
RSeiz: A Channel Selection based Approach for Rapid Seizure Detection in the IoMT

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Outline of the talk

- ❑ Introduction
- ❑ Novel Contributions
- ❑ Design of the Proposed System
- ❑ Experimental Results
- ❑ Conclusions and Future Research

Epilepsy and Seizures

- ❑ Epilepsy is characterized by recurrent and spontaneous seizures.
- ❑ A seizure is defined as an abnormal electrical activity in the brain marked by loss of consciousness and convulsions.
- ❑ People with epilepsy are more prone to sudden unexplained death (SUDEP) than healthy people

Consumer Electronics for Seizure



Source: <https://spectrum.ieee.org/the-human-os/biomedical/diagnostics/this-seizuredetecting-smartwatch-could-save-your-life>



Source: <https://www.empatica.com/embrace2/>

Embrace2: Smartband which uses Machine learning to detect convulsive Seizures and notifies caregivers.

Medical grade smart watch: It detects generalized clonic-tonic Seizures and notifies physicians.

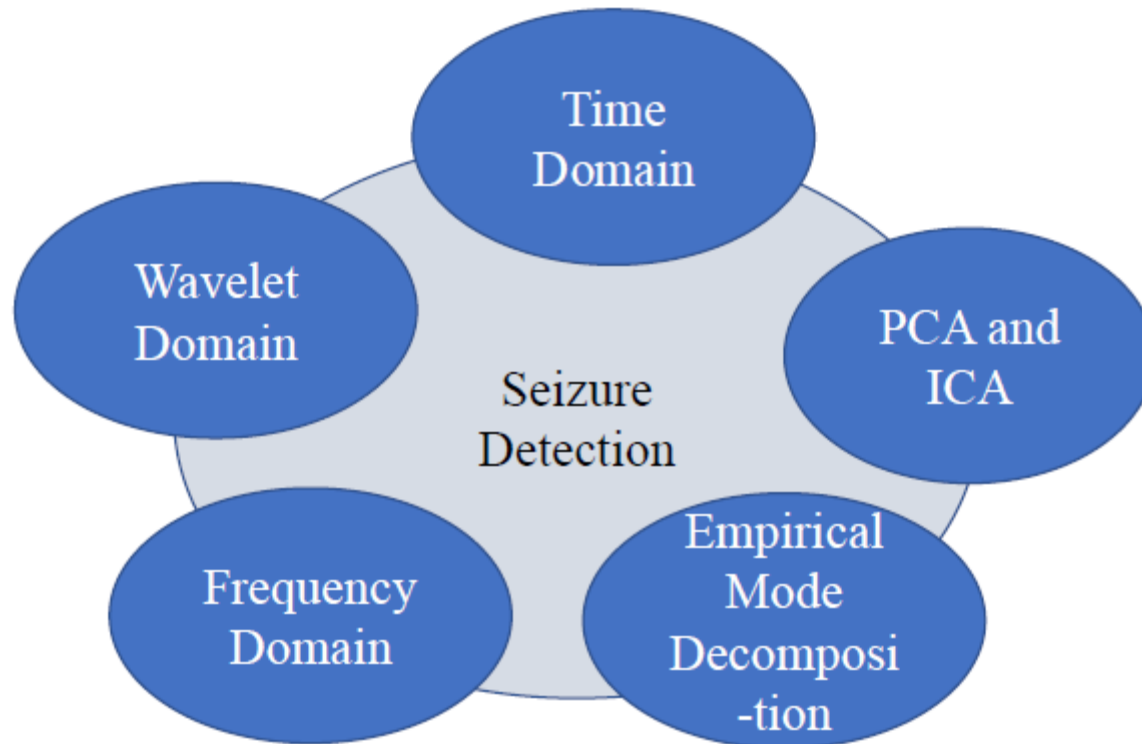
Consumer Electronics for Seizure

- ❑ U.S regulators have recently approved the first medical grade smart watch, a novel piece of consumer electronics product for neurological health, detects epileptic seizure and sends alert to the physician for proper actions.
- ❑ A significant research needs to be conducted for the detection of partial seizures and efficient drug delivery system.
- ❑ Consumer electronics is available to ECG, but not to EEG. The proposed system advances consumer electronics by bringing seizure detection and control to smart health care system.

Motivations: Seizure Detection

- ❑ Almost 1% of the world population and 3 million people in the US are affected by seizures.
- ❑ Anti-epileptic drugs are used to control seizure, but 30% of patients are refractory to medication.
- ❑ Surgery is restricted to cases where there can be no damage to the eloquent cortex.
- ❑ There is a high rate of sudden unexplained death (SUDEP) in epilