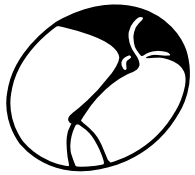


Tympan

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

You Have a Great Audio Idea!

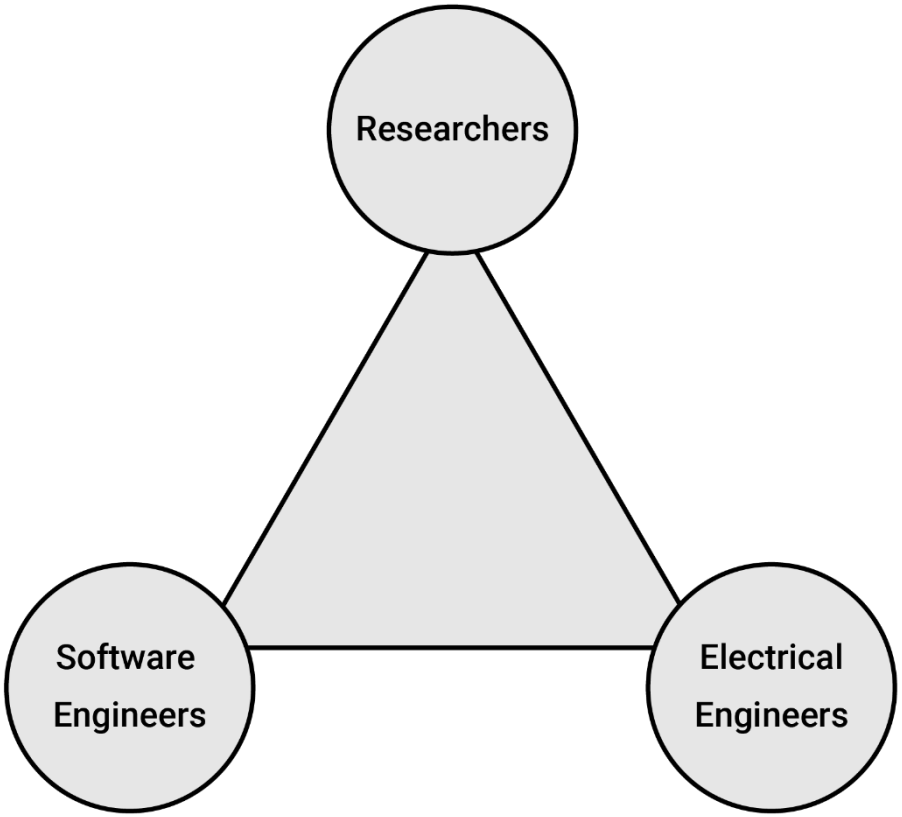
You try your idea via post-processing

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

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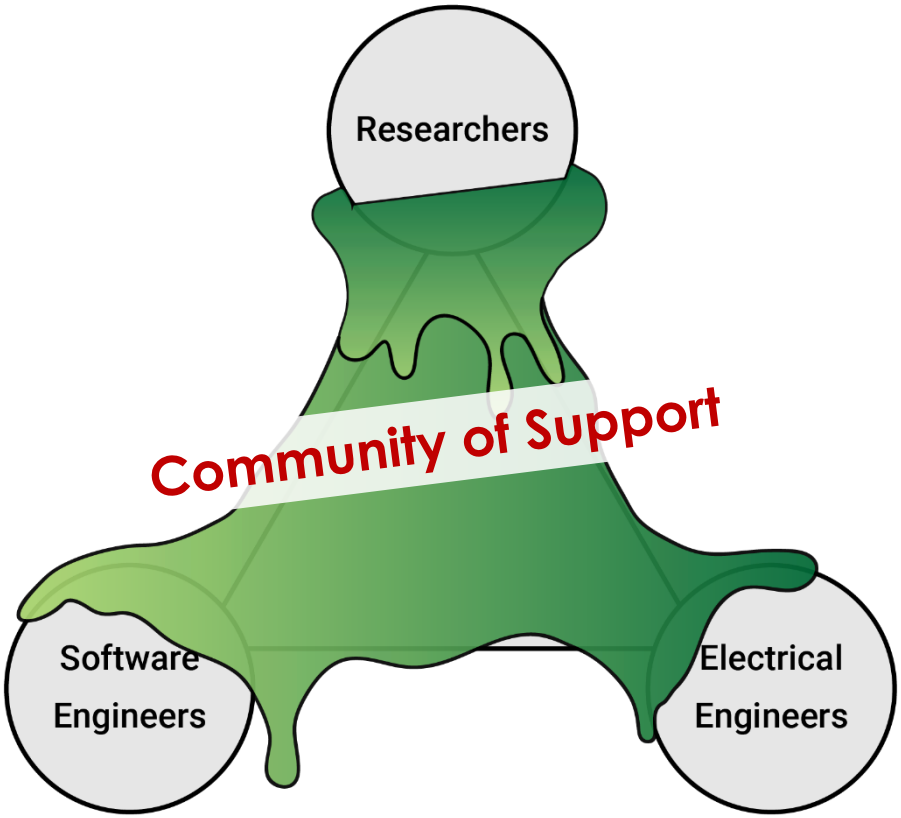
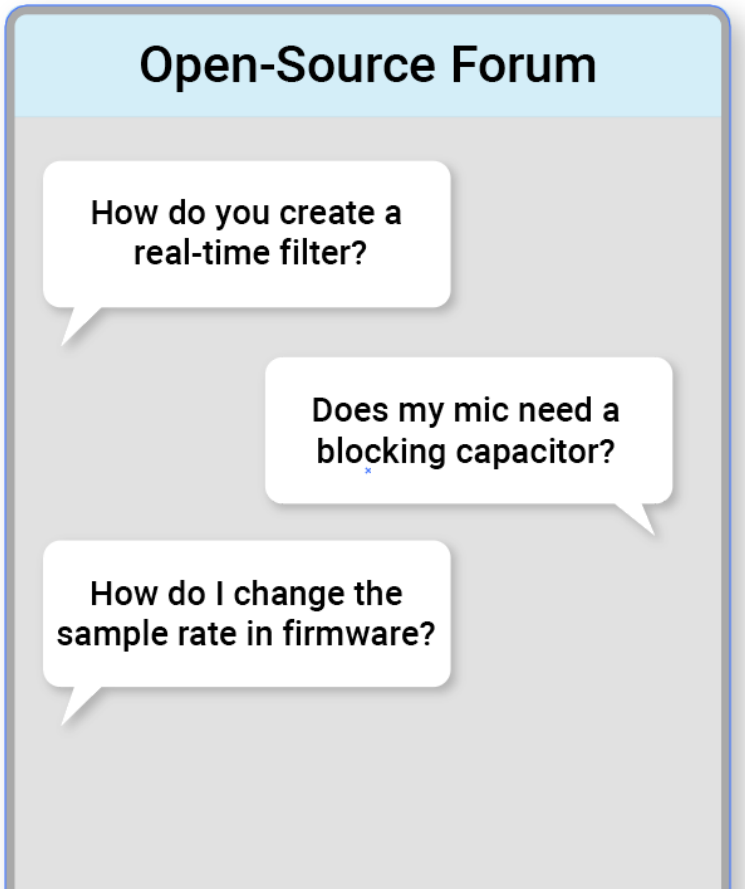
How Do You Create a Real-Time Prototype?

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





How Do You Share Your Results?

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

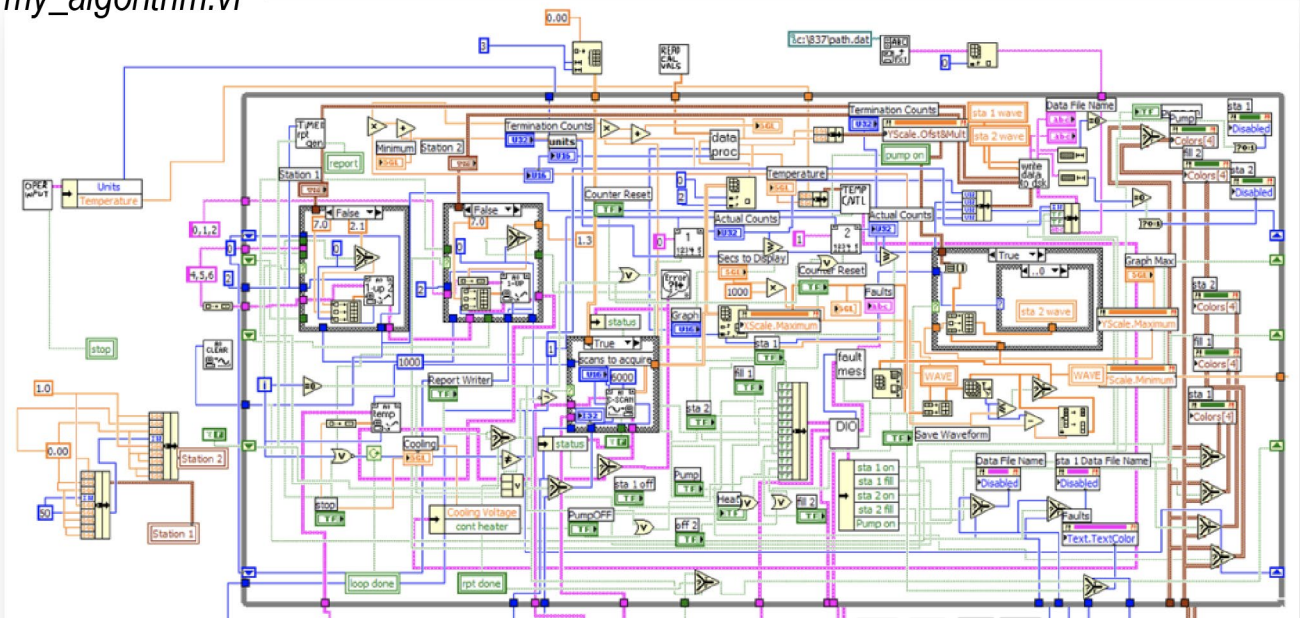
Send

From: Professor Frankenstein

Subject: Re: How do I reproduce your results?

