



Project MARKUS: Ai Driven Solutions

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What is ASD?

Autism Spectrum Disorder, a developmental disability that causes serious social, behavioral and communication challenges.

- Diagnosis for Autism Spectrum Disorder (ASD) encompasses:
  - Autistic Disorder; Pervasive Developmental Disorder (PDD-NOS); Asperger Syndrome
- Signs and Symptoms:
  - Social, Emotional, and Communication problems
- Behavioral Therapy used to treat ASD
  - Helps in cognitive and social development.
  - Helps develop daily living skills
  - Assists individuals communicating with the Community
  - Each individual is different and requires different forms of therapy
- Behavioral therapy is commonly used with children
  - Not many people treat ASD in adults or teens.

"Findings estimate autism affects 1 in 45, or 2.21 percent, of U.S. adults." - AutismSpeaks [1,2,5]

Common Occurrences with ASD

Each person with ASD is different, but through interviews, we have been able to narrow down some common trends through interviews and research:

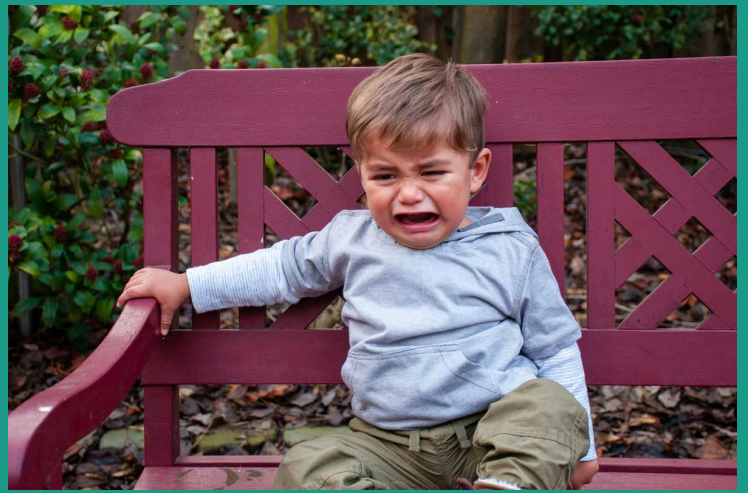
- Sensory Overloads
  - Sounds, loud or high pitched.
  - Fluorescent lights
  - Such sensations can be painful
- Strong smells as triggers
- Discomfort in clothing
- Loss in routines may cause problems
- Lack of micro-expressions
  - Indicator of someone on the spectrum

Upon a disturbing noise, an individual with ASD may cover their ears to limit pain.

Information gathered in conjunction with Jennifer Morgan, Sofia Lumbo, and Marianne [1,2,6]

What are meltdowns?

- Meltdowns : is an intense response to overwhelming circumstances—a complete loss of behavioral control.
  - Causes of Meltdown: Sensory Overload, Information Overload, Emotional Overload
  - Examples: Physical Sign of Anxiety, Need to leave the environment, or physical harm towards oneself



What can we do?

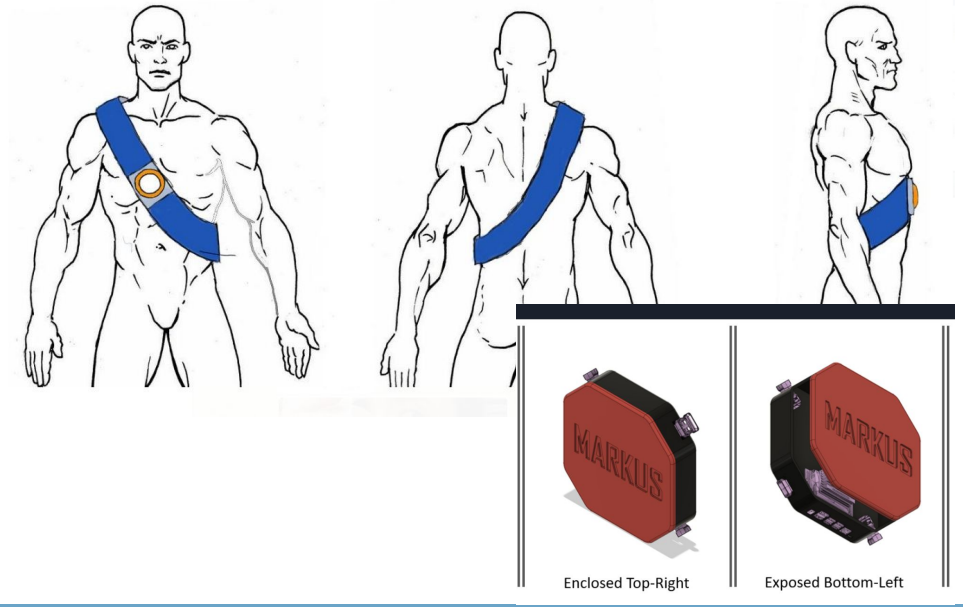
- Preventive Measure for Meltdown.
  - Deescalate the situation
  - Interruption and Transitions
  - Practice Routine and practice change in routine
  - Provide Safe Space
  - Redirect their attention elsewhere.
  - Early **Intervention** is key to saving lives

Information gathered in conjunction with Jennifer Morgan, Sofia Lumbo, and Marianne [3,4]

Meet Markus

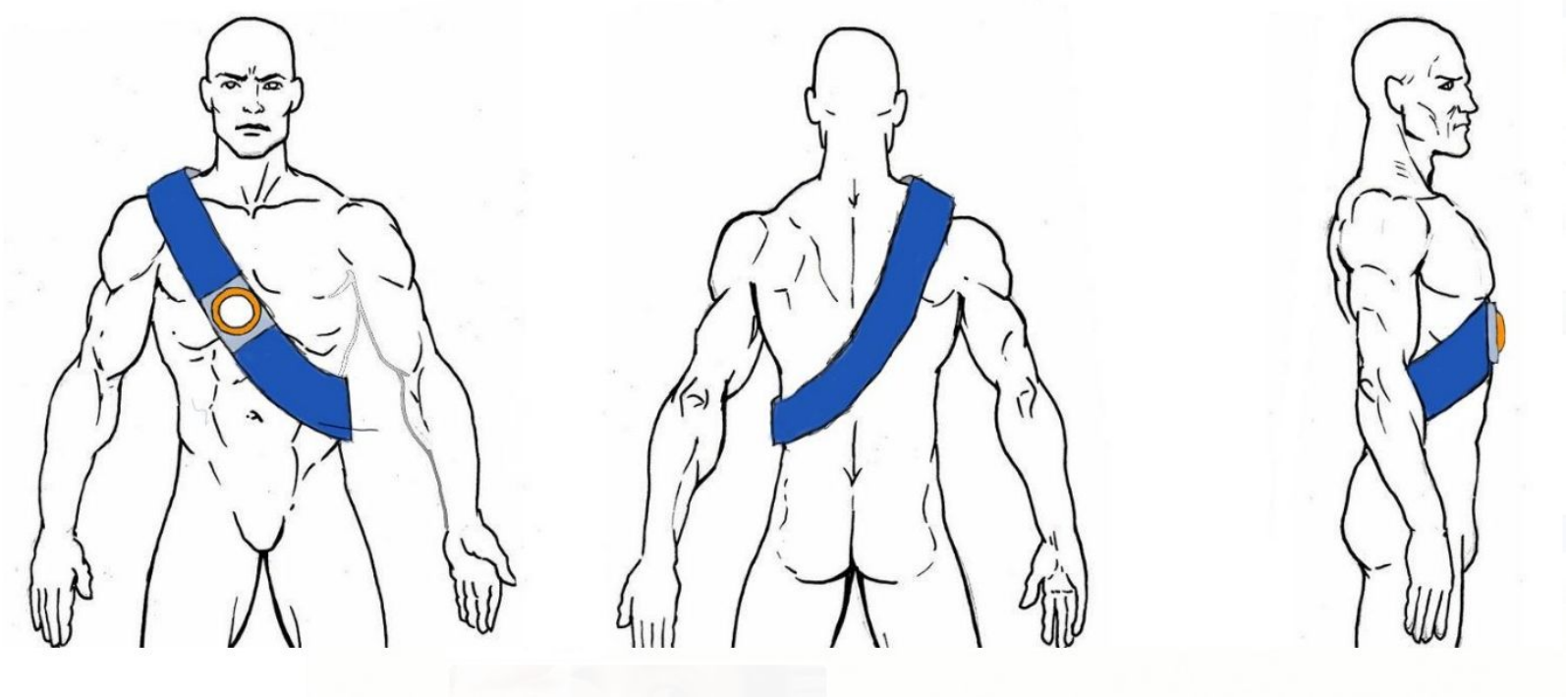
Markus is a Wearable device that will watch and monitor the wearer and their environment.

