AI for wearable ECG prototype (ResNet + SE model) Tech 07 class project

Related to a virtual poster presentation at SciPy 2025
https://www.scipy2025.scipy.org/

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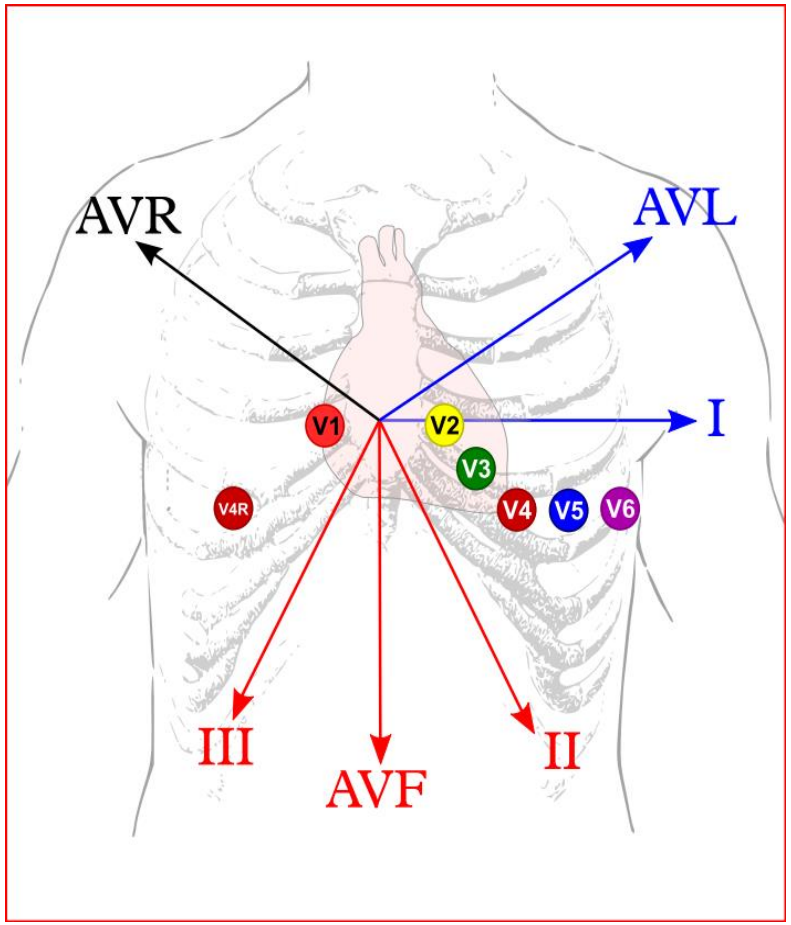
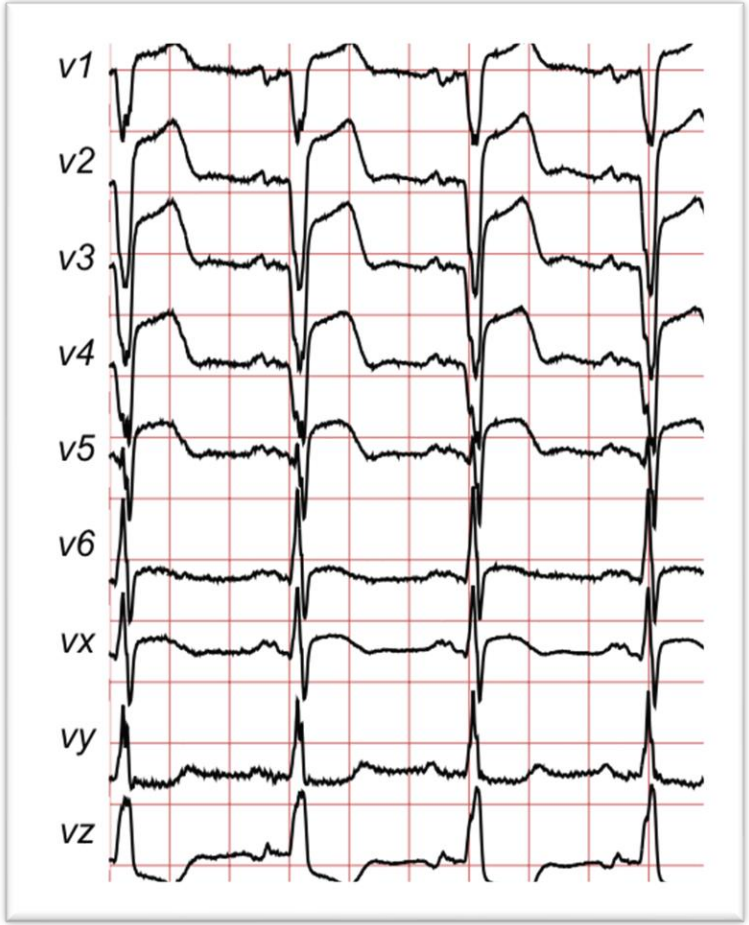
github: https://github.com/JennEYoon/ECG-transform