Thank you for inquiring about my research. See attached.

my_algorithm.vi



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?

Open-Source Audio Platform

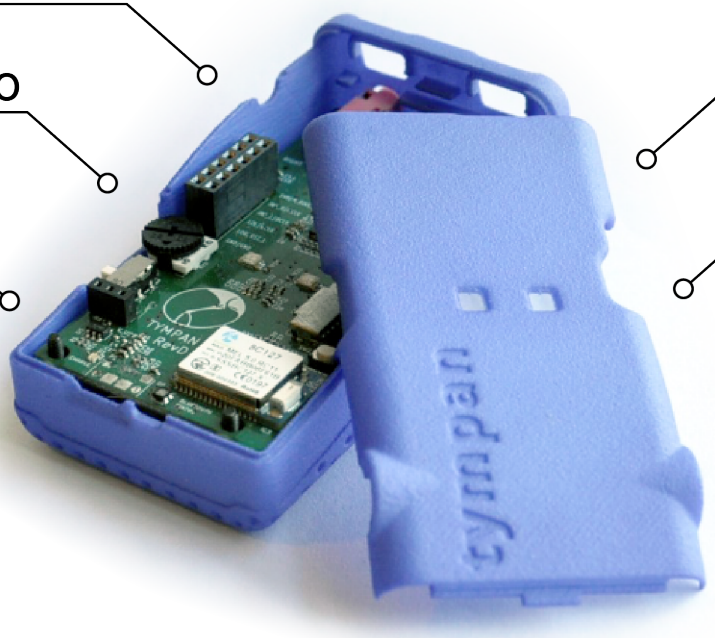
Easy to Program

High-Quality Audio

Portable

Real-Time Processing

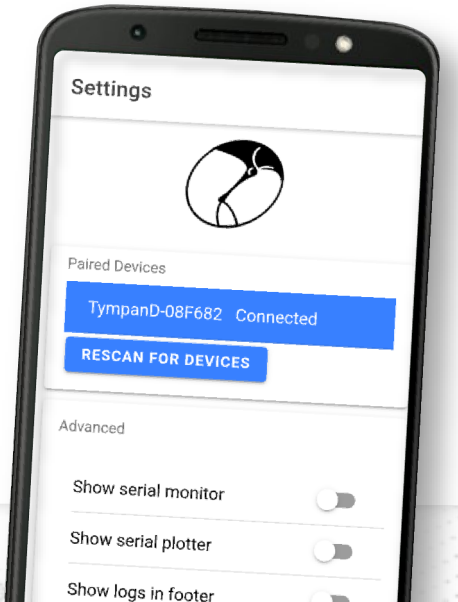
Flexible Phone App



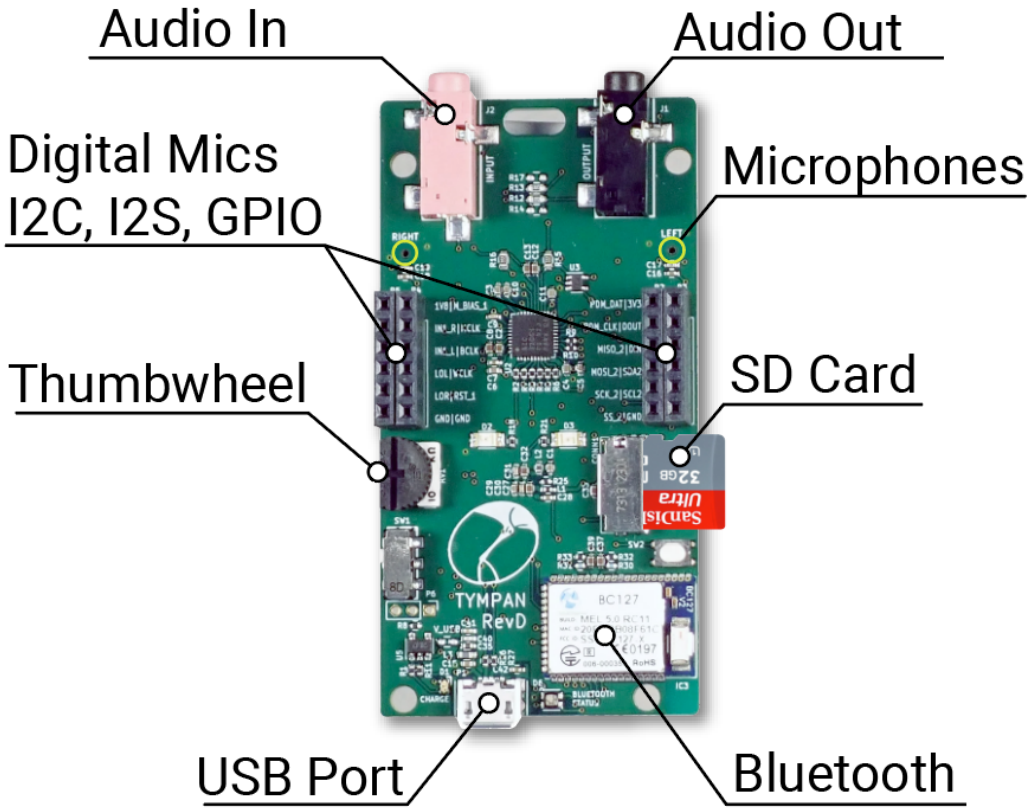
BTE Earpieces*

Tympan

*Based on a design by
Harinath Garudadri, UCSD



What's Under the Hood?