- Artificial Intelligence
  - Monitor for Noise, stimuli
  - Microphone
- Stress levels
  - Heart Rate
- Location
- Temperature
  - Environmental Attributes
- Camera



While the belt is on, Markus will be able to utilize Ai to ensure the user is well.
With this technology, Markus will be able to prevent or deescalate meltdowns, help find a missing person, and speak to them.

Information gathered in conjunction with Jennifer Morgan,Sofia Lumbo and Marianne



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Markus AI Model

The brain of Markus will be using a custom built deep learning model. The Ai will be able to understand environmental sounds and determine if a meltdown is imminent with information from other sensors.

Training

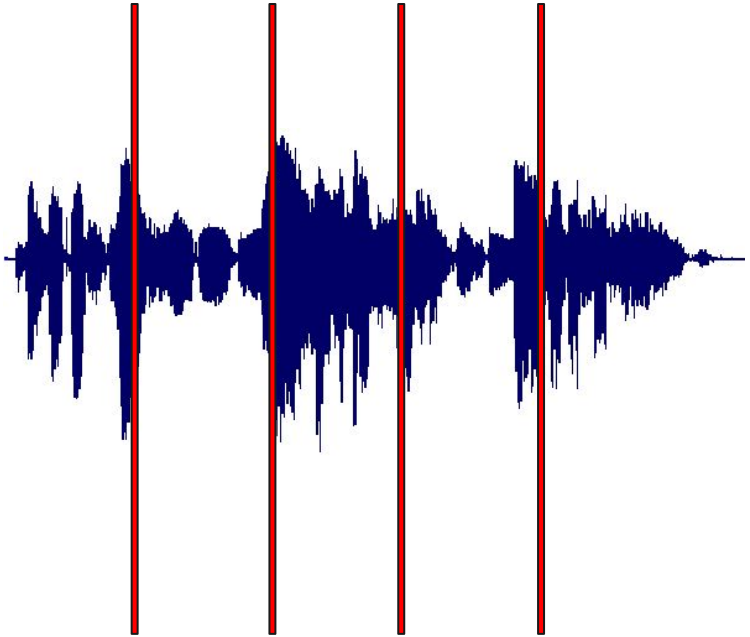
Audio Samples were recorded from a variety of environments like:

- Malls
- Retail stores
- Restaurants
- Festivals
- Public Areas

Audio Samples were then split up to 1.5 seconds each and used for training.

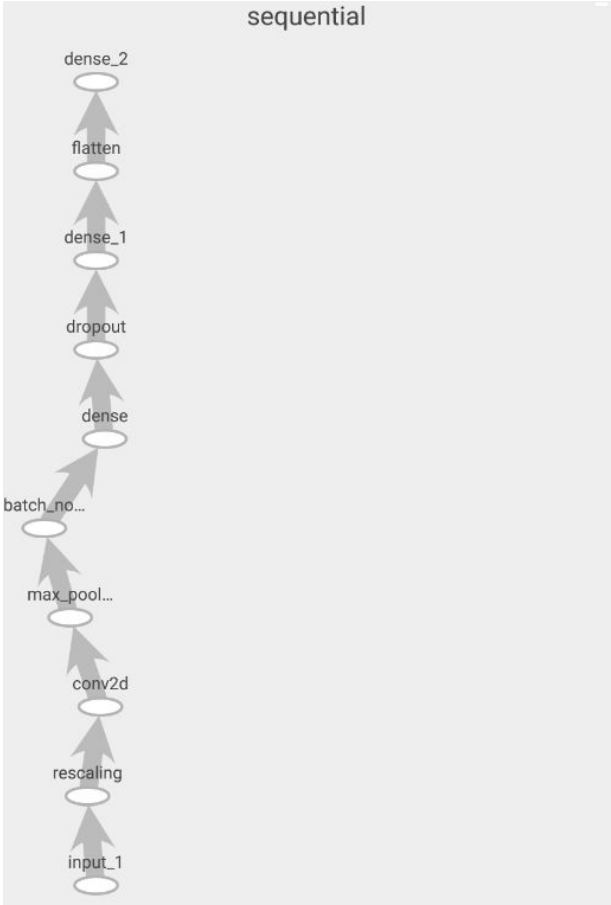
Every 1.5 seconds, Markus interprets the environment's sounds into 6 categories

- Quiet, Small Conversation, Large conversation, Stimuli Wind, noise



Markus Artificial Intelligence

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
rescaling (Rescaling)        (None, 314, 235, 3)       0
_________________________________________________________________
conv2d (Conv2D)              (None, 314, 235, 64)      1792
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 104, 78, 64)       0
_________________________________________________________________
batch_normalization (BatchNo (None, 104, 78, 64)       256
_________________________________________________________________
dense (Dense)                (None, 104, 78, 256)      16640
_________________________________________________________________
dropout (Dropout)            (None, 104, 78, 256)      0
_________________________________________________________________
dense_1 (Dense)              (None, 104, 78, 128)      32896
_________________________________________________________________
flatten (Flatten)            (None, 1038336)           0
_________________________________________________________________
dense_2 (Dense)              (None, 8)                 8306696
=================================================================
Total params: 8,358,280
```

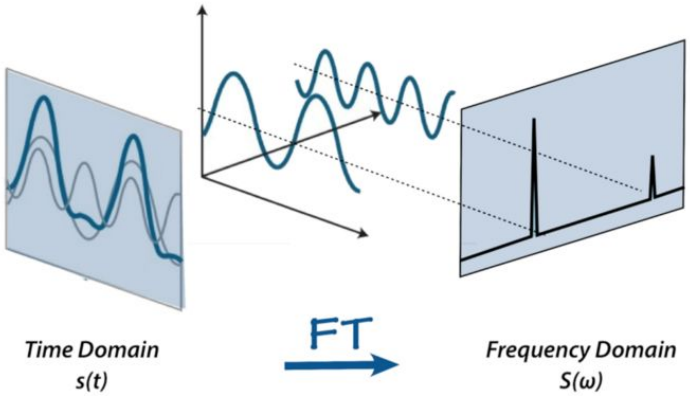


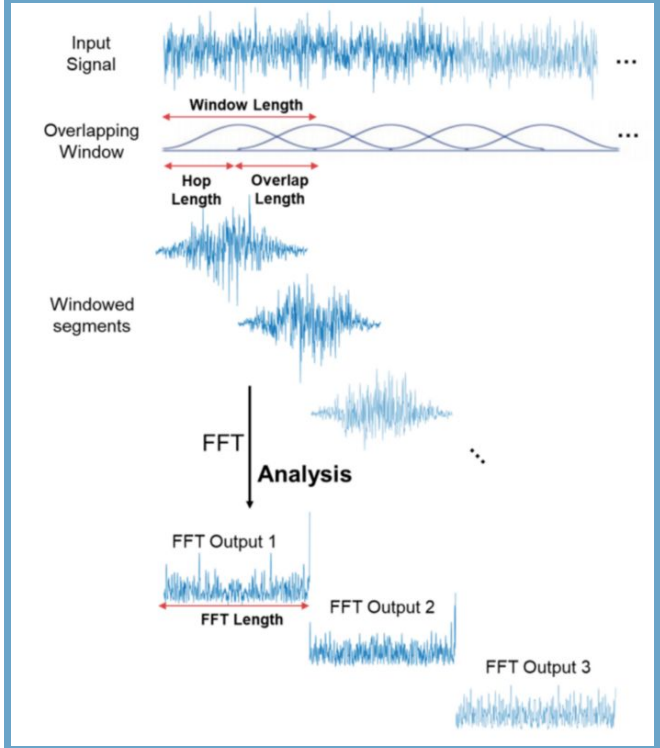
Markus Artificial Intelligence

To train the Ai, we converted sound signals into a Mel Spectrogram model.

What is a spectrogram…. Better yet what is a Mel Spectrogram

- A Spectrogram is a Fourier Transform of it's signals
  - A Fourier transform decomposes signals into their individual frequencies and their amplitudes
  - To make the spectrogram, a Fourier Transform is used in segments of the audio signal.
- A Spectrogram is a group of overlapping Fourier Transforms.



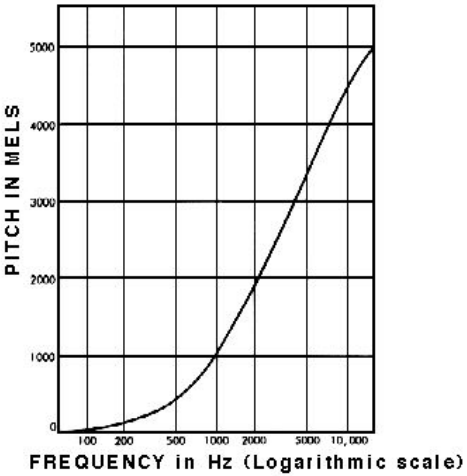


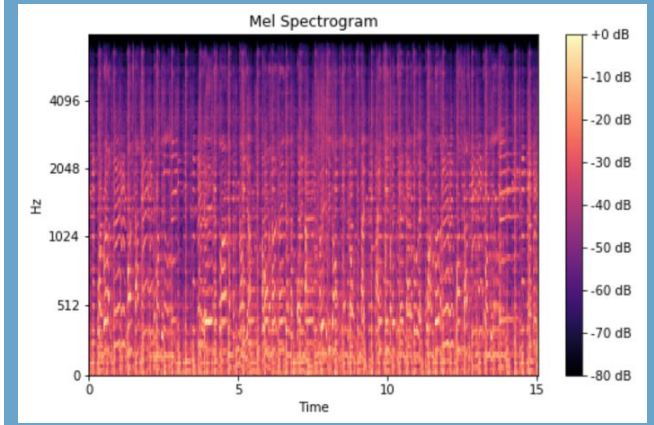
Markus Artificial Intelligence

Okay, what about a Mel Spectrogram?

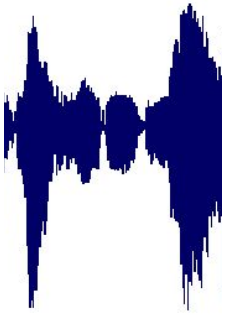
- A Mel Spectrogram is a spectrogram converted to how human's interpret sound
  - Humans can tell the difference between a 500 and 1000 Hz sound
  - However, we can not tell the difference between a 10,000 and 15,000 Hz Sound

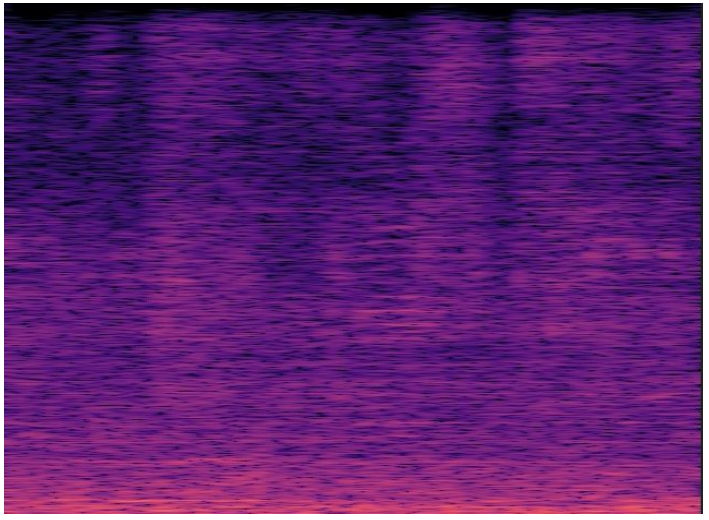
- Depending on the frequency of the sound, it is given a pitch value that is equivalent to how we interpret sound.
  - This interpretation is then calculated into a new spectrogram





Markus Artificial Intelligence



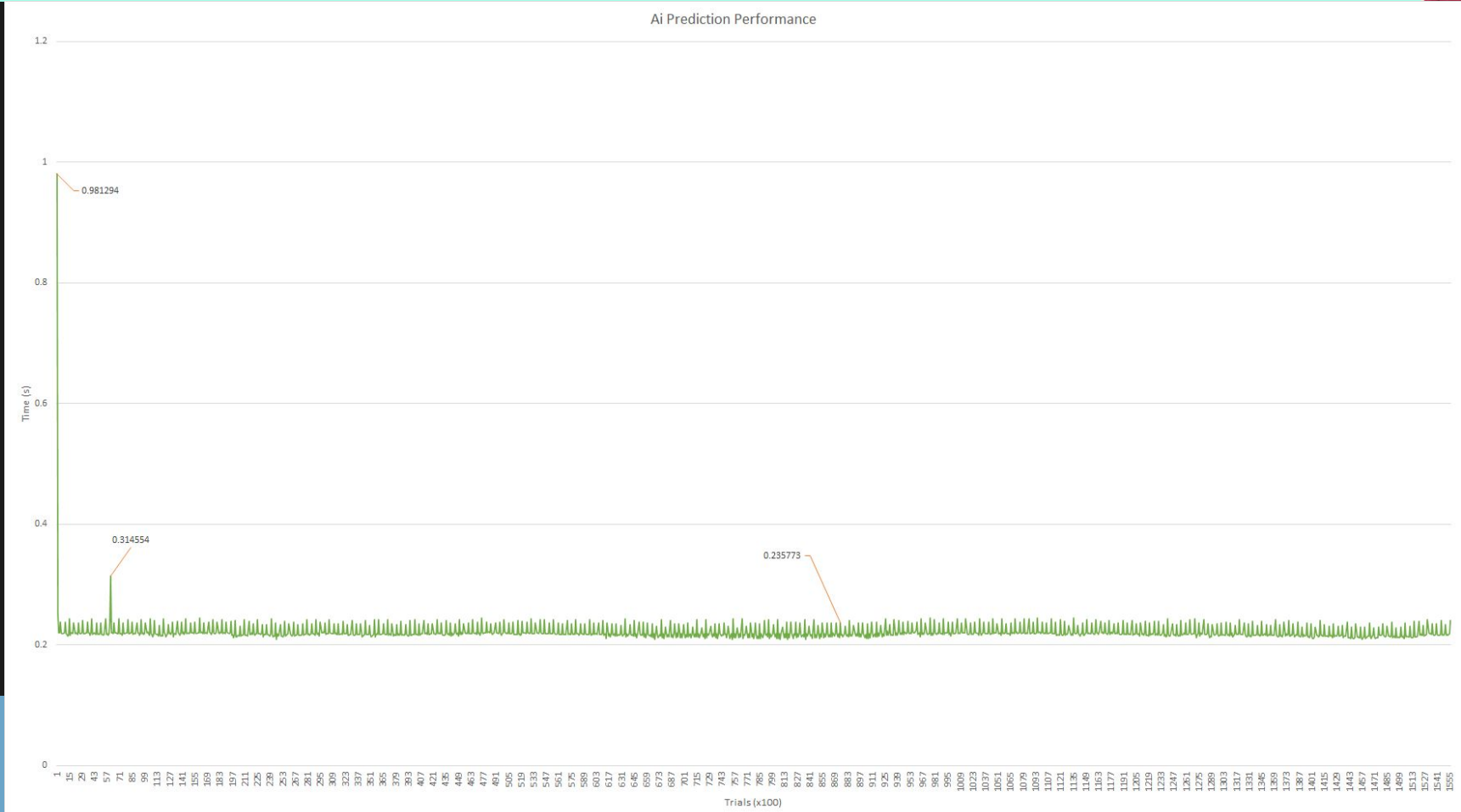


Run: Predict

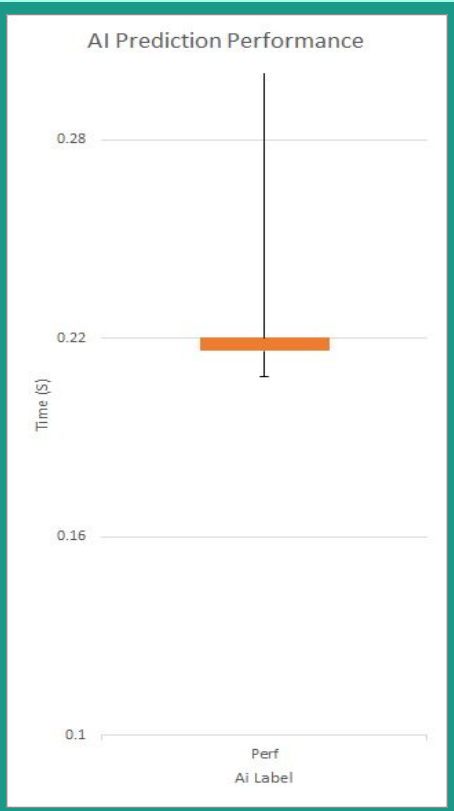
```
2021-05-11 12:40:59.821866: I tensorflow/compiler/jit/xla_gpu_device.cc:99] Not creating XLA devices, tf_x
2021-05-11 12:41:02.771446: I tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:116] None of the ML
Crowd_Conversation  :  tf.Tensor(3.7946368e-06, shape=(), dtype=float32)
Large_Conversation  :  tf.Tensor(0.9999821, shape=(), dtype=float32)
Noise  :  tf.Tensor(4.8197033e-09, shape=(), dtype=float32)
Quiet  :  tf.Tensor(7.261787e-10, shape=(), dtype=float32)
Small_Conversation  :  tf.Tensor(2.8564311e-06, shape=(), dtype=float32)
Stimuli  :  tf.Tensor(1.1161165e-05, shape=(), dtype=float32)
Unknown  :  tf.Tensor(0.0, shape=(), dtype=float32)
Wind  :  tf.Tensor(1.4856623e-10, shape=(), dtype=float32)

Process finished with exit code 0
```

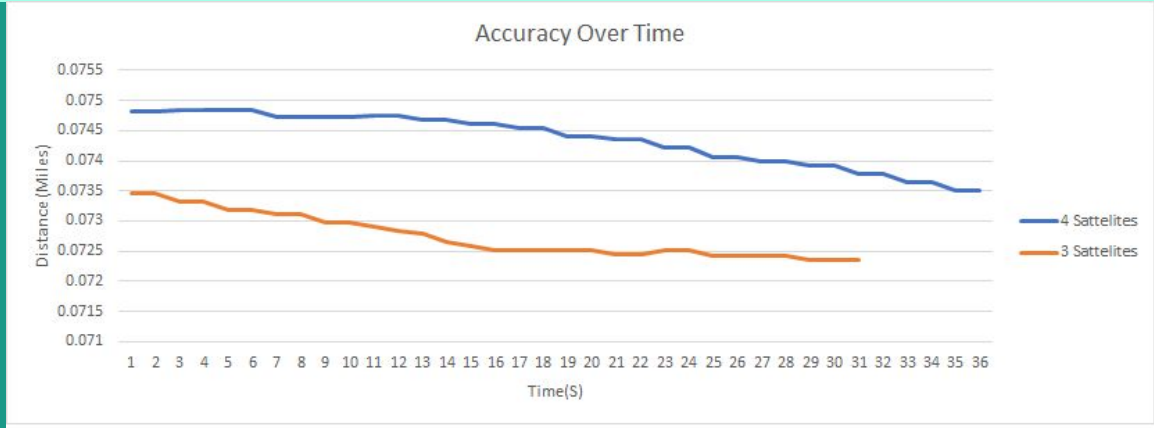
Markus Artificial Intelligence Performance

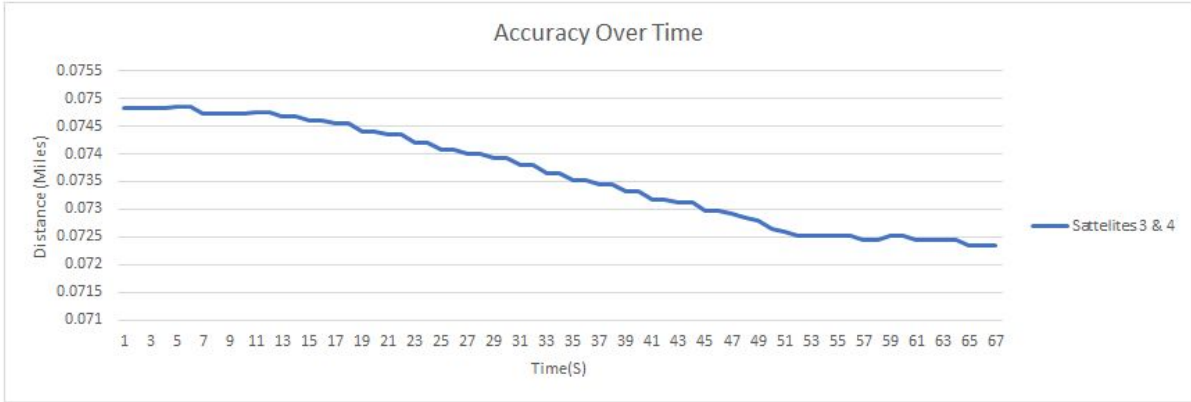


Markus Artificial Intelligence Performance

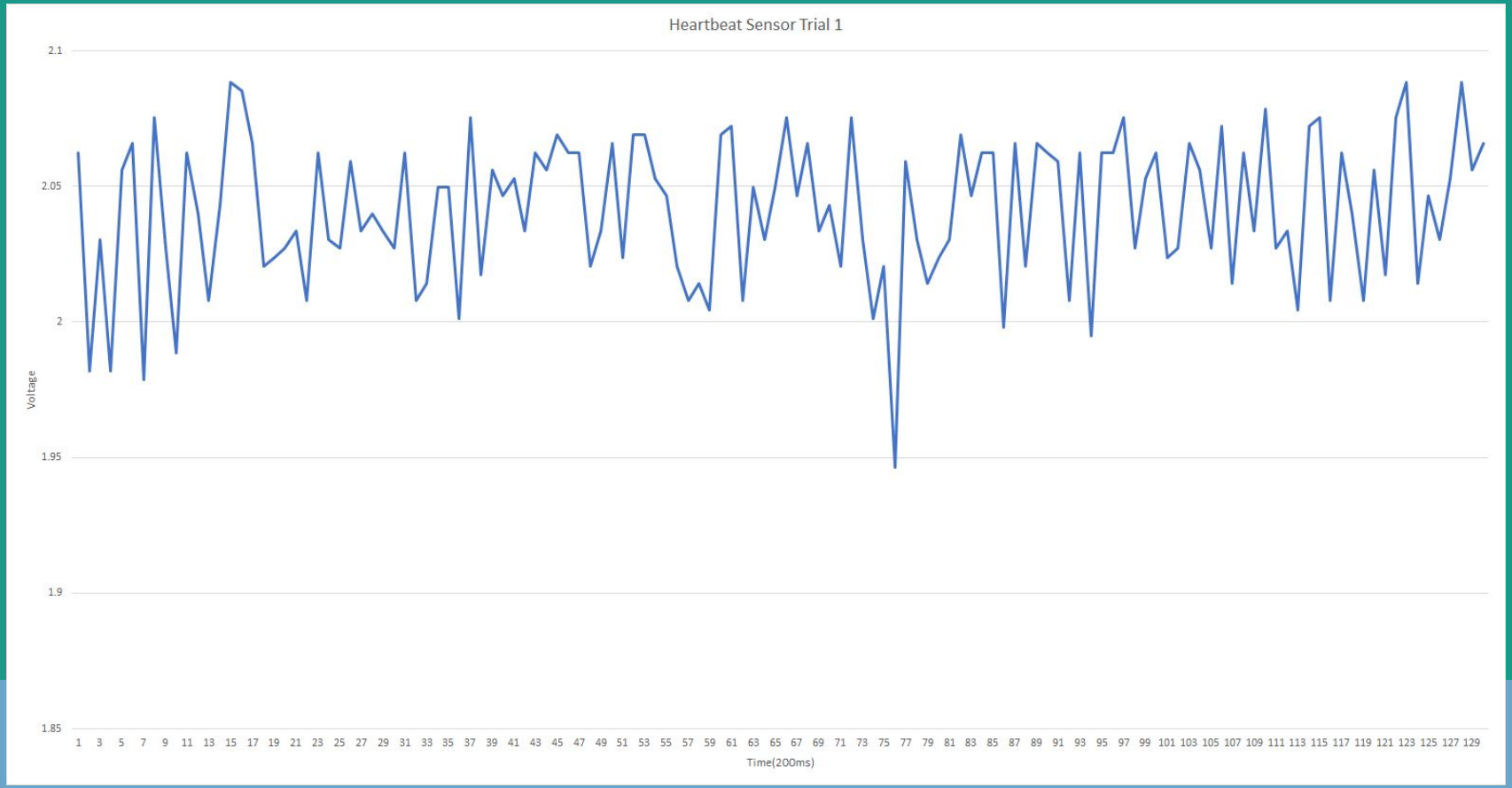


GPS Sensor Performance

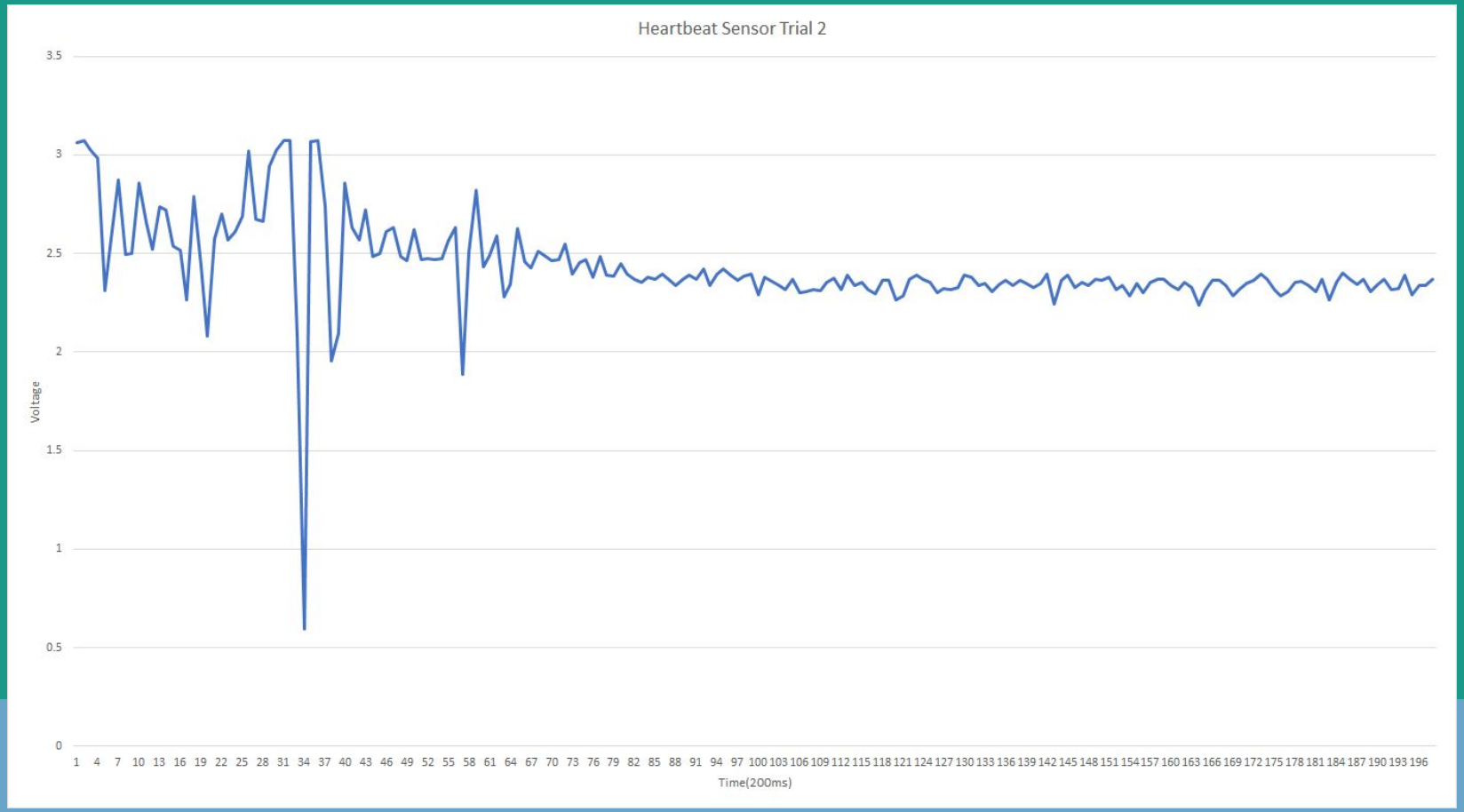




Heart Beat Sensor Performance

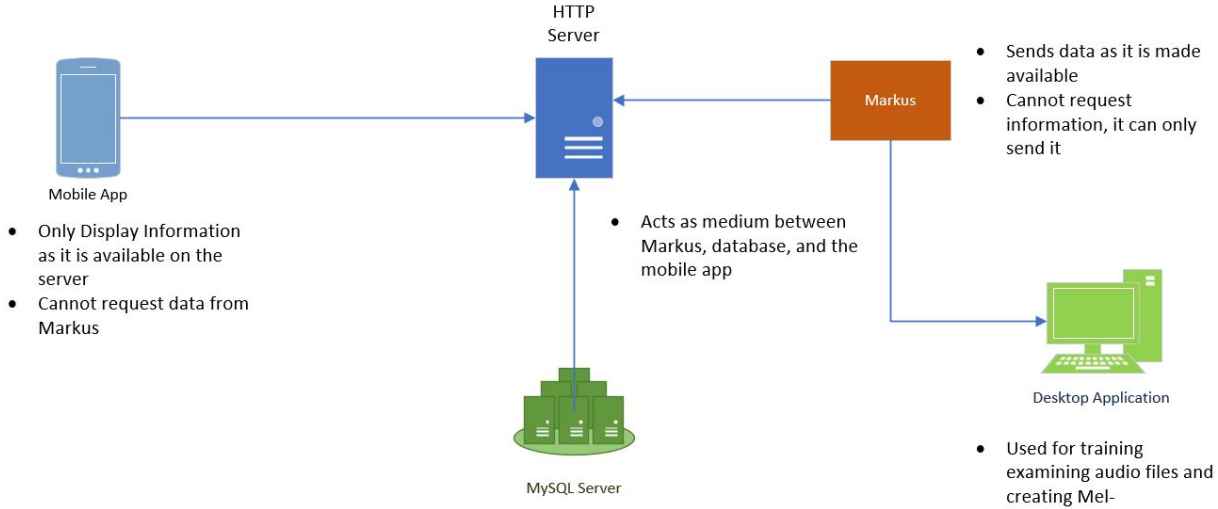


Heart Beat Sensor Performance



Heart Beat Sensor Performance

Putting it all together - Servers



- Sends data as it is made available
- Cannot request information, it can only send it

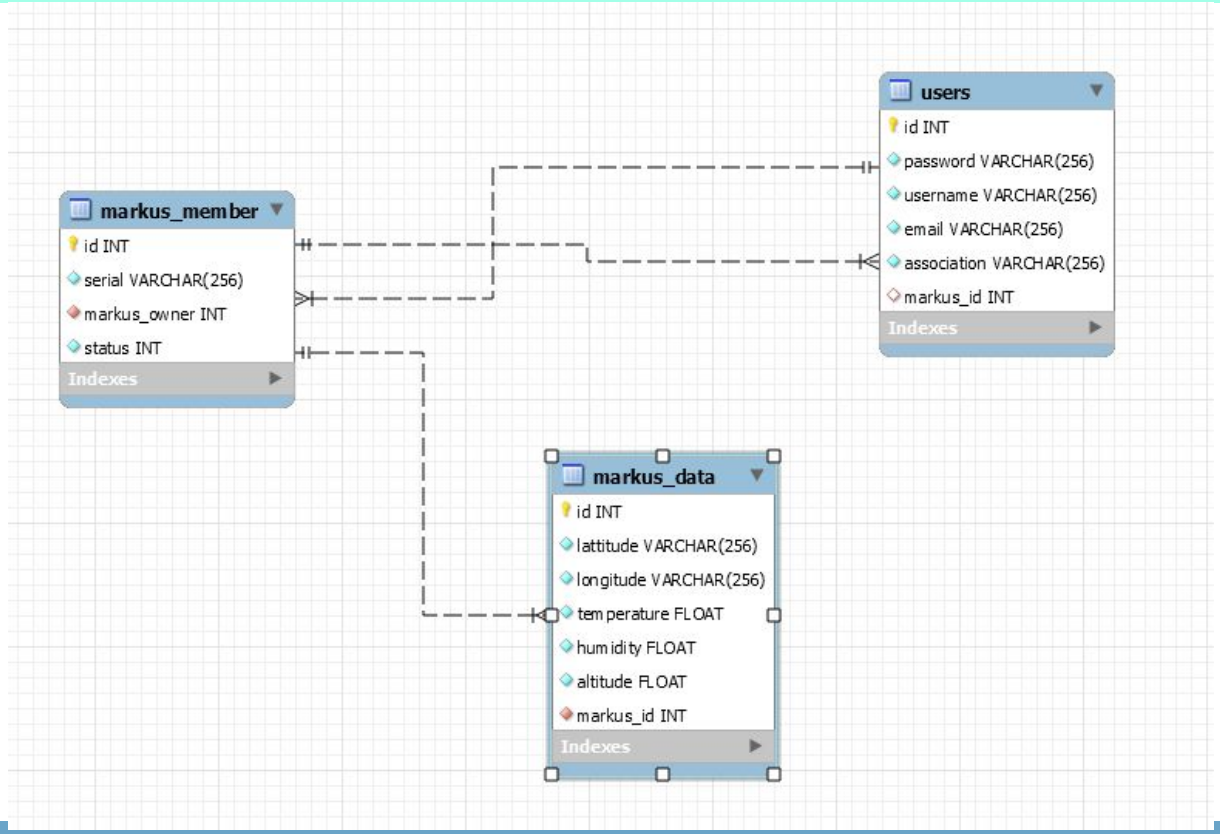
- Only Display Information as it is available on the server
- Cannot request data from Markus

- Acts as medium between Markus, database, and the mobile app

- Stores all information from Markus for later use.
- Not for immediate data

- Used for training examining audio files and creating Mel-Spectrograms.
- The user can categorize this for their use and add to the models training

Putting it all together - Servers



Tools to create the Mobile Application

React Native and Expo.IO

-React Native allows for the Combination of JavaScript, CSS, and HTML all combined into one to create native mobile application for both IOS and Android Devices

-Expo.io an online IDE used to build React Native application and test with in real time. Expo.io allows for the application to be loaded onto a mobile device for live testing as well

Expo

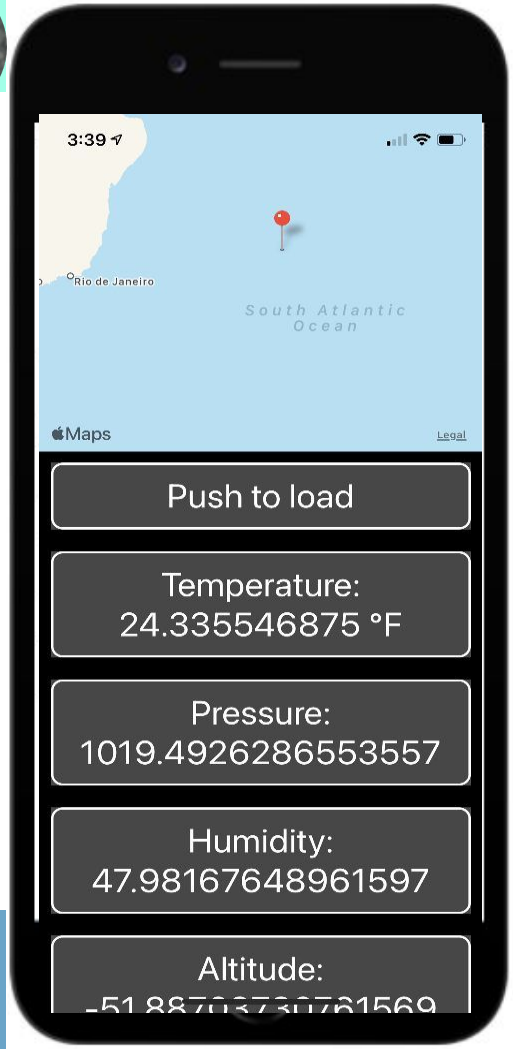
React Native

Mobile Application

With the mobile app, a guardian or caretaker can directly monitor their individuals status and environment. Everything Markus can see and hear is sent directly to the phone

- With an Embedded Camera and Microphone Markus can live stream video and calls.
- Markus' location, pressure, altitude, and humidity are directly sent to the app.
- The ai's interpretation of the environment is also sent to the app.

All information is updated as it is made available

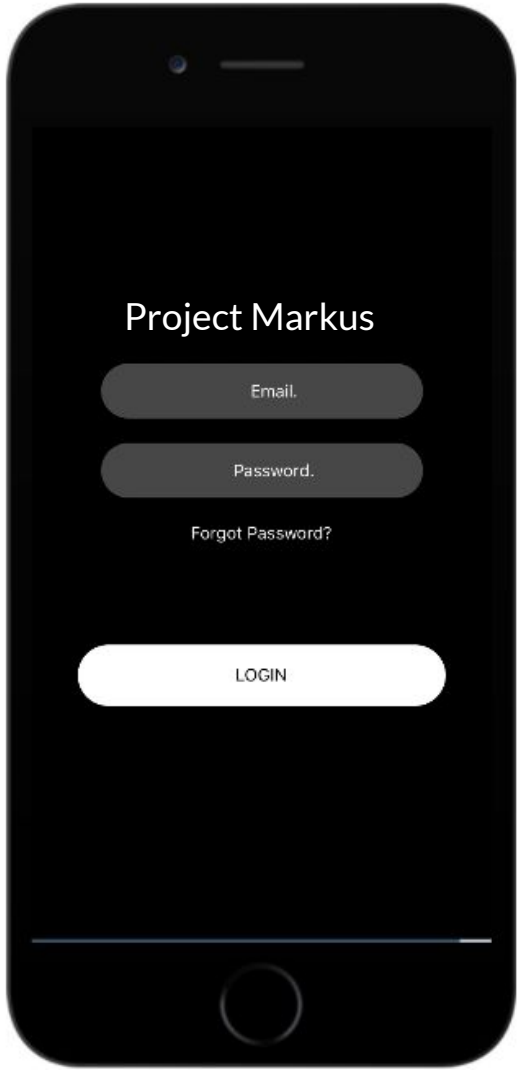


Mobile Application (2)

Each User will be prompted to create an account to have access to their monitoring system

- Currently, a log in screen has been created.
- Each user will be allowed to create a log account that will be unique to each person device
- All Markus AI devices are tracked through a serial number and mac-address.
- **Future Devices will have built in LTE using IMEI serial numbers.**

We plan to incorporate more quality of life aspect of the application as the summer progresses



NVIDIA Jetson Nano - The Brain

GPU	128-core Maxwell
CPU	Quad-core ARM A57 @ 1.43 GHz
Memory	4 GB 64-bit LPDDR4 25.6 GB/s
Storage	microSD (not included)
Video Encode	4K @ 30 | 4x 1080p @ 30 | 9x 720p @ 30 (H.264/H.265)
Video Decode	4K @ 60 | 2x 4K @ 30 | 8x 1080p @ 30 | 18x 720p @ 30 (H.264/H.265)
Camera	2x MIPI CSI-2 DPHY lanes
Connectivity	Gigabit Ethernet, M.2 Key E
Display	HDMI and display port
USB	4x USB 3.0, USB 2.0 Micro-B
Others	GPIO, I^2C, I^2S, SPI, UART
Mechanical	69 mm x 45 mm, 260-pin edge connector

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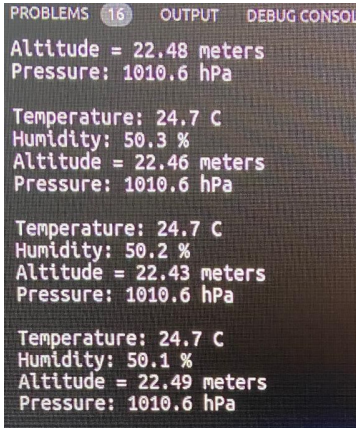
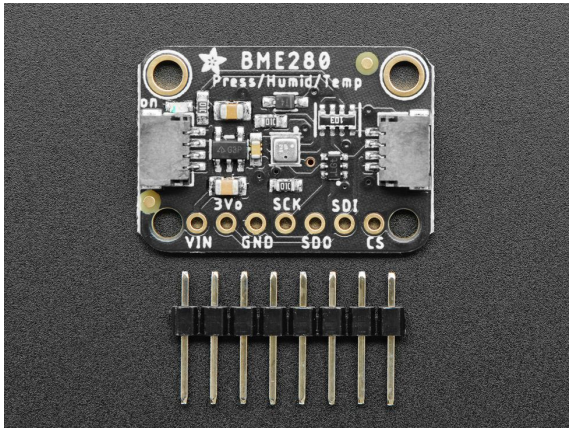
Information gathered in conjunction with Jennifer Morgan,Sofia Lumbo and Marianne

Temperature Sensor

BME280: Environmental sensor that measures Temperature, Humidity, Pressure, and Altitude

- Can be wired using I2C or SPI
- Temperature accuracy with ∓ 1.0C
- Humidity accuracy with ∓ 3%
- Pressure accuracy with ∓ 1 Hpa
- Altitude accuracy with ∓ 1 meter
-

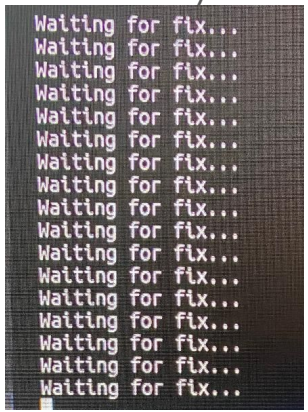


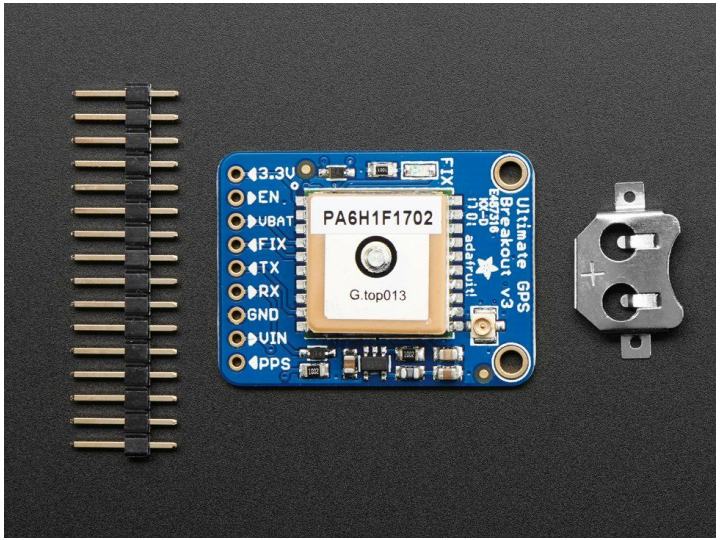


GPS Sensor

Ultimate GPS Breakout V3: High quality GPS module that can track up to 22 satellites on 66 channels.

- Uses UART terminal
- Uses 3.3 - 5V
- Can connect any 3V active GPS antenna for better accuracy
-



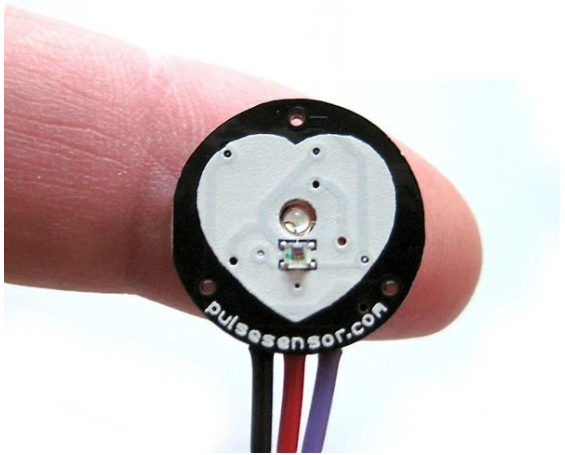


Heart Rate Sensor

Pulse Sensor: uses Photoplethysmography (PPG) to determine heart rate. PPG accuracy are heavily affected by measurement procedure and environmental factors.

- Analog Signal
- Uses 3 - 5V
- Can be worn around finger, or earlobe

```
aw ADC Value:  32960
DC Voltage: 1.714479285877775V
aw ADC Value:  31744
DC Voltage: 1.4179903868162052V
aw ADC Value:  37440
DC Voltage: 1.7273701075761043V
aw ADC Value:  27584
DC Voltage: 1.4469947356374455V
aw ADC Value:  34048
DC Voltage: 1.633911650263218V
aw ADC Value:  28864
DC Voltage: 1.405099565117876V
aw ADC Value:  33344
DC Voltage: 1.5243396658274204V
aw ADC Value:  32768
DC Voltage: 1.711256580453193V
aw ADC Value:  36992
```



Camera

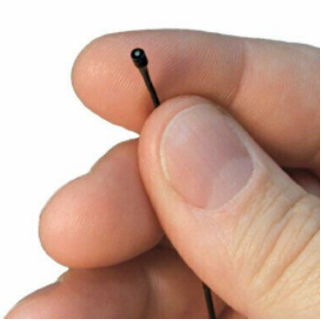
Raspberry Pi Module V2:

- Small Compact Size
- Resolution up to 1080p at 30 fps
- Still resolution of 8 Megapixels
- Horizontal Field of View of 62 degrees

Microphone and Speaker

Apple Earpods: The design of the EarPods is defined by the geometry of the ear. Which makes them more comfortable for more people than any other earbud-style headphones

- Any 3.5mm auxiliary cable headset will work
- Processes incoming data into mel spectrogram for the ai
    - All incoming data is saved as a wav file



