EpilepsyNet: Interpretable Self-Supervised Seizure Detection for Low-Power Wearable Systems

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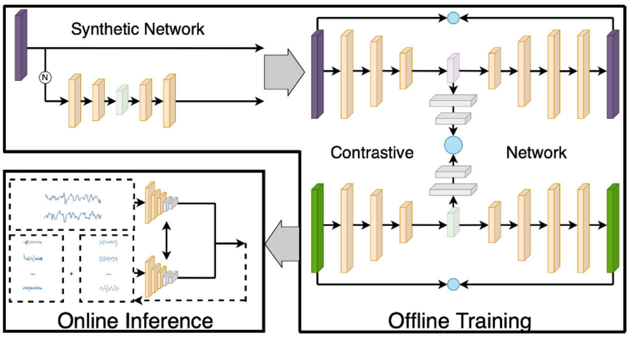
Motivation & Research goals

Epilepsy, as one of the most common neurological disorders, is characterized by recurrent and unpredictable seizures, **affecting around 65 million people worldwide**. However, the current gold standard of epilepsy monitoring has limitations for monitoring outside the hospital environment, and it needs a large amount of data to feed deep-learning models [13,15-18]. But **new patients usually do not have any collected and labeled seizure data**, a major challenge that has been recognized. The aim of this research is to design a method without any need for labeled seizure data for new patients, and **for resource-constrained wearable systems**.

Methods

We propose EpilepsyNet for resource-constrained wearable systems, the first interpretable self-supervised network for seizure detection **without any need for labeled seizure data** for new patients in training.



Step 1: Synthetic Network: synthesize seizure data by adding Gaussian noise to non-seizure data.

Step 2: Contrastive Network: to be trained by two kinds of constructed pairs.

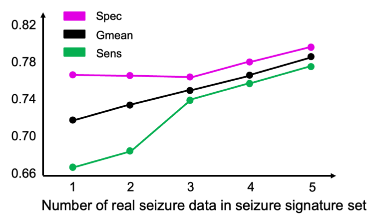
Step 3: Online Inference: the detected seizure data can be incorporated into the signature sets on the e-Glass wearable system without the need to retrain the model.

Results

Our network without using any real seizure data in training, has a **comparable performance** with the case with real seizure data.

Type	Approach	Real Seizure In Training	Real Seizure In Signature Sets	Real Seizure In Evaluation	Re2Cons	Sens(%)	Spec(%)	Gmean(%)
Basic	EpilepsyNet + Real Seizure	✓	×	✓	✓	63.3	89.4	73.3
	EpilepsyNet	×	×	✓	✓	**60.7**	**91.5**	**72.2**
Incremental	iEpilepsyNet + Real Seizure	✓	✓	✓	✓	80.7	79.8	80.2
	iEpilepsyNet - Re2Cons	×	✓	✓	×	76.2	77.7	76.8
	iEpilepsyNet	×	✓	✓	✓	**78.9**	**79.7**	**79.2**
SoA	Fully-Supervised CNN [25]	✓	–	✓	–	71.4	91.5	80.8

The Gmean increases in the **incremental inference** when we increase the number of real seizure patterns in the seizure signature set from one seizure to five seizures.



Our approach can be deployed in resource-constrained wearable devices, reaching up to **1.3 days of battery life on a single charge.**

Mode	Duty Cycle	Current
Active	5.02%	22.45mA
Low-power	94.98%	6.40mA
Battery life (225 mA·h)	100%	31.2 hours

References

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Else

My research interests also include The Internet of Things (IoT), mobile health, edge AI, and Neural architecture search (NAS), etc. If you want more information or seek potential collaboration, please feel free to contact me.