Areteus ECG prototype (Areteus.us)

ECG 12-signal device, on t-shirt



Electrodes placement diagram
Source: ECGpedia.org



Sample ECG plot

ECG Datasets

ECG datasets used for 47 years (<2018)

- MIT-BIH

  Hospital recording on 2 channels, 47 patients, 30 minute recording time. Old recordings and machines, 1975-79.

  Patients were moving around. Some non-readable signals were hand corrected by doctors & may have biases.

- PTB original

  Hospital recording on 15 channels, 294 patients, 10 second recording time, using newer machines, 1990-1997.

  Good quality data, but too small patient number to run complex models or output more than a few diagnostic classes

New 12-signal datasets (2018-2021)

- Large patient numbers, about 100,000 total
- High Quality 12-signal (latest hospital ECG machines)
- Multiple hospitals, multiple countries (China, USA, Germany, Europe)
- Efforts to standardize diagnostic class labels
- Developed with recent deep learning models in mind (ResNet, SENetworks, Transformers, RNN)

Sources	Countries	Locations	Total patients (n)	Total ECGs (n)
Chapman-Shaoxing and Ningbo	China	Shaoxing People's Hospital Ningbo First Hospital	45,152	45,152
CPSC and CPSC-Extra	China	11 unnamed hospitals	Unknown	10,330
G12EC	USA	Emory University Hospital	15,738	10,344
PTB and PTB-XL	Germany and other European countries	University Clinic Benjamin Franklin Physkalisch Technische Bundesantalt	19,147	22,353
SPH	China	Shandong Provincial Hospital	24,666	25,770