```
* recording
*done recording
C:\Markus\audioFiles/home/allen/Desktop/pyPro/output.wav_____________
/home/allen/Desktop/pyPro/output
tf.Tensor(
[4.1353732e-02 1.2210716e-02 2.3345764e-01 2.1510798e-02 4.8010629e-03
 6.6741657e-01 3.9263651e-07 1.9249134e-02], shape=(8,), dtype=float32)
-10.734751224517822 seconds
```

```
Run:  Predict
2021-05-11 12:40:59.821866: I tensorflow/compiler/jit/xla_gpu_device.cc:99] Not creating XLA devices, tf_x
2021-05-11 12:41:02.771446: I tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:116] None of the ML
Crowd_Conversation  :  tf.Tensor(3.7946368e-06, shape=(), dtype=float32)
Large_Conversation  :  tf.Tensor(0.9999821, shape=(), dtype=float32)
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Quiet  :  tf.Tensor(7.261787e-10, shape=(), dtype=float32)
Small_Conversation  :  tf.Tensor(2.8564311e-06, shape=(), dtype=float32)
Stimuli  :  tf.Tensor(1.1161165e-05, shape=(), dtype=float32)
Unknown  :  tf.Tensor(0.0, shape=(), dtype=float32)
Wind  :  tf.Tensor(1.4856623e-10, shape=(), dtype=float32)

