SeizurEShield

Live life on your own terms.

So what is epilepsy?

- **Fourth** most common neurological disorder *worldwide*

- Characterized by recurring, abnormal surges of electricity in the brain that cause seizures.

  - Seizure severity can range from brief attention loss to full on convulsions

- Typically diagnosed via "electroencephalography", or EEG

  - Records the electrical activity of your brain for doctors to check for abnormal electrical events.

The risk factors spare no one.

Age

Age naturally increases your risk for epilepsy, due to a variety of factors

Family History

Epilepsy can be inherited genetically, albeit rarely, and can skip generations.

Lifestyle

Any activities with a large chance of head injury significantly increases risk!

Medical history

Anything that can cause brain damage increases your risk, like:

- Seizures
- Severe inflammation
- Strokes
- Hypoxia

Other Conditions

Any conditions that cause "hyper-excitable neurons" can cause epilepsy, including:

- Alzheimer's' Disease
- Multiple Sclerosis
- Neurodegenerative diseases

1 in 10 people will experience a seizure in their lifetimes.

Four main treatment types, no cures.

Medicinal

30+ medicines are currently available to treat epilepsy, including:

- Mood stabilizers (ex: lithium)
- Nerve pain medicines (ex: topiramate)
- Anticonvulsants (ex: gabapentin)

Surgical

These options may be recommended if other methods don't work, and include things like:

- Deep brain stimulation
- Resective surgery
- *(in extreme cases)* Complete hemispheral separation

Alternative

A range of options outside conventional medical practices, like:

- Transcranial stimulation
- Herbal remedies
- Acupuncture
- Aromatherapy

Lifestyle

Options typically used in combination with other previously mentioned methods, like:

- Ketogenic or fasting diets
- Exercise
- Stress reduction techniques

55 million people

The WHO estimates this many people currently suffer from epilepsy worldwide.

This is about as many people as those who have Alzheimer's disease.

Seizures are usually unpredictable by the people who have them.

Independence

Seizures being unpredictable means:

- Safety risks in being alone
- Often can't hold a drivers' license
- Increased dependence on others

Many extra costs

EEGs can take anywhere from several hours to several *days* to interpret. This leads to:

- Increased costs for care (hotels, long drives, etc)
- Inconsistent costs (difficult to budget)

"Auras" are unreliable

Some people report "auras", or a feeling that a seizure is coming on. But:

- These are only common in one type of epilepsy
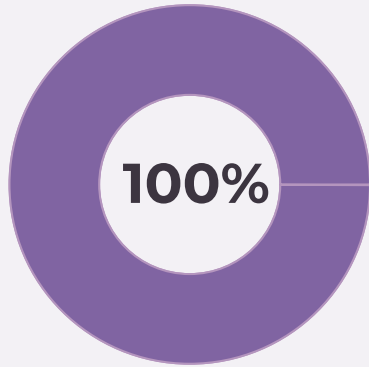- The warning times are often inconsistent

SEIZURESHIELD

Empowering individuals with epilepsy through advanced machine learning solutions to better monitor their seizure activity, enhancing their quality of life and ensuring their dignity and safety.
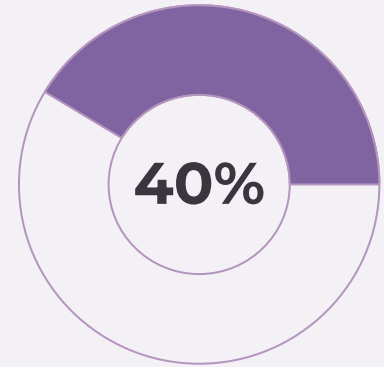
Project Proposal and Survey of Target Users

100%

Want a system that can detect seizures (unpredictability is a main concern)

80%
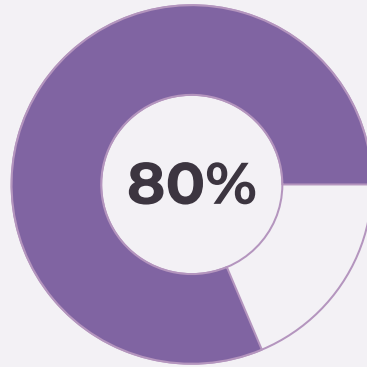
Want an app or a device-integrated solution that notifies emergency contacts

40%

Want the solution to have at least 80% accuracy or a low false-negative rate

Market space and commercial methods

The global market for epilepsy monitoring devices was worth ~$489 million in 2021, and is poised to reach $615 million by 2026.
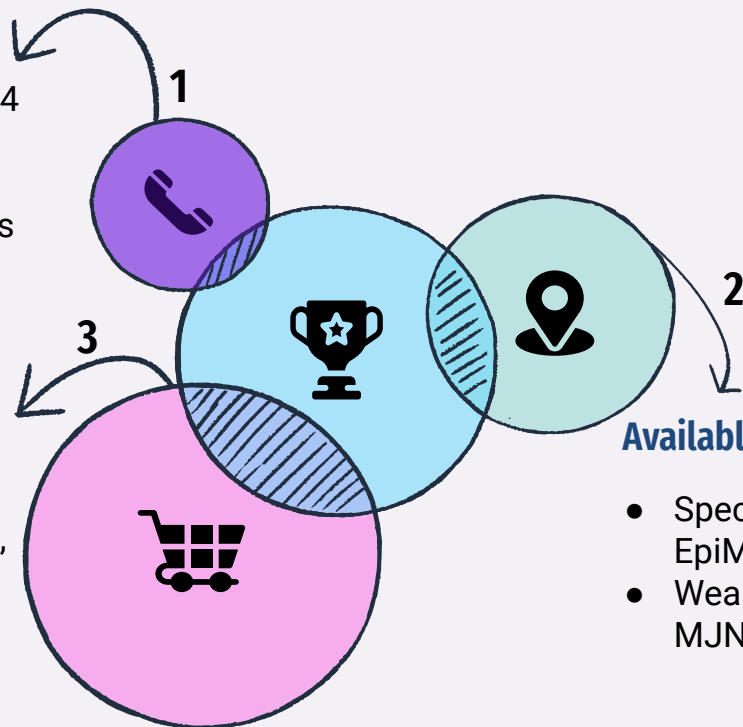
MVP Target User
Those who have access to EEG files

Detection
Currently only 4 products on market that detect seizures

1

Early Prediction
Possible with Machine Learning, not yet available.

3

2

Available Products

- Specialized watch- EpiMonitor
- Wearable headset- MJN, Byteflies

Minimal Viable Product

Machine Learning Algorithm

Backend Development (Internal Functionality)

Frontend Development (User Interface)

Detects seizure activity from EEG recordings

- Uses deep learning techniques on user-submitted EEG data to detect any and all seizure activity

Provides integral parts of app capabilities

- Uses Flask API endpoints to allow important things like uploading, cleaning, and processing files to happen.

Curates for the best possible user experience

- Provides a user-friendly visualization of each EEG, and marks where our algorithm detected seizure activity.

Application Demo

Exploratory Data Analysis

About the Data:

- 14+ years of clinical EEG data collected at Temple University Hospital

- Anonymized, curated, and paired with clinical reports (annotations)

- 51% female, 49% male

- Age range: <1 year to >90 years old, average 51.6 years old

- ~17k total sessions from ~11k unique subjects (using 10% for this project)
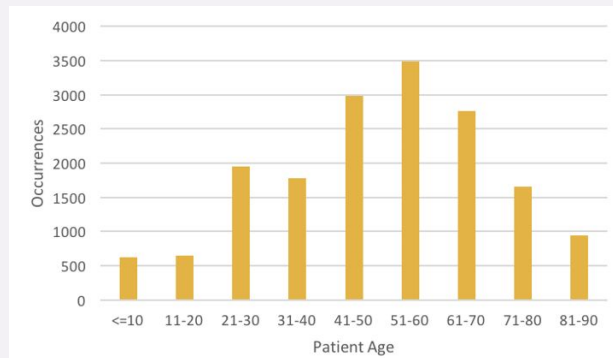
Directory	# of Patients	# of Files	# of Files with Seizures	# of Sessions	# of Sessions with Seizures	Total Duration (seconds)	Total Duration of Seizure Events (seconds)	Percentage of Duration of Seizure Events
Dev	53	1832	324	342	113	1,567,972	71,871.8	4.58%
Train	579	4664	872	1175	352	3,277,229	175,125	5.34%
Eval	43	865	195	126	63	459,713	27246.7	5.93%