Li-Poly Battery

Tympan

Built on the Teensy

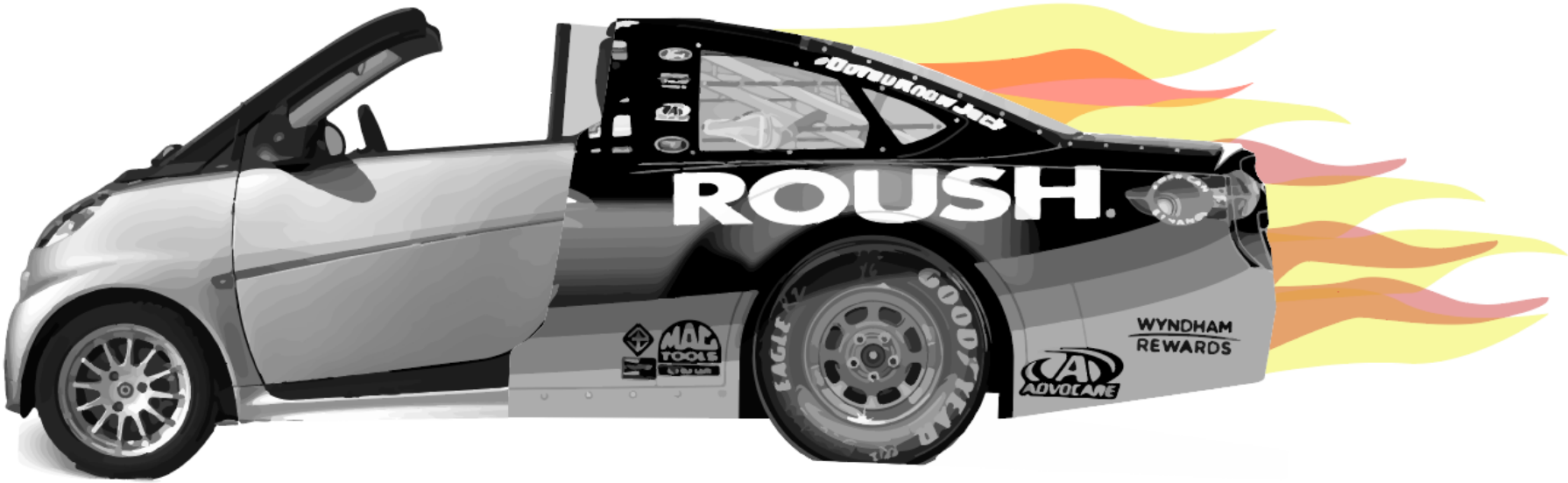
Simple Interface

ARDUINO

+

Powerful Backend

Teensy®



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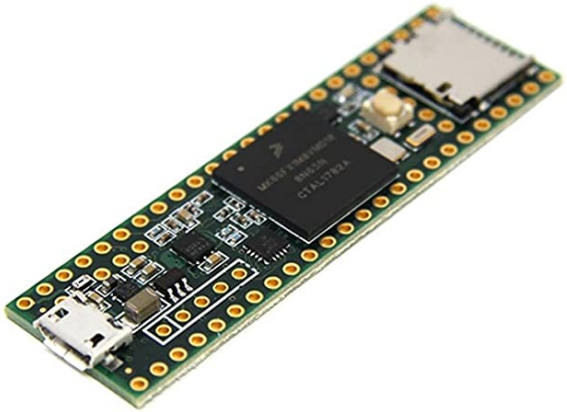
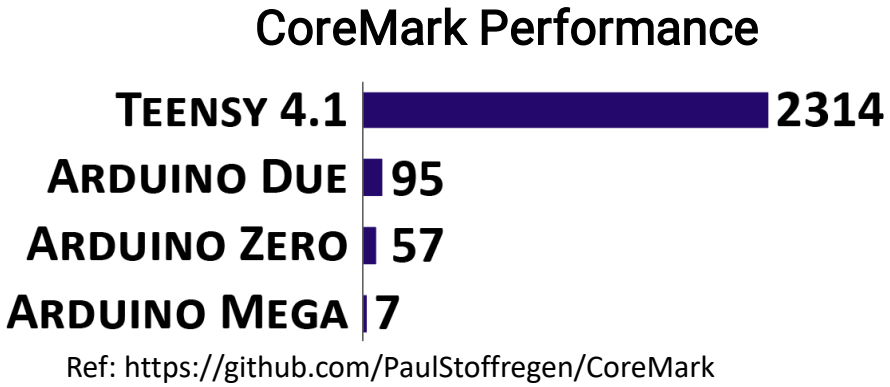
Built on the Teensy

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!**





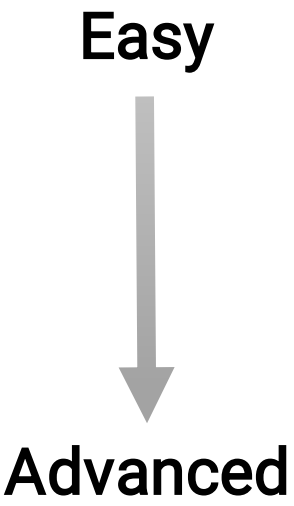
Ref: https://github.com/PaulStoffregen/CoreMark

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!!!



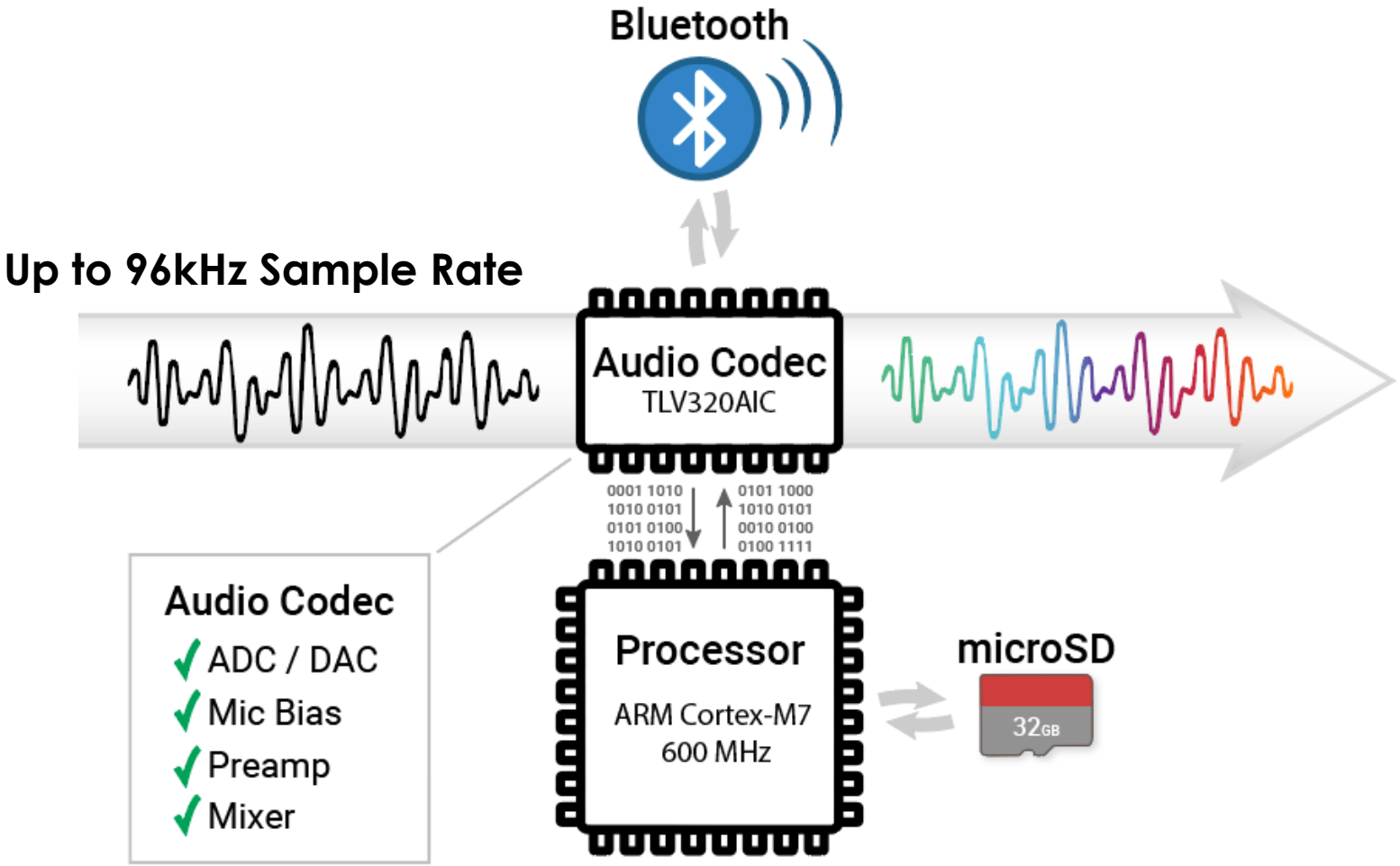
Demo after the Break

Many Inputs, Many Outputs

Tympan

How to Get Audio to the Processor?