Process finished with exit code 0
```
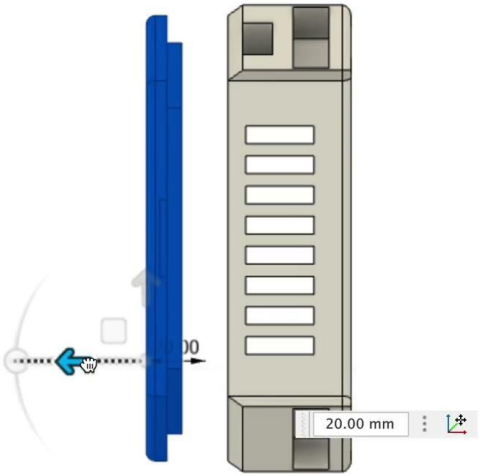

Demo



3D Model of MARKUS Enclosure

Figure -. Cost of Materials

Items	Cost
Nvidia Jetson Nano 2GB	$59.00
Samsung 128GB MicroSD	$16.99
Raspberry Pi Camera Module V2	$28.59
PulseSensor Heart Rate Monitor	$24.99
Adafruit MCP3008	$6.00
Adafruit BME280	$23.95
Adafruit Ultimate GPS Breakout V3	$39.75
TOTAL	$199.27

Customer Segments

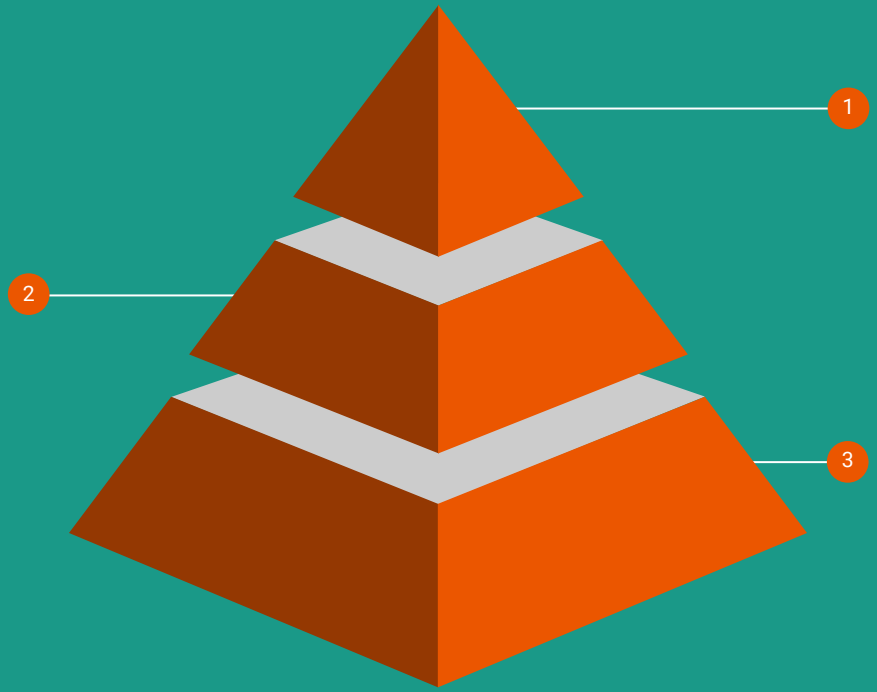
The *apex* for Markus:

- ASD Community
- Parents, Guardians, Caretakers
- Assistive-needs Community

Channels of Contact

The *floors* connecting *Value* to *Customer*:

- Private & Non-Profit Autism Organizations
- Certified Therapists
- Healthcare Professionals



Value Propositions

The *foundation* being built with:

- Accessibility
- User-Friendly
- Modularity
- Cost-Efficient

MARKUS: It's Business

So what... Why should we care?

Markus is meant to replace human interaction when it is not possible for someone to be there.

- Preventing meltdowns from occurring
- Assisting in the de-escalation of meltdowns
- Finding lost individuals that wonder from supervised areas (AKA wondering)
- Learning when a meltdown is going to take place for each individual.
- Introduce new and familiar grounding exercises
- Early Stage Intervention, when no one is there to intervene.

We hope Markus will become a common assistant that can help those with ASD cope with unpredictable situations and a thing called life.

Project Shortcomings and Problems

- Mel Spectrogram performance is slow.
- Ai may be biased.
- Server is unable to stream microphone and camera data.
- Pulse Sensor cannot be fit correctly for accurate data
- No Data exists in relation to autism and meltdowns.

What's Next?

Work to finetune our proof of concept and prototyping.
Working with Treatment centers all over the US and around the world to research, gather info, and improve Markus AI on ASD individuals.
We will build an online presence using our social media platforms such as:

1. Facebook (Groups such as family with ASD, posting and advertising, Instagram videos/posts)
2. Google (SEO, Youtube Videos)
3. Twitter (Videos)
4. Feature our products on Forbes/Tech Magazines/Startups/etc
5. Crowd Funding: Startups/Indiegogo/etc
6. Website presence and product info
7. Forums: Participate in forums and discussions website

Fundings (could be in any order):
Venture capitalists
Angel investors
Crowdfunding
Equity crowdfunding
Incubators
Grants
Friends and Family

UH Red Labs

The Bauer College of Business's Red Labs has selected us to continue with our project. This is a great opportunity for us because it will allow us to:

- Gather necessary knowledge in order to create start up
- Network with professionals.
- Keep developing our device.
- Present prototype to industry professionals and companies.

The opportunity offered by Red Labs is a big step into one day making our device available to people with special needs.

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Supplementary Slides

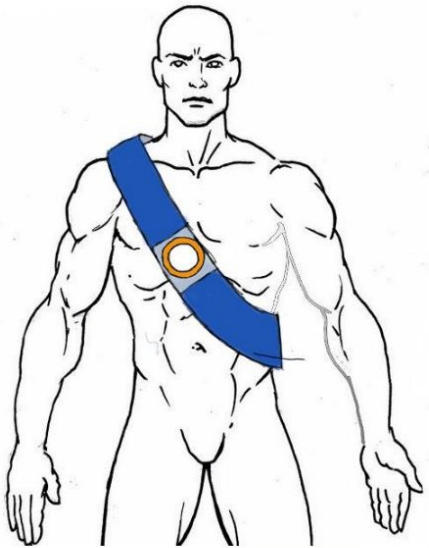
Gavin Marquez: **(Leader)** Hardware and Sensors Lead

Alexander Duvall: (**Assistant Leader)** Software and Firmware Lead

Allen Torres: **(Resource Manager)** System and Automation Lead

Joel Martinez: **(Scribe)** Communication and Networking Protocol Lead

Saif Momin: (**Reflector**) Modeling and Prototyping Lead



THANK YOU