Raw Dataset

- **~80 GB** of raw EEG (.EDFs)
- **~23,000** files
- Different numbers of electrodes used across files
- **Converted files** from EDF format to CSV for easier processing

Validation

- Ensured consistent data formatting
- Replaced **any null or incomplete data** with N/A to prevent aggregation in final results

Data Pipeline

Standardization

- Used **electrode mappings** ("montages") to standardize all data into using **20 EEG channels**
- Joined **physician annotations** to data via timestamps

Modelling

- Final outputs used to **train** and **test** our machine learning algorithm

Baseline Model- ResNet-18

- Similar research using the Temple University EEG dataset was very limited

  - We built our baseline model referencing a 2021 research paper[1] published by *Khalkhali et. al.* from Temple University.

  - ResNet-18 is a convolutional neural network composed of 18 connected layers, and is often used for image analysis
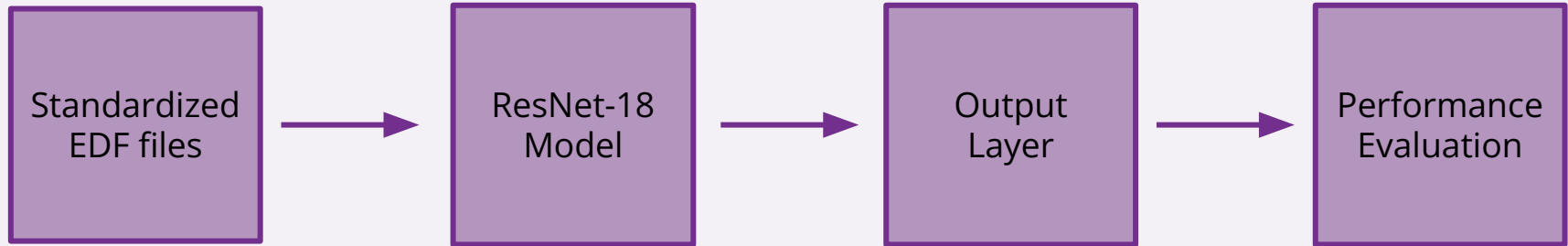
Standardized EDF files	→	ResNet-18 Model	→	Output Layer	→	Performance Evaluation

[1] "Low Latency Real-Time Seizure Detection Using Transfer Deep Learning" - Neural Engineering Data Consortium, Temple University, Philadelphia, Pennsylvania, USA
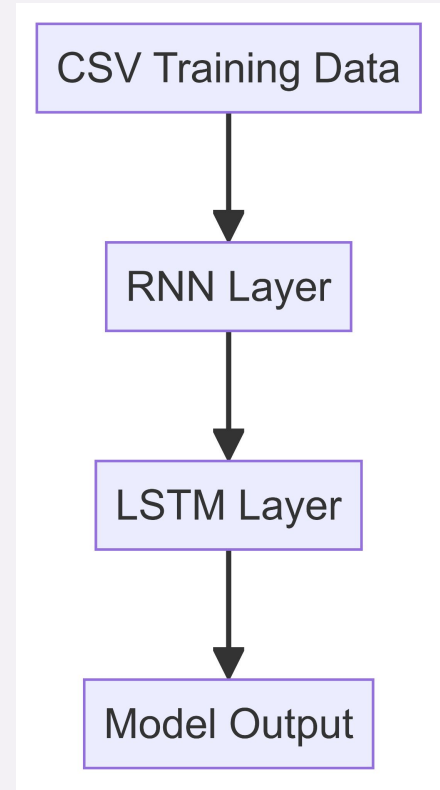
Final Model Architecture