Audio Codec digitizes the audio stream for processing



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Bluetooth Phone App

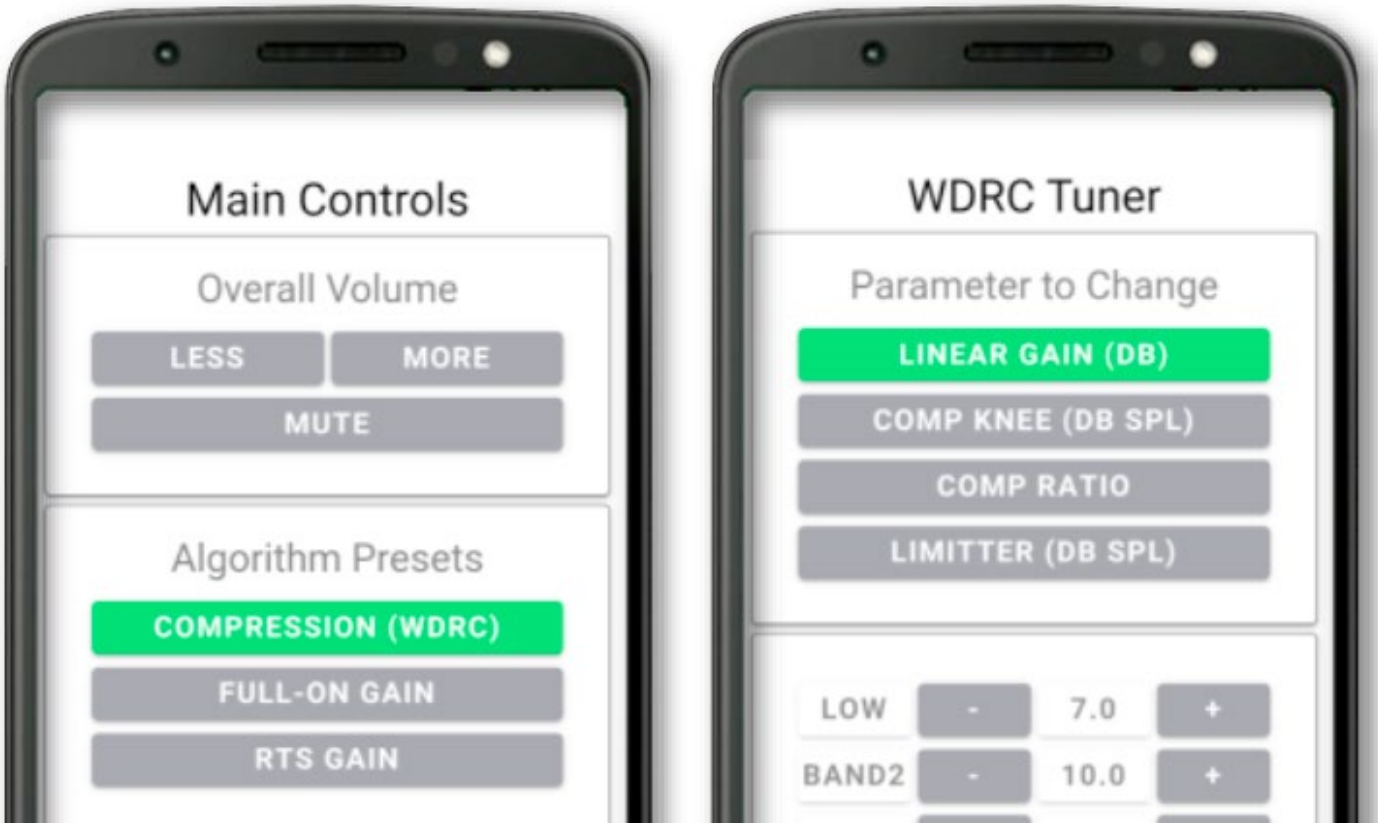
Full App for Configuring a Hearing Aid

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

Adjust Settings on the Fly!

GET IT ON Google Play

Download on the App Store



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?

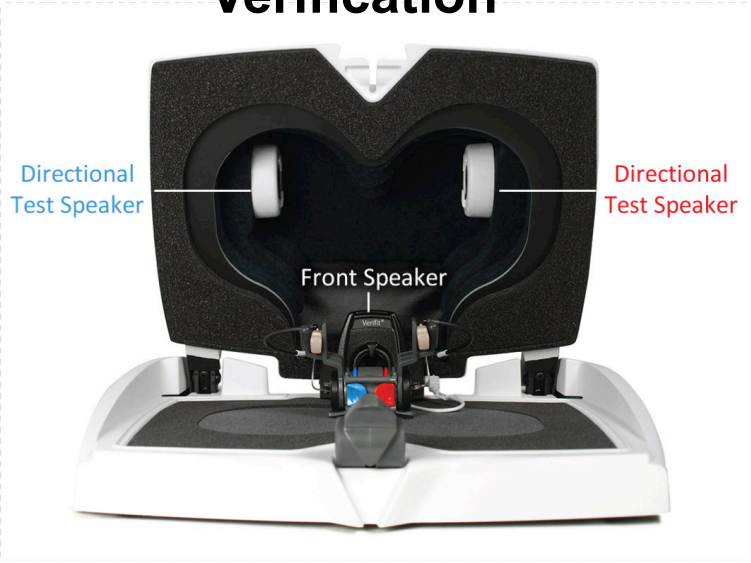
Electroacoustic Study

Joshua Alexander
Associate Professor
Purdue University

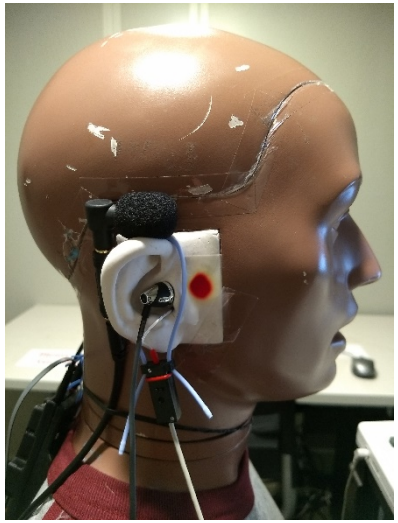
Human Behavioral Study

Marc Brennan
Assistance Professor
Univ. of Nebraska-Lincoln

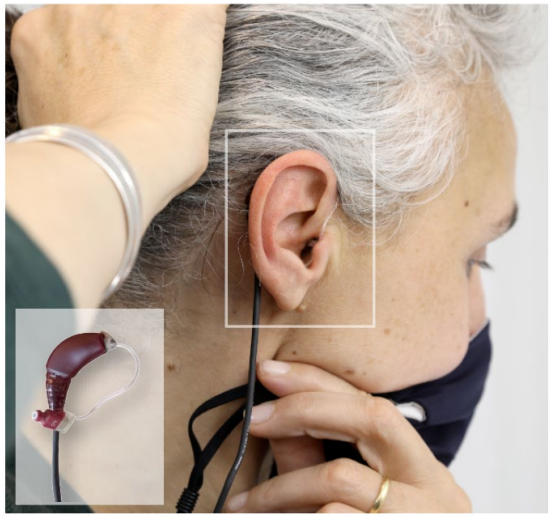
Hearing Aid Verification



KEMAR Manikin



Human Studies



Tympan

What Else Could a Tympan Be?

Mixed-Noise Sound Level Meter

Christopher Smalt
Technical Staff
MIT Lincoln Laboratory

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

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:

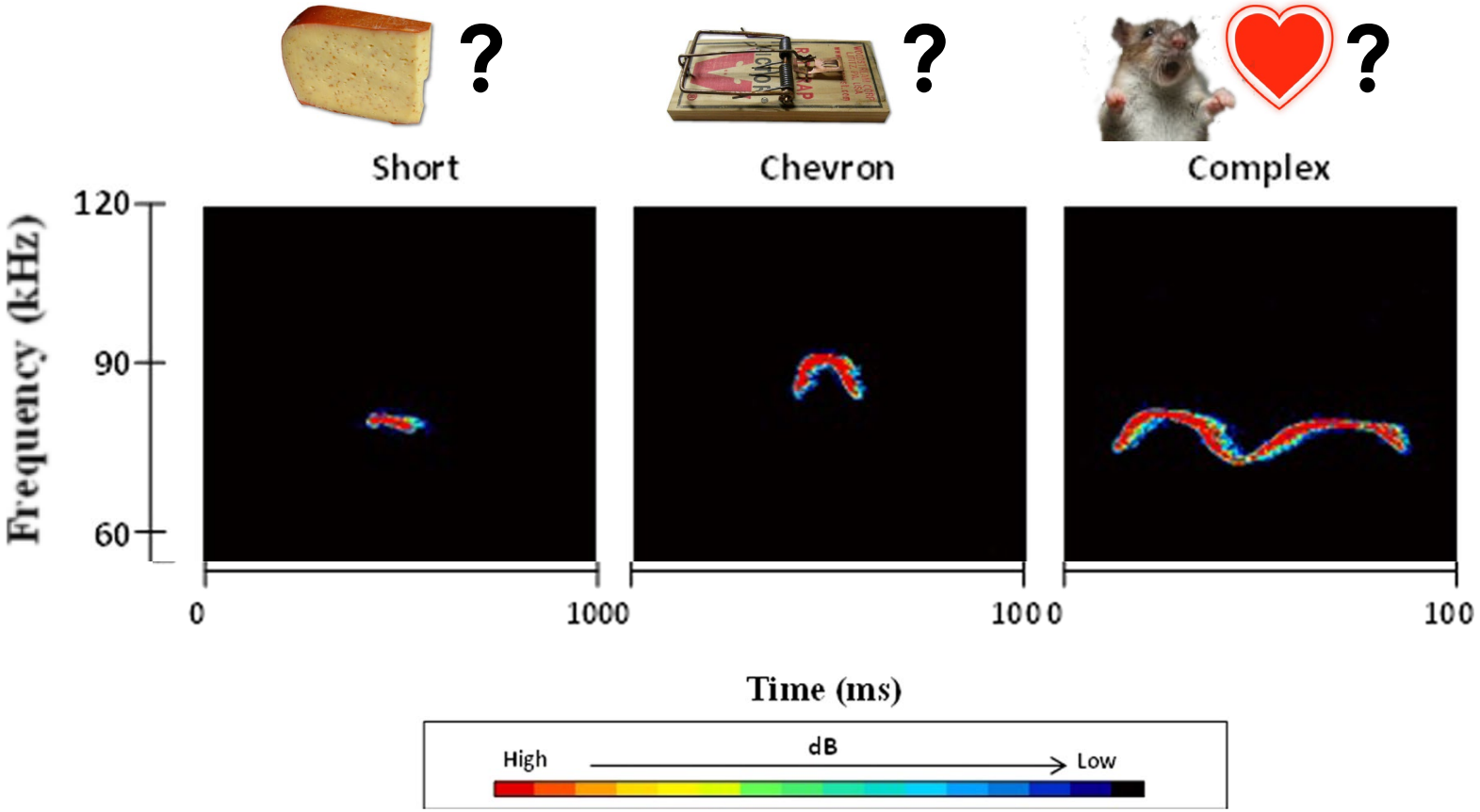
- Speech: Analyze speech in real time to improve understanding in noisy environments
- Noise: Build a custom sound level meter
- Voice: Record larynx activity using an accelerometer
- Sensors: Use the Tympan as a stethoscope

See Link For More Info

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

Rats Make Ultrasonic Vocalizations?!?

