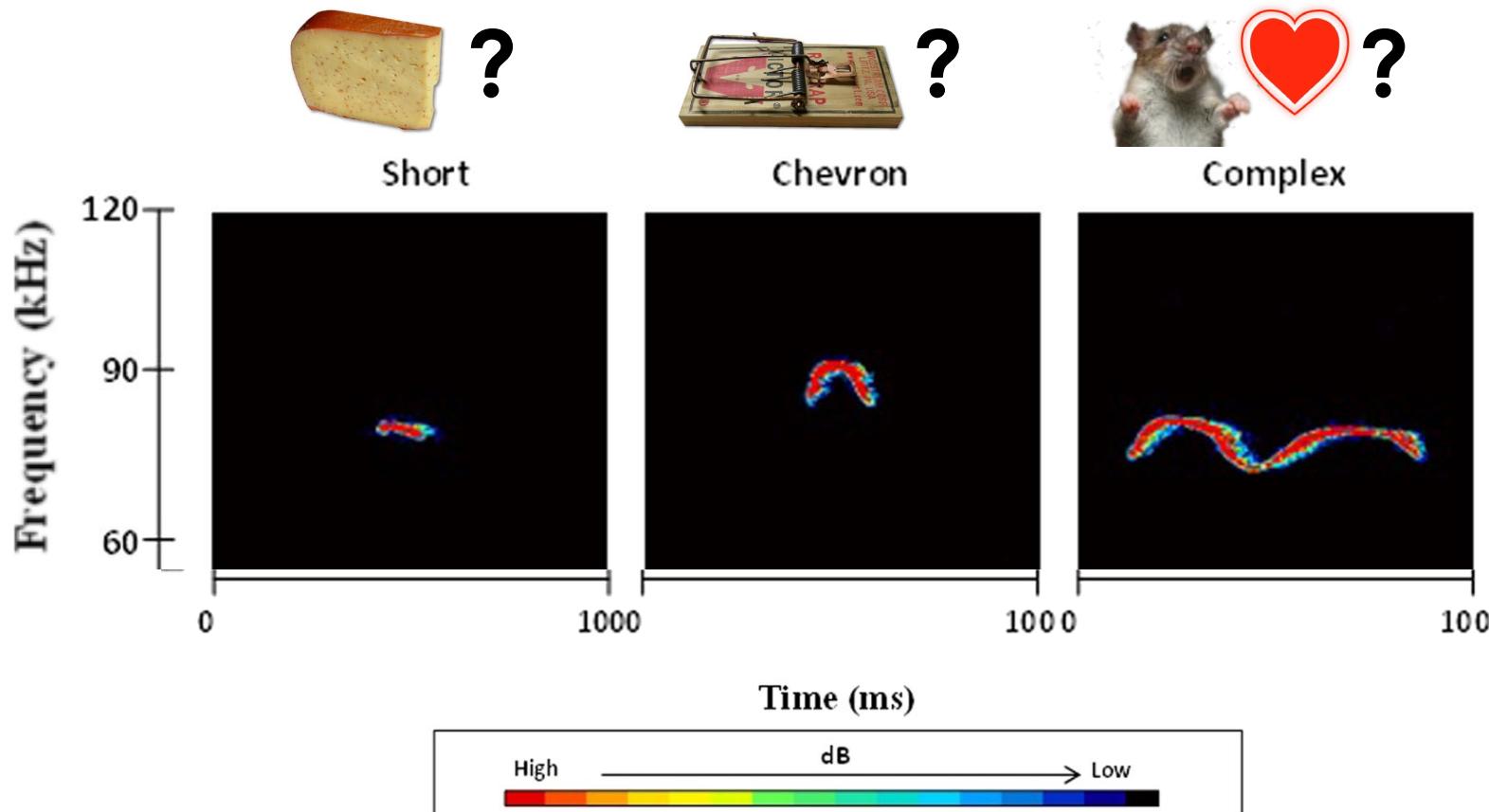
<https://shop.tympan.org/pages/asa-conference-2021>



Tympan

Rats Make Ultrasonic Vocalizations?!?