Datasets Used

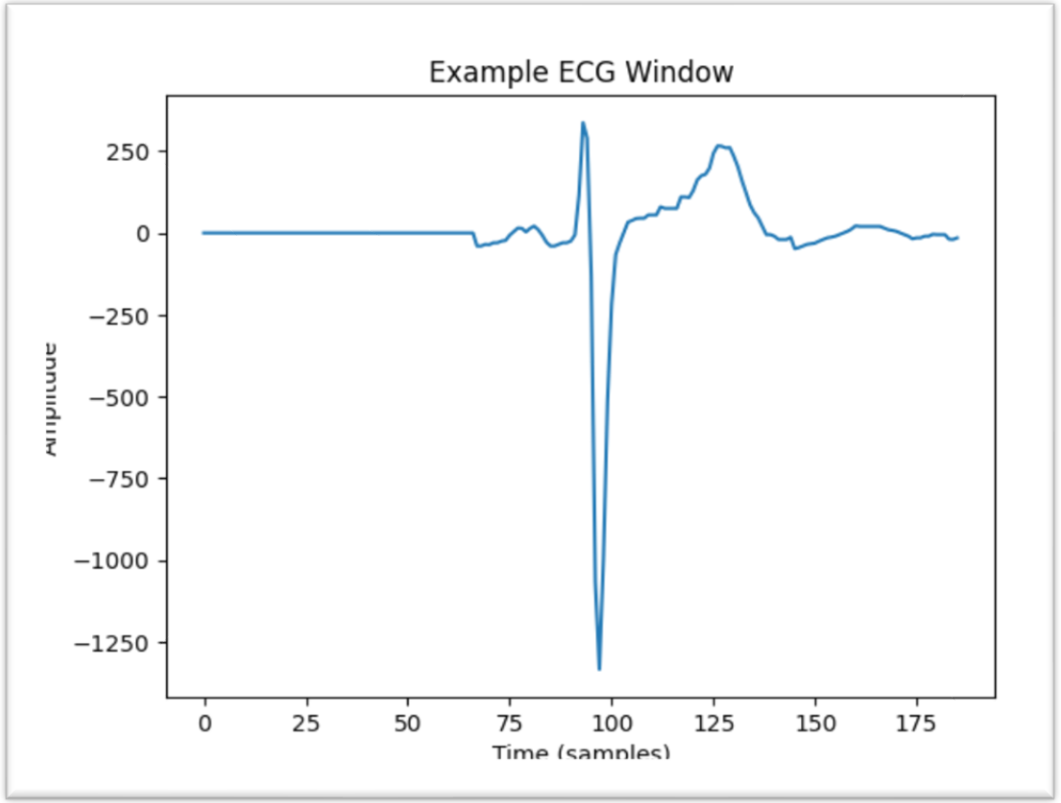
Data Processing

From new, large 12-signal datasets (2018-2021 collections) PTB-XL dataset was selected with about 22,000 patients, 10 second recording length. From this, 1,000 patients were selected for a test run.

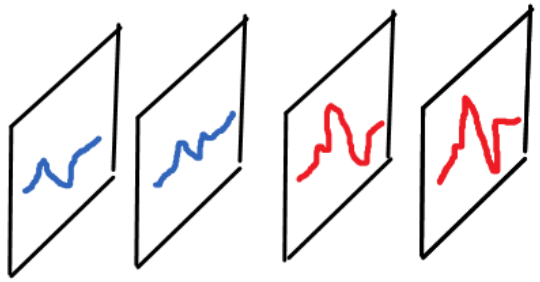
ECG signals data processing

- Peak center, split into 1.5 sec. windows, zero pad left & right.
- Baseline meander fix to zero
- Filters usually applied but not performed since may have information value:
  - Peak to peak distance standardizing
  - Peak amplitude standardizing
  - Removing negative values (squaring)
  - random split, overlapping split (less accuracy, image models also center object)
  - much longer time windows (not relevant for deep learning, better suited for time-series)
  - no relationship, feed each one of 12 signals independently (not as accurate for some conditions)

Image, peak centering, zero padding

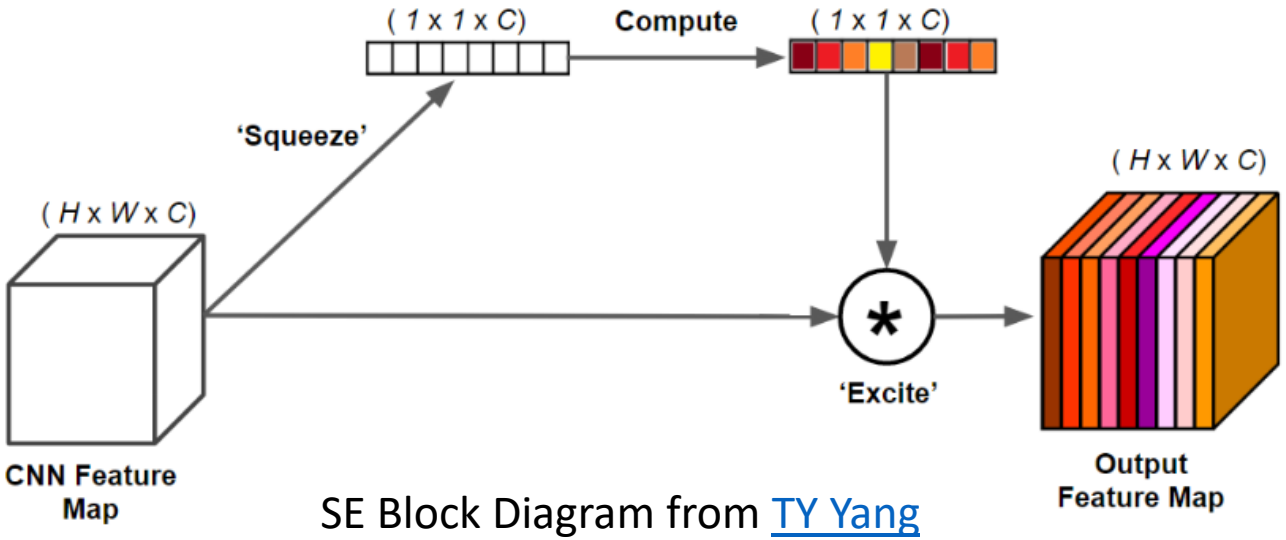


ResNet (Residual Network) + SE (Squeeze and Excite)