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



Vogel, A.P., Tsanas, A. & Scattoni, 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

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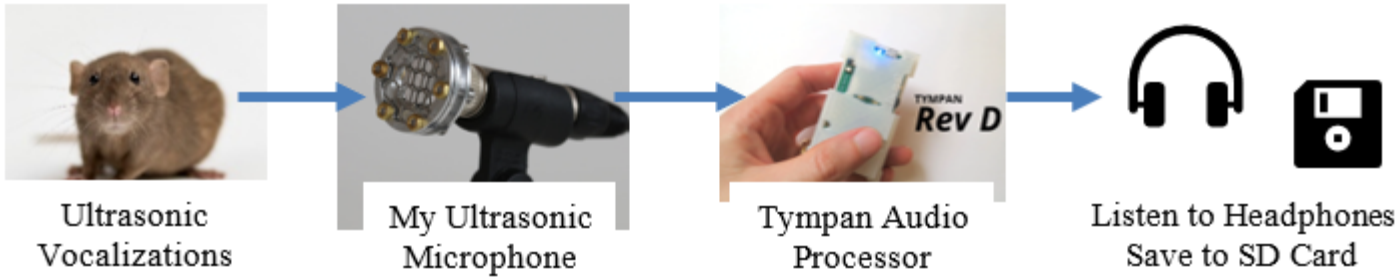
Looking for a Short 1-Page Proposal

- 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.

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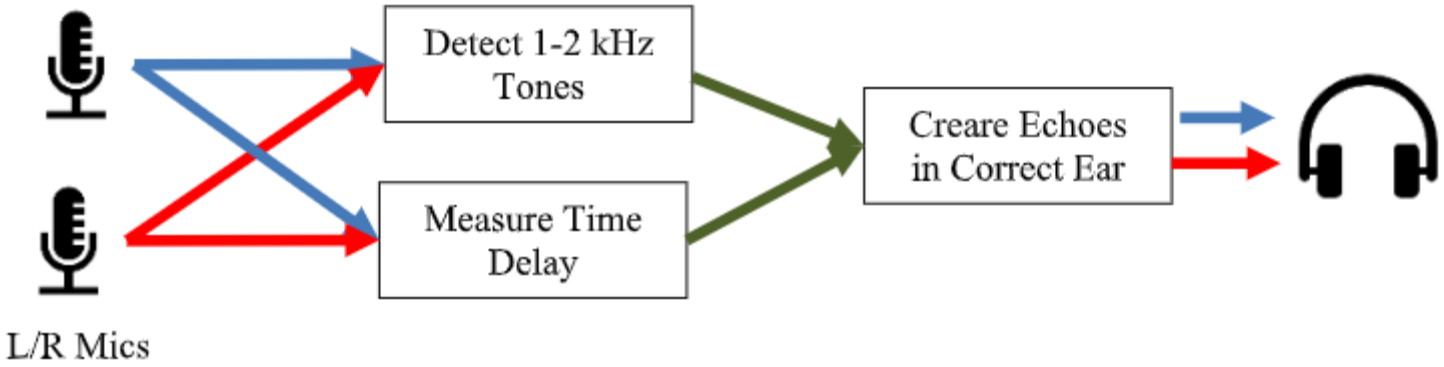
Locate Backup Tones from a Truck?

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

Tympan

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

acoustic camouflage 2pSA1

Teach Signal Processing

Record Field Data for Multi-Talkers

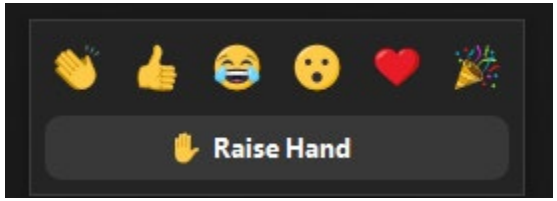
Speech Segragation 2pPP6

Gauge Ice Thickness using Ultrasound

Measure Auditory Reaction Time

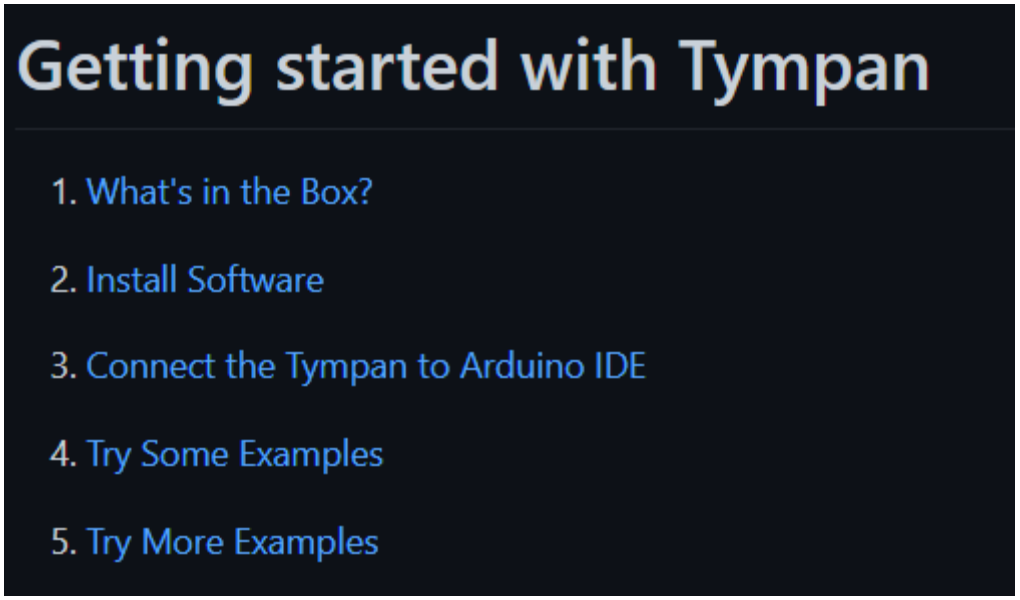
Let’s Hear Your Ideas!

- 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

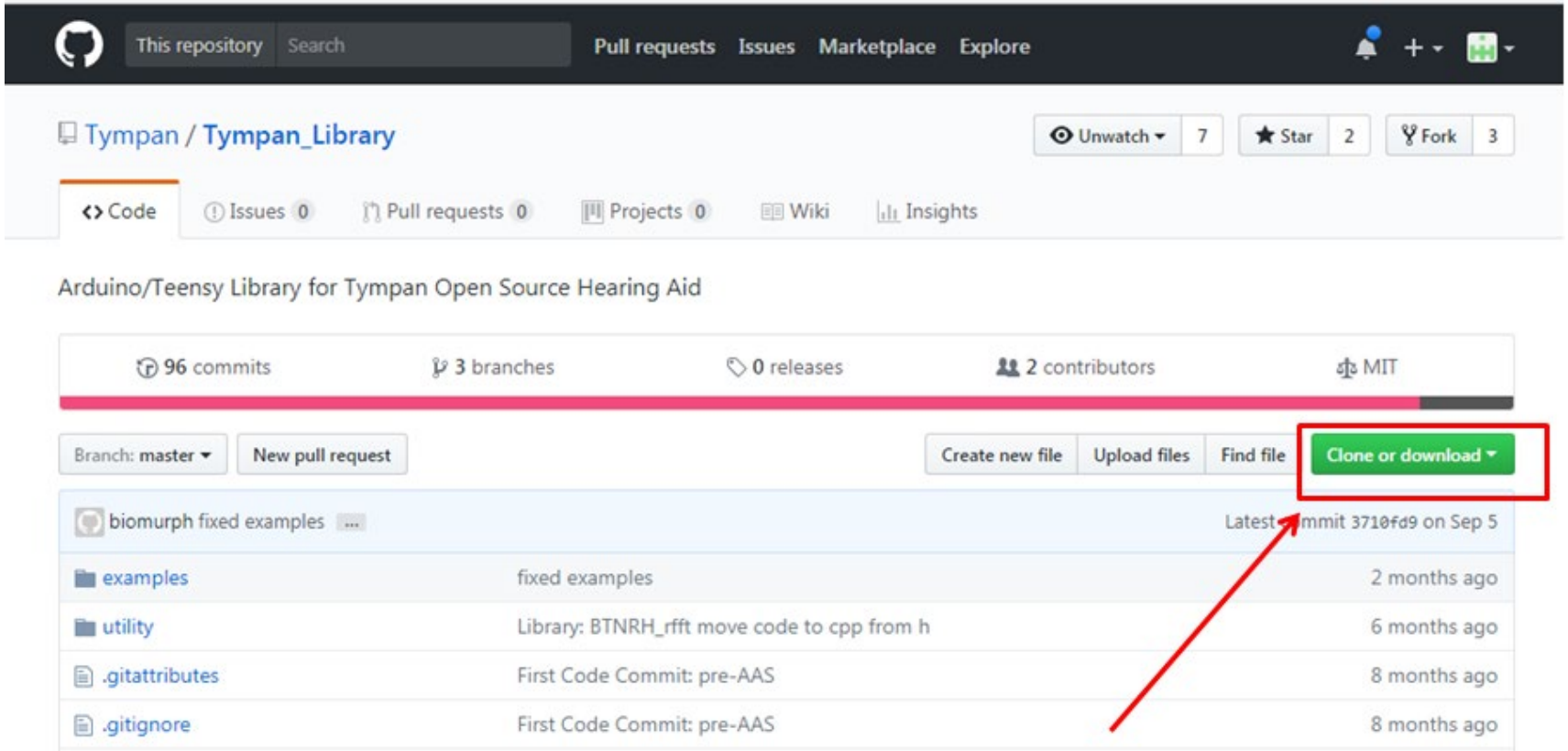
Google: “Tympan Getting Started”