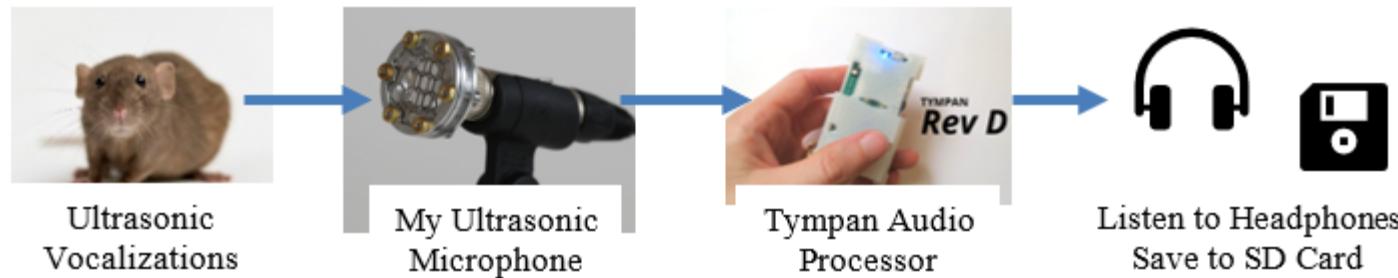
Could we shift them down in frequency
so human researchers can hear them in real-time?



Vogel, A.P., Tsiaras, A. & Scattolini, M.L. Quantifying ultrasonic mouse vocalizations using acoustic analysis in a supervised statistical machine learning framework. *Sci Rep* 9, 8100 (2019). <https://doi.org/10.1038/s41598-019-44221-3>

Looking for a Short 1-Page Proposal

- Idea: Shifting ultrasonic rat vocalizations so humans can hear them
- Your Motivation: Study rat vocalizations in real-time
- Proposed Approach: Use the Tympan “Frequency Shifter” example to shift the rat sounds down to audible frequencies



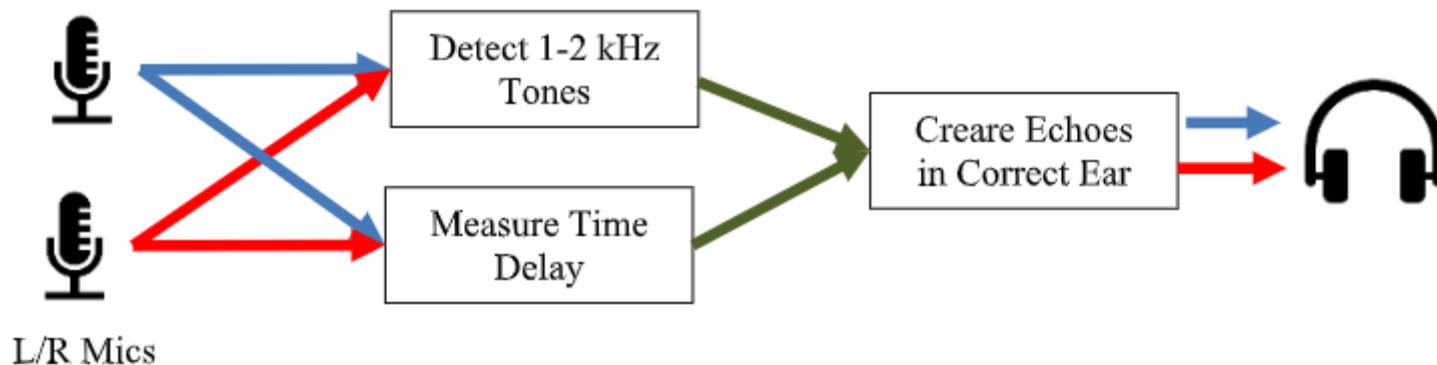
- Desired Result: To have a system that will let me listen to (and record) ultrasonic rat vocalizations in real-time.

Locate Backup Tones from a Truck?



Locate Backup Tones from a Truck?

- Idea: A device that can help you locate where backup tones are coming from
- Your Motivation: Backup tones are easy to hear but can be hard to localize.
- Proposed Approach: Base location on the time delay between L & R mics and play echoes of the tone in the ear closest to the sound source



- Desired Result: A device that plays audible cues to indicate where a truck is backing up.

Could a Tympan Be Used To...