Layers included:
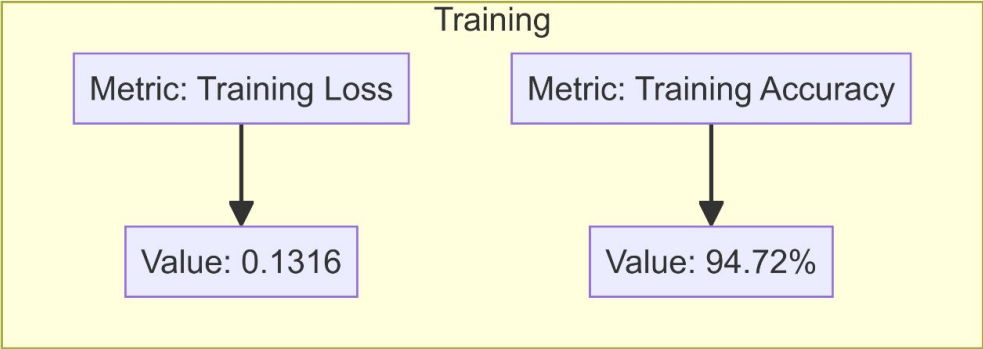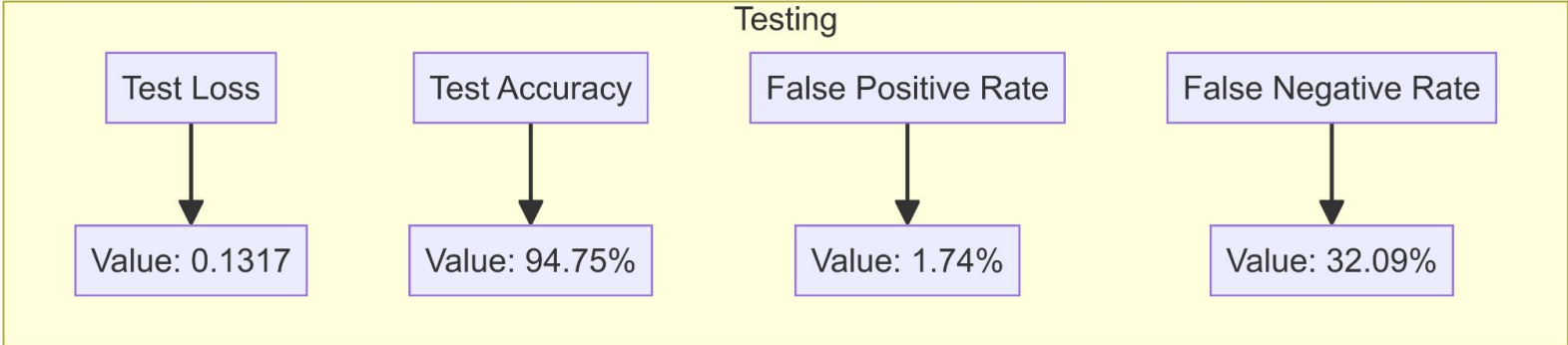
1. **RNN Layer**

    a. Good for time series based data

    b. Allows for the model to understand context

    c. Captures information about previous elements in the sequence

2. **LSTM Layer**

    a. Used to overcome issues with RNNs for long term dependencies

    b. A fix for the vanishing and exploding gradient problems

CSV Training Data

↓

RNN Layer

↓

LSTM Layer

↓

Model Output

Results and Discussion

Testing

Test Loss	Test Accuracy	False Positive Rate	False Negative Rate
Value: 0.1317	Value: 94.75%	Value: 1.74%	Value: 32.09%

Training

Metric: Training Loss	Metric: Training Accuracy
Value: 0.1316	Value: 94.72%

Performance Comparisons

Model Comparisons	True Positive	True Negative	False Positive	False Negative	Overall Accuracy
Neural Engineering Data Consortium's ResNet-18[1]	83%	60%	17%	40%	Unstated
SeizurEShield ResNet-18	89%	62%	11%	38%	90%
SeizurEShield RNN+LSTM	70%	98%	1.74%	32%	95%

[1] "Low Latency Real-Time Seizure Detection Using Transfer Deep Learning" - Neural Engineering Data Consortium, Temple University, Philadelphia, Pennsylvania, USA

Future Directions/Mission Revamp

1. Perform in-depth optimization on the algorithm to lower the false negative rate

2. Implement more signal processing to the raw data (band-pass filters, Fourier Transforms, etc.)

3. Test more data lengths as RNN inputs

4. Test xLSTM layers (an improved version of normal LSTM layers)

5. Test adding more and varied types of layers to the model (*e.g.* multiple RNN or LSTM layers with different sequence lengths)

Once these steps are taken, we would adapt the optimized model to also perform seizure prediction.

SEIZURESHIELD

Empowering individuals with epilepsy through advanced machine learning solutions to better monitor their seizure activity, enhancing their quality of life and ensuring their dignity and safety.

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