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

Installing Software

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



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

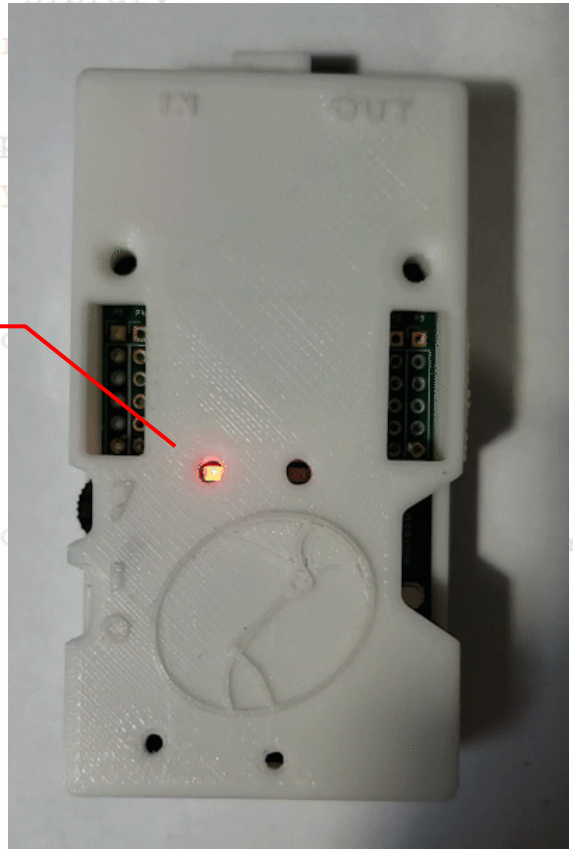
Setup runs once

Loop runs forever

Blink an LED

Blinky §

```
1  //include the Tympan Library
2  #include <Tympan_Libr
3
4  //Initialize the Tymp
5  Tympan     myTympan(Ty
6
7  void setu
8    // put your setup
9  }
10
11 void loop() {
12   // put your main co
13
14   myTympan.setRedLED
15   delay(1000);
16
17   myTympan.setRedLED
18   delay(1000);
19 }
```