Measure Motion
of the Larynx



Measure Ultrasound
Absorption in Nature



Teach Signal
Processing



Record Field Data
for Multi-Talkers



Gauge Ice Thickness
using Ultrasound



Measure Auditory
Reaction Time



Let's Hear Your Ideas!

- What technological limitations do you face?
- Is there field data you wish you could collect?
- Could a custom phone app be useful to your research?
- Are there sensors you are hoping to integrate?
- Do you have an unusual application involving infrasound, ultrasound, or hydrophones?
- Do you have an idea on how to improve the Tympan Earpieces?



Getting Started

Google: “Tympan Getting Started”

Getting started with Tympan

1. [What's in the Box?](#)
2. [Install Software](#)
3. [Connect the Tympan to Arduino IDE](#)
4. [Try Some Examples](#)
5. [Try More Examples](#)

<https://github.com/Tympan/Docs/wiki/Getting-Starting-with-Tympan>



Tympan

Installing Software

- Install Arduino and Teensy Software
- Clone (or download) the Tympan Library from GitHub

The screenshot shows the GitHub repository page for 'Tympan / Tympan_Library'. The repository description is 'Arduino/Teensy Library for Tympan Open Source Hearing Aid'. Key statistics shown are 96 commits, 3 branches, 0 releases, 2 contributors, and an MIT license. The 'Clone or download' button is highlighted with a red box and a red arrow pointing to the latest commit message, which reads 'Latest commit 3710fd9 on Sep 5'. The repository contains files like 'examples', 'utility', '.gitattributes', and '.gitignore'.

File	Description	Time
examples	fixed examples	2 months ago
utility	Library: BTNRH_rfft move code to cpp from h	6 months ago
.gitattributes	First Code Commit: pre-AAS	8 months ago
.gitignore	First Code Commit: pre-AAS	8 months ago



Tympan

Blink an LED

Blinky §

```
1 //include the Tympan Library
2 #include <Tympan_Library.h>
3
4 //Initialize the Tympan
5 Tympan      myTympan(TympanRev::D);
6
7 void setup() {
8     // put your setup code here, to run once:
9 }
10
11 void loop() {
12     // put your main code here, to run repeatedly:
13
14     myTympan.setRedLED(LOW);
15     delay(1000);
16
17     myTympan.setRedLED(HIGH);
18     delay(1000);
19 }
```

} Imports and initializes
the Tympan Library

} Setup runs once

} Loop runs forever

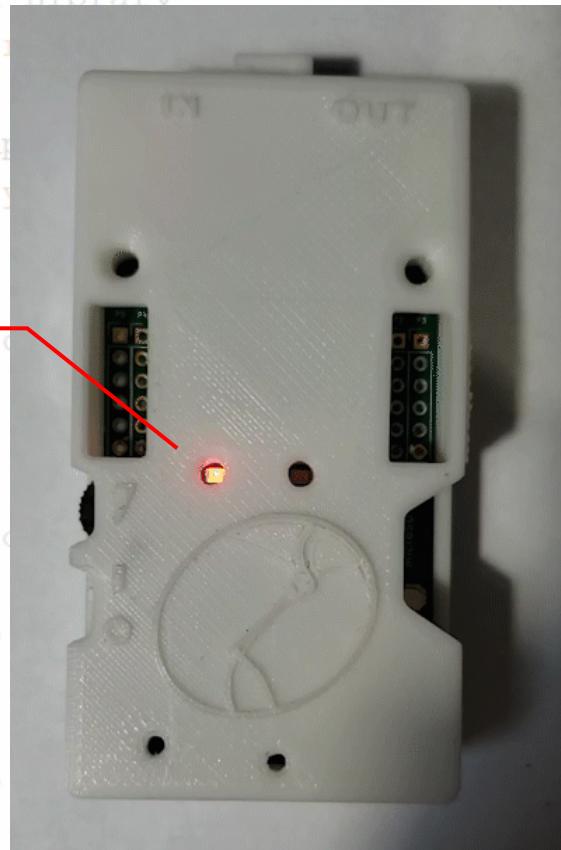


Tympan

Blink an LED

Blinky\$

```
1 //include the Tympan Library
2 #include <Tympan_Lib.h>
3
4 //Initialize the Tympan
5 Tympan myTympan(TYMPAN);
6
7 void setup() {
8     // put your setup code here, to run once:
9 }
10
11 void loop() {
12     // put your main code here, to run repeatedly:
13
14     myTympan.setRedLED();
15     delay(1000);
16
17     myTympan.setRedLED();
18     delay(1000);
19 }
```



} Setup runs once

} Loop runs forever



Tympan

Learn By Example

Let's record some sounds to SD card



tympan github



All

Images

News

Videos

Shopping

More

Settings

Tools

About 24,200 results (0.40 seconds)

<https://github.com> › Tympan

⋮

[Tympan · GitHub](#)

Repositories · Tympan_Library. Arduino/Teensy Library for Tympan Open Source Hearing Aid ·
Tympan_Remote_App. Mobile App for Controlling Tympan.

[Tympan/Tympan_Library](#)

Arduino/Teensy Library for Tympan
Open Source Hearing ...

[Tympan](#)

Open-source hearing aid and
hearing aid development tools ...

[Tympan Audio Design Tool](#)

html design tool for Tympan audio
systems. Contribute to ...



[Tympan/Tympan_Remote_App](#)

Tympan Remote App. Mobile App
for Controlling Tympan. Built ...

<https://shop.tympan.org/pages/asa-conference-2021>



Tympan

Learn By Example

https://github.com/Tympan/Tympan_Library/tree/master/examples

The screenshot shows the GitHub repository page for 'Tympan / Tympan_Library'. The repository has 14 stars. The navigation bar includes 'Code' (selected), 'Issues' (13), 'Pull requests' (1), 'Actions', 'Projects', and a 'Watch' button. Below the navigation bar are buttons for 'master' (selected), 'Go to file', 'Add file', and 'Code'. The main content area displays a list of commits. The commit by 'chipaudette' titled 'BasicGain_wApp: enabling serialPlot...' is highlighted with a red box around the 'examples' folder icon. A white cursor arrow points towards this highlighted commit.

Commit	Description	Date	Actions
chipaudette BasicGain_wApp: enabling serialPlot...	... ✓ on Dec 7, 2020	559	
docs	Add brief tutorial on configuring Platform...	9 months ago	
examples	BasicGain_wApp: enabling serialPlotter by...	6 months ago	
extras/lib_info/SdF...	structure library, Add SdFat_Gre, add S...	3 years ago	
src	dated Example: Adding an indicator to ...	7 months ago	

<https://shop.tympan.org/pages/asa-conference-2021>



Tympan

Learn By Example

Screenshot of a GitHub repository page for "Tympan / Tympan_Library".

The repository has 14 stars and 67 forks.

Navigation links include: Code, Issues (13), Pull requests (1), Actions, Projects, Wiki, and ...

The current branch is master.

The path is Tympan_Library / examples /

A pull request by chipaudette is shown: BasicGain_wApp: enabling serialPlotter by default, merged on Dec 7, 2020.

The repository contains several example folders:

- 01-Basic (Add files via upload, 7 months ago)
- 02-Utility (Example: SLM 2-chan, Improve comments, 2 years ago)
- 03-Intermediate (WDRC_FIR_8Band: fix Travis errors?, 17 months ago)
- 04-FrequencyDomain (mantShifter: clarify comments, 12 months ago)
- 05-FullSystems (Examples: update to reduce Travis errors, 17 months ago)

A red box highlights the 02-Utility folder. A cursor icon is positioned over the 02-Utility folder.



Learn By Example

master ▾ Tympan_Library / examples / 02-Utility / Go to file Add file ...

chipaudette Example: SLM 2-chan, Improve comments ... X on Dec 24, 2019 History

..