Input Signal Channels

The main idea of an SE Block is: **Assign each channel of a feature map a different weightage (excitation) based on how important each channel is (squeeze).**



SE Block Diagram from [TY Yang]

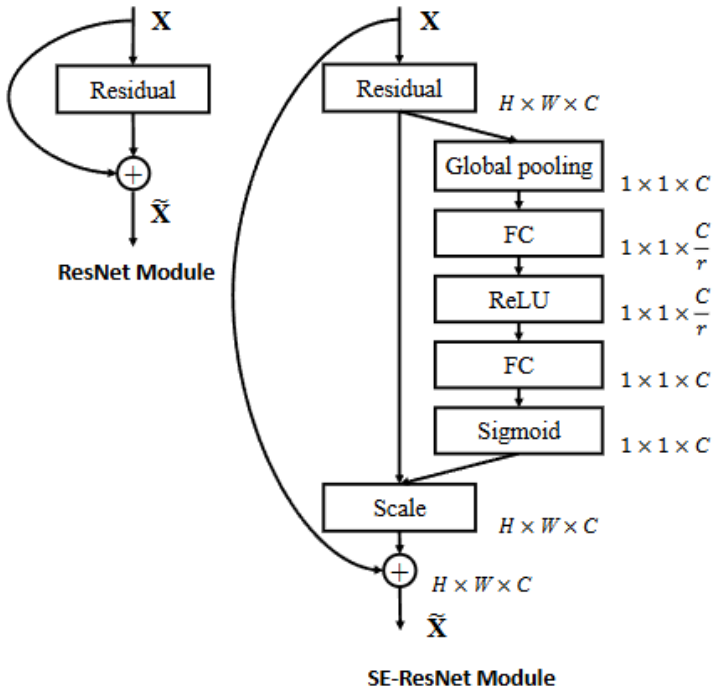


Fig. 3. The schema of the original Residual module (left) and the SE-ResNet module (right).

Results & Future Steps: What I hope to show

COMPLETED WORK

CNN, Random Forest, old MIT-BIH, PTB data:
Accuracy, F1 score: earlier models
* MIT-BIH (2-signals, small sample)
* PTB original (12-signals, small sample)

Areteus device inference:
- proof of concept, using one person, healthy heart data, 30 recordings taken over 2 days.
Translate binary/hex into usable numpy format

FUTURE WORK

ResNet+ SE, PTB-XL 12-signal data:
Accuracy, F1 score
Binary classification
4-6 class classification
24 class classification
Comparison of PTB-XL with SPH data

Future Steps:
Areteus device: to gather many more patient data, and from large number of abnormal diagnostic classes.

Areteus device: to test for model accuracy when user moves or when user did not attach all 12-nodes at right locations.

Areteus device: how to adapt the device to different body sizes? Initially medium t-shirt size is available, but small and large sizes are planned. Will need to test device accuracy on users with varying body sizes.

AI models: Transformer + RNN model is also a good candidate. Uses 2-stage training to makes full use of 12-signal dataset.

AI for wearable ECG prototype (ResNet + SE model)

We're looking for volunteers to contribute abnormal heart beats data.

We're planning a kick-starter funding, Areteus ECG (https://areteus.us/)

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https://github.com/JennEYoon/ECG-transform/tree/main/Tech07-project

Deep Residual Networks, c. 2015: https://arxiv.org/abs/1512.03385

Yannic Kilcher: https://www.youtube.com/watch?v=GWt6Fu05voI

Squeeze-and-Excitation (SE) Networks, c. 2017: https://arxiv.org/abs/1709.01507
Soroush Mehraban: https://youtu.be/3b7kMvrPZX8?si=g0JY09P5dIPMXwRj