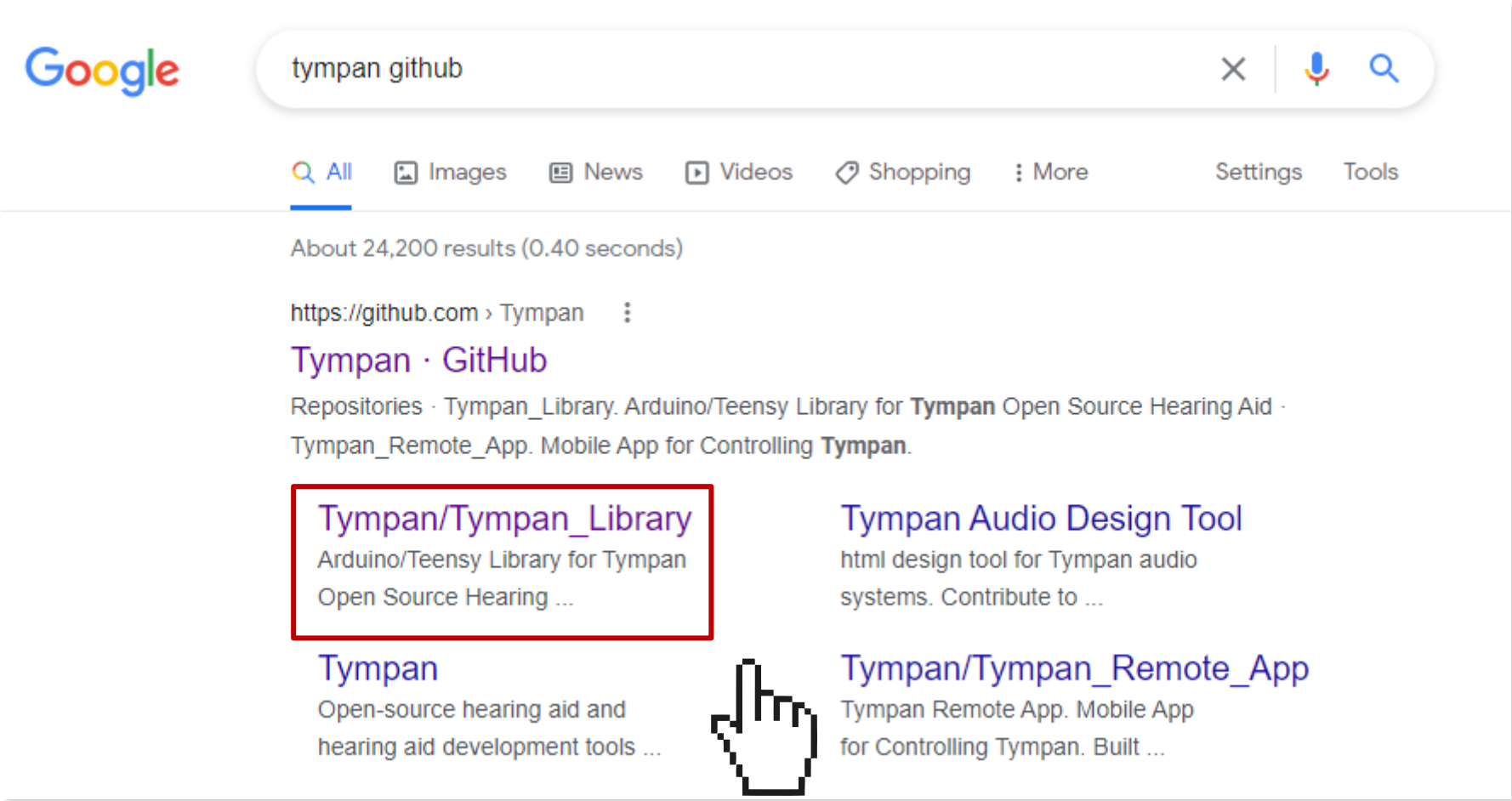
Setup runs once

Loop runs forever

Tympan

Learn By Example

Let's record some sounds to SD card



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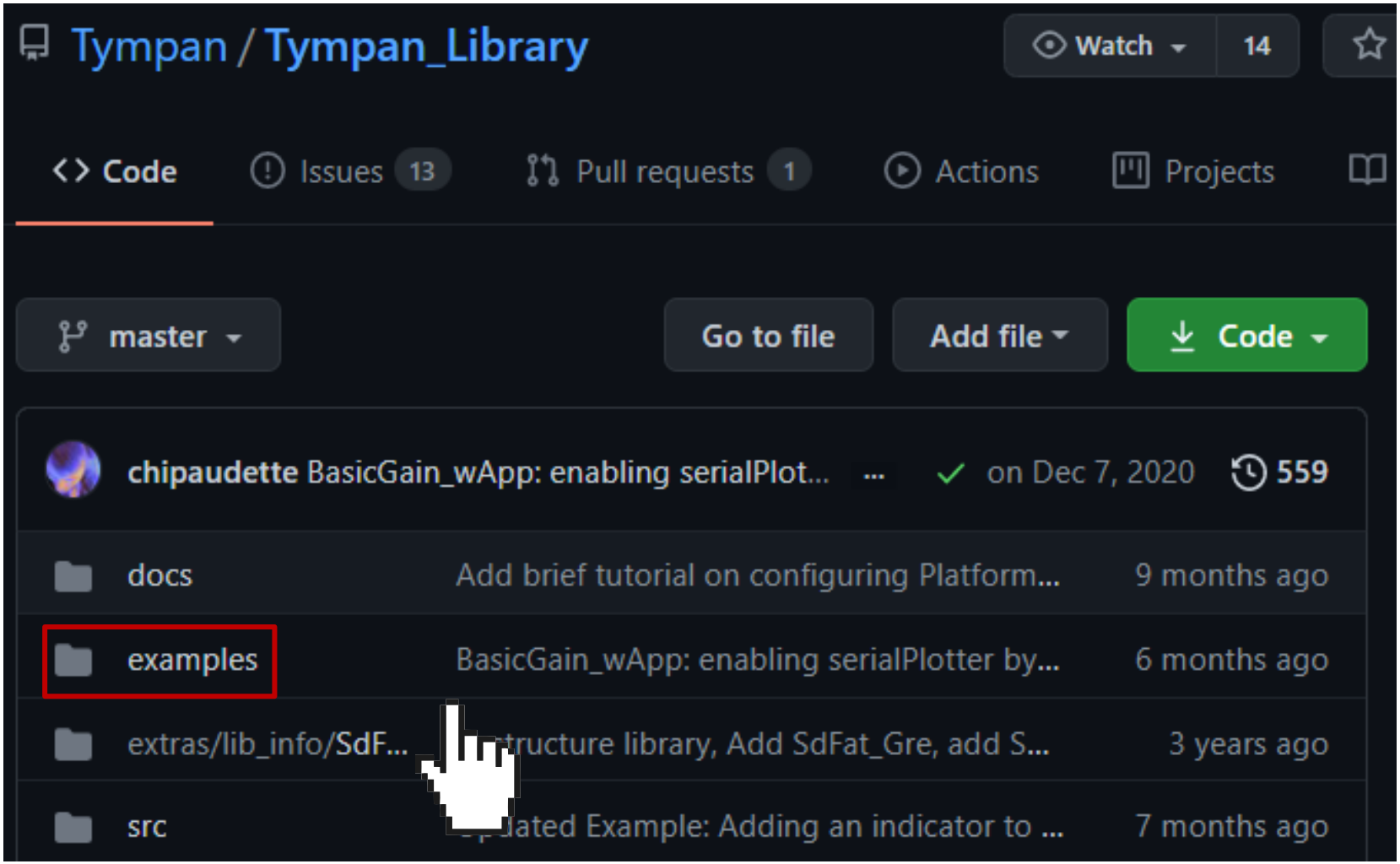
Learn By Example

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



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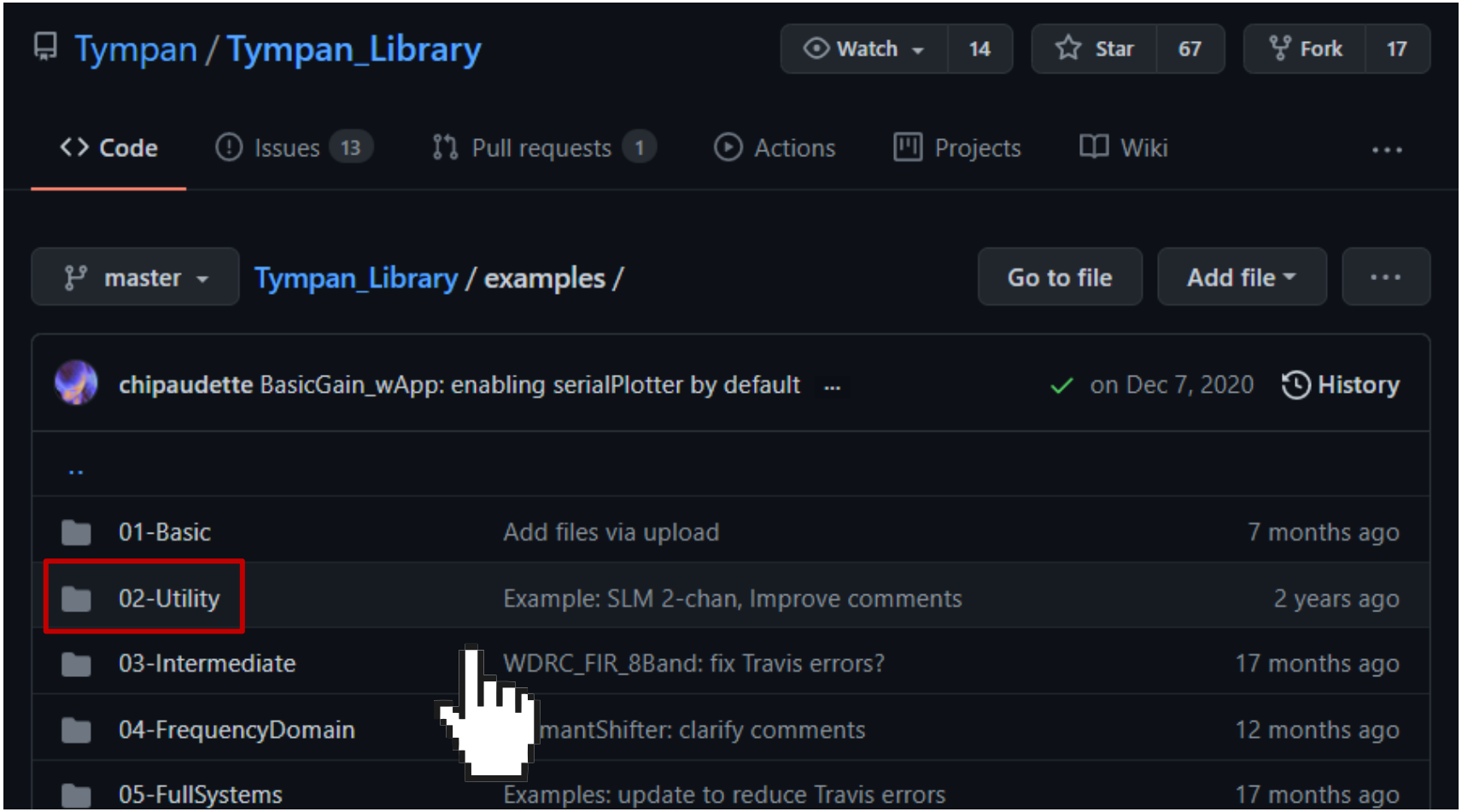
Tympan

Learn By Example



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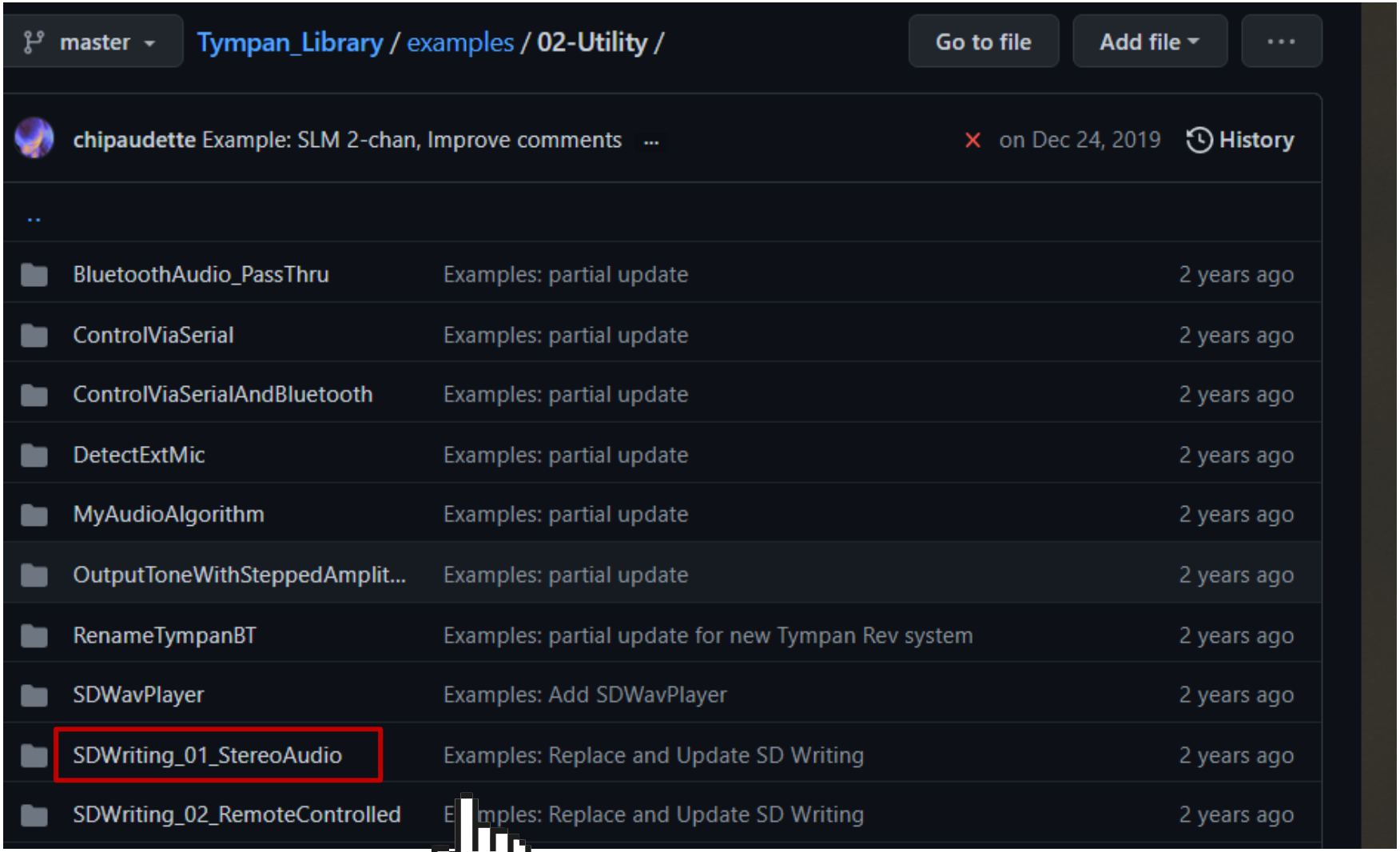
Learn By Example