BluetoothAudio_PassThru	Examples: partial update	2 years ago
ControlViaSerial	Examples: partial update	2 years ago
ControlViaSerialAndBluetooth	Examples: partial update	2 years ago
DetectExtMic	Examples: partial update	2 years ago
MyAudioAlgorithm	Examples: partial update	2 years ago
OutputToneWithSteppedAmplit...	Examples: partial update	2 years ago
RenameTympanBT	Examples: partial update for new Tympan Rev system	2 years ago
SDWavPlayer	Examples: Add SDWavPlayer	2 years ago
SDWriting_01_StereoAudio	Examples: Replace and Update SD Writing	2 years ago
SDWriting_02_RemoteControlled	Examples: Replace and Update SD Writing	2 years ago



<https://shop.tympan.org/pages/asa-conference-2021>



Tympan

Simple Audio Gain

Audio Input → Gain Algorithm → Audio Output

BasicGain §

```
1 //here are the libraries that we need
2 #include <Tympan_Library.h> //include the Tympan Library
3
4 //create audio library objects for handling the audio
5 Tympan myTympan(TympanRev::D);
6 AudioInputI2S_F32 i2s_in;
7 AudioEffectGain_F32 gain1, gain2;
8 AudioOutputI2S_F32 i2s_out;
9
10 //Make all of the audio connections
11 AudioConnection_F32 patchCord1(i2s_in, 0, gain1, 0);
12 AudioConnection_F32 patchCord2(i2s_in, 1, gain2, 0);
13 AudioConnection_F32 patchCord11(gain1, 0, i2s_out, 0);
14 AudioConnection_F32 patchCord12(gain2, 0, i2s_out, 1);
15
16 // define the setup() function, the function that is called on
17 const float input_gain_dB = 20.0f; //gain on the microphones
```

} Create Audio Objects

} Route Audio

Define variables



Simple Audio Gain

Setup runs once

```
16 // define the setup() function, the function that is called
17 void setup() {
18     //allocate the dynamic memory
19     AudioMemory_F32(10);
20
21     //Enable the Tympan to start the audio flowing!
22     myTympan.enable();
23
24     //Choose the desired input
25     myTympan.inputSelect(TYMPAN_INPUT_ON_BOARD_MIC);
26     //myTympan.inputSelect(TYMPAN_INPUT_JACK_AS_MIC);
27     //myTympan.inputSelect(TYMPAN_INPUT_JACK_AS_LINEIN);
28
29     //Set the desired volume levels
30     myTympan.volume_dB(0);
31     myTympan.setInputGain_dB(0);
32
33 } //end setup()
```

Set Length of Processing Blocks

Enable Audio

Choose Input

Set Initial Gain



Tympan

Simple Audio Gain

Loop runs forever

```
36 // loop runs forever
37 void loop() {
38     myTympan.setInputGain_dB(5.0);
39     myTympan.setRedLED(HIGH);
40     myTympan.setAmberLED(LOW);
41     delay(3000);
42
43     myTympan.setInputGain_dB(15.0);
44     myTympan.setRedLED(LOW);
45     myTympan.setAmberLED(HIGH);
46     delay(3000);
47
48 } //end loop();
```

Set Gain
Set LEDs
Then wait



Tympan

Change the Gain using a Serial Terminal

Example: SDWriting_02_RemoteControlled

```
20 | usb_serial_class *USB_Serial = &Serial;      Create a Serial object
21 |
22 | //begin the serial comms (for debugging)
23 | USB_Serial->begin(9600);                    Begin Serial @ 9600bps
24 |
25 | 57 if (Serial.available()) {
26 | 58   respondToByte((char)Serial.read());    //USB Serial
27 | 59 }
28 |
29 | 66 //respond to serial commands
30 | 67 void respondToByte(char c) {
31 | 68   Serial.print("Received character "); Serial.println(c);
32 |
33 | 69
34 | 70 switch (c) {
35 | 71   case 'k':
36 | 72     changeGain(3.0);
37 | 73     printGainLevels();
38 | 74     break;
39 | 75   case 'K':
40 | 76     changeGain(-3.0);
41 | 77     printGainLevels();
42 | 78     break;
43 | 79 }
44 | 80 }
```

Annotations:

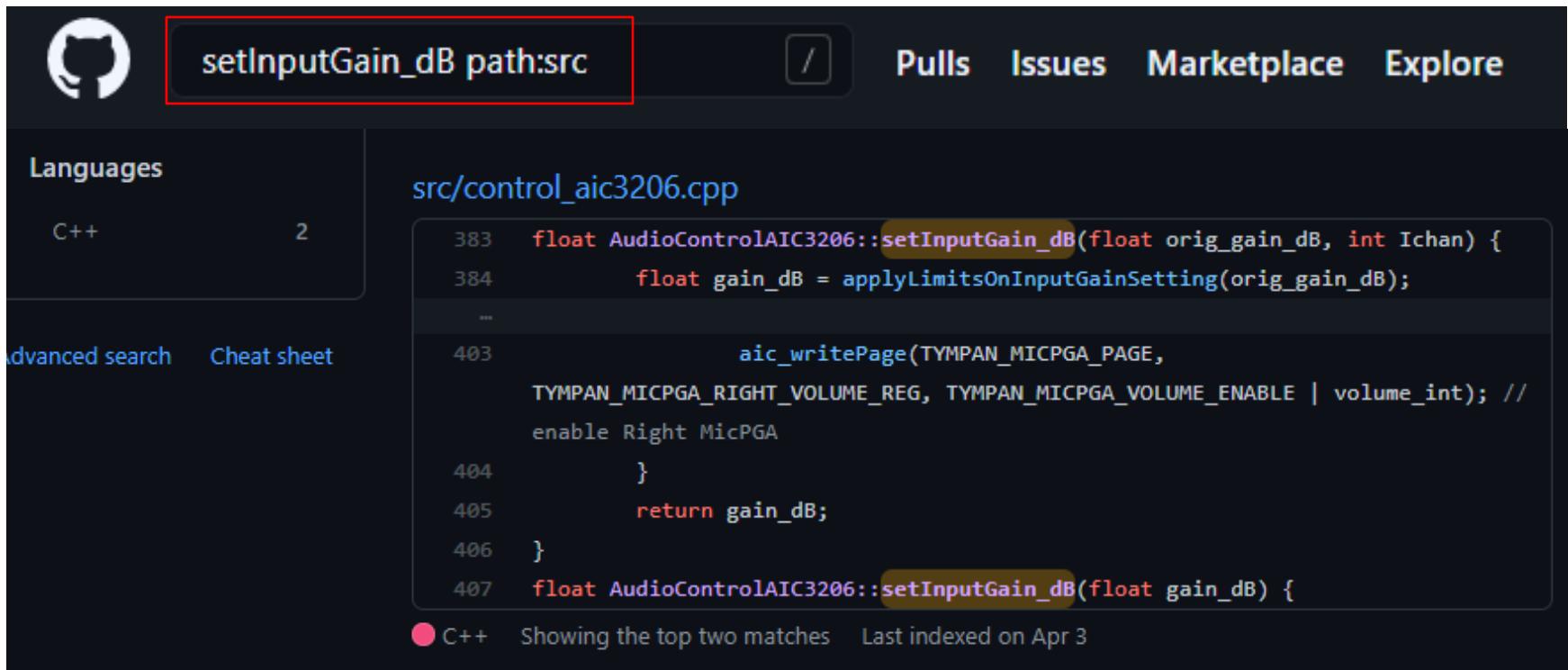
- A red arrow points from the text "Read Incoming Serial Data" to the line `respondToByte((char)Serial.read());`.
- A large curly brace on the right side groups the code from line 57 to 79 under the heading "Change the Gain".



Dig a Little Deeper

What does “setInputGain_dB” do?

- control_aic3206.cpp



The screenshot shows a GitHub search interface with a red box highlighting the search term "setInputGain_dB path:src". The results page displays code from the file "src/control_aic3206.cpp". The code snippet includes several instances of the "setInputGain_dB" function, with the first two highlighted by yellow boxes. The code is written in C++ and involves audio control logic for a MicPGA.

```
383     float AudioControlAIC3206::setInputGain_dB(float orig_gain_dB, int Ichan) {
384         float gain_dB = applyLimitsOnInputGainSetting(orig_gain_dB);
385         ...
403             aic_writePage(TYMPAN_MICPGA_PAGE,
404                         TYMPAN_MICPGA_RIGHT_VOLUME_REG, TYMPAN_MICPGA_VOLUME_ENABLE | volume_int); // enable Right MicPGA
405         }
406     }
407     float AudioControlAIC3206::setInputGain_dB(float gain_dB) {
```

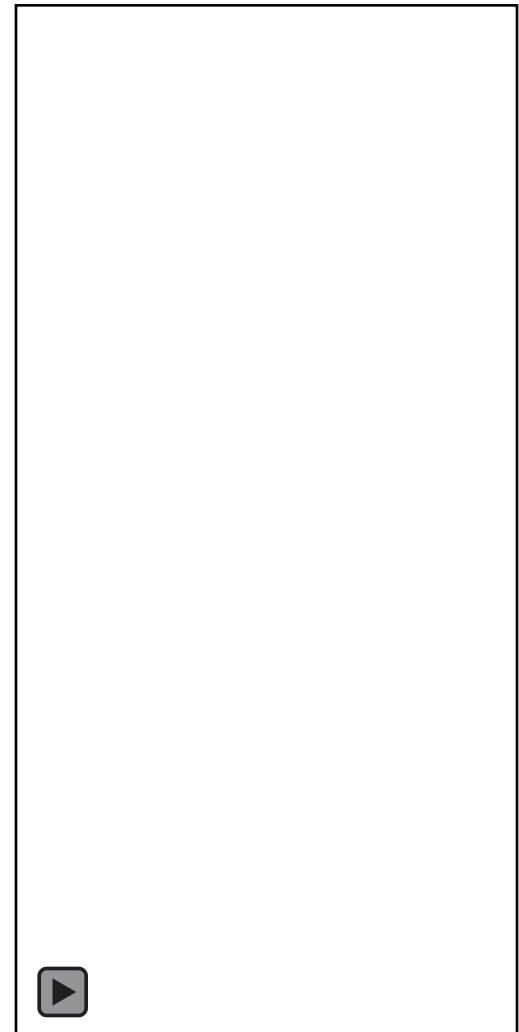
C++ Showing the top two matches Last indexed on Apr 3

Custom Phone App

01-BasicGain_wApp

- **addPage**
 - **addCard**
 - **addButton**

```
//Add first page to GUI
page_h = myGUI.addPage("MyFirstPage");
    //Add a card under the first page
card_h = page_h->addCard("Change Loudness");
        //Add a "--" digital gain button with the Label("--");
card_h-> addButton("--", "K", "minusButton", 4);
```



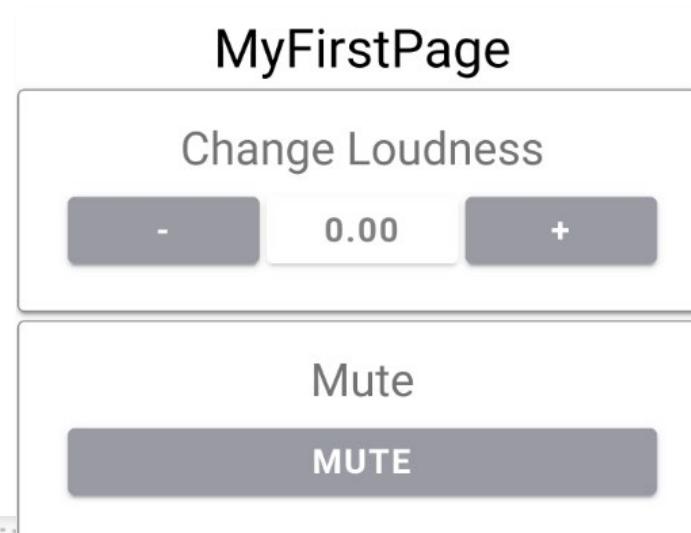
We Need a “Mute” Button

- Add a serial command so that “M” sets the gain to 0

```
127     case 'M':  
128         changeGain(-1.0*digital_gain_dB);  
129         printGainLevels();  
130         setButtonText("gainIndicator", String(digital_gain_dB));
```

- Add a new Card and a Mute button

```
162     card_h = page_h->addCard("Mute");  
163     card_h-> addButton("Mute", "M", "muteButton", 12);
```



ASA Challenge

Submit a Proposal by June 20

- Top 10 Applicants will be awarded **Free Tympans!**

For more info, visit:

- <https://shop.tympan.org/pages/asa-conference-2021>

Or drop by the Tympan-ASA forum:

- <https://forum.tympan.org/c/2021-asa-challenge/5>

Thank You!!!



Tympan