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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 or
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

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

Change the Gain using a Serial Terminal

Example: SDWriting_02_RemoteControlled

```
20 usb_serial_class *USB_Serial = &Serial;

28   //begin the serial comms (for debugging)
29   USB_Serial->begin(9600);

57   if (Serial.available()){
58   respondToByte((char)Serial.read());   //USB Serial
59   }

66 //respond to serial commands
67 void respondToByte(char c) {
68   Serial.print("Received character "); Serial.println(c);
69
70   switch (c) {
71     case 'k':
72       changeGain(3.0);
73       printGainLevels();
74       break;
75     case 'K':
76       changeGain(-3.0);
77       printGainLevels();
78       break;
79   }
80 }
```

Create a Serial object

Begin Serial @ 9600bps

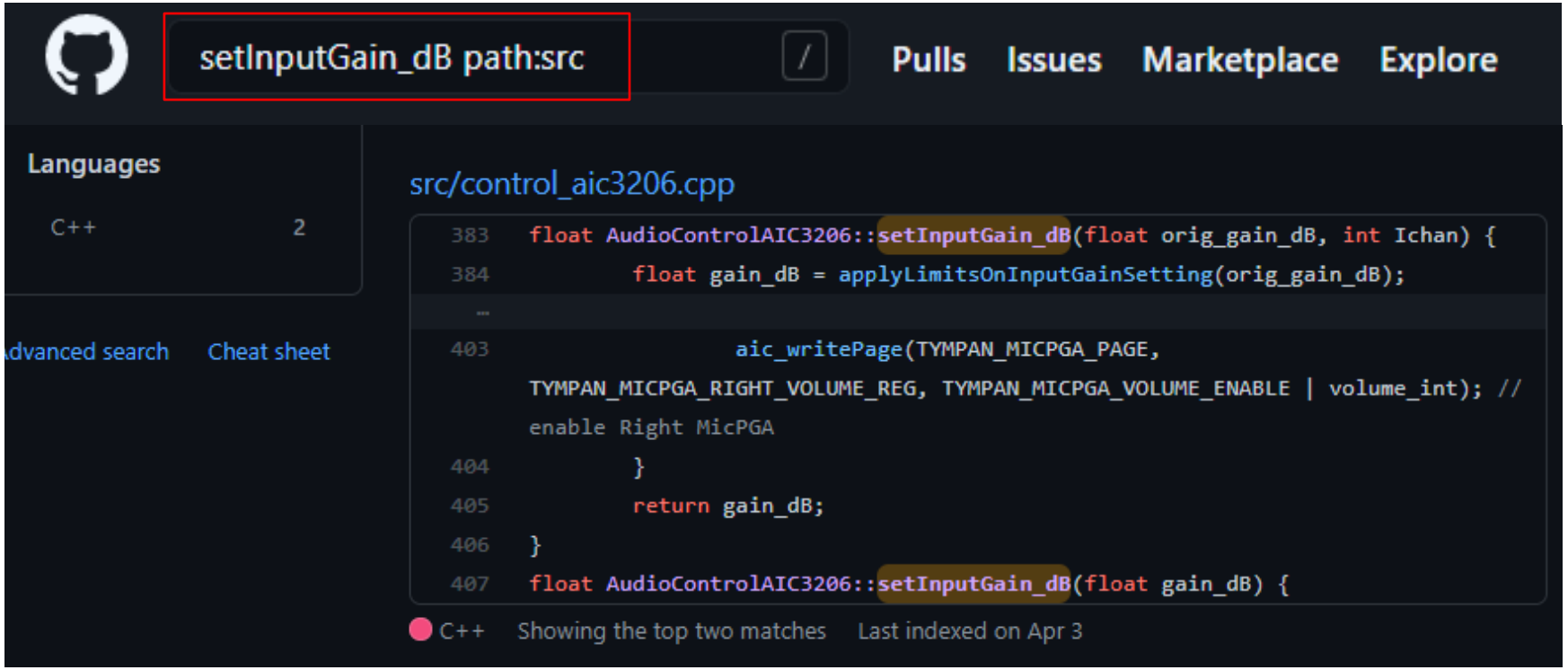
Read Incoming Serial Data

Change the Gain

Dig a Little Deeper

What does “setInputGain_dB” do?

- control_aic3206.cpp



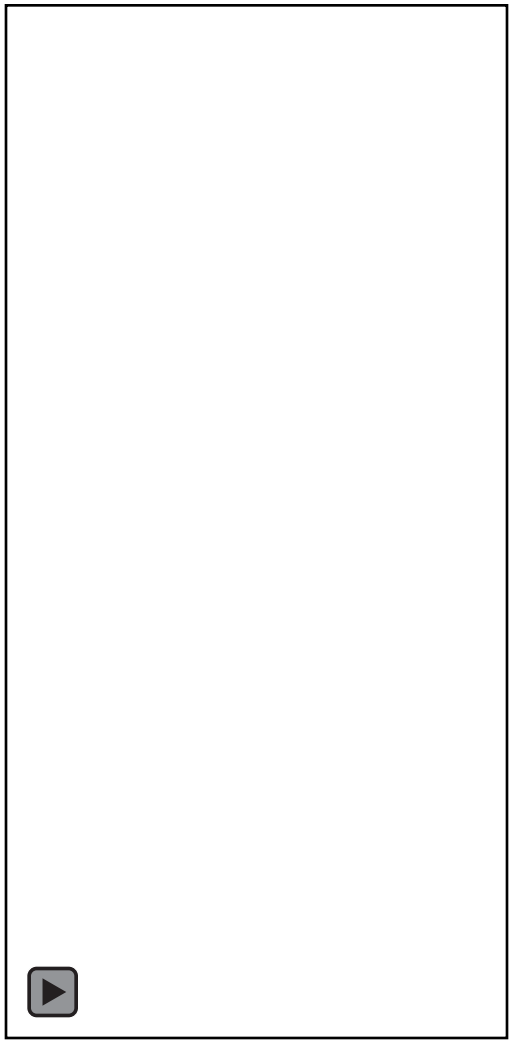
Tympan

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);
```



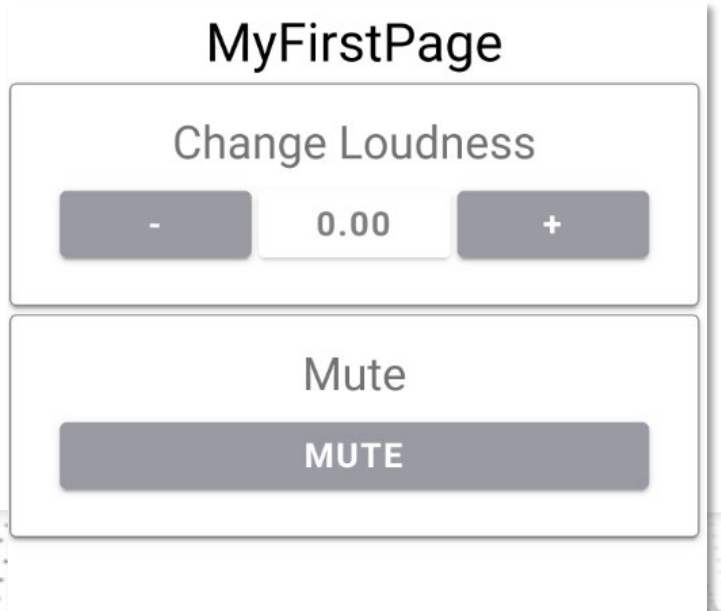
We Need a “Mute” Button

- **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);
```



Tympan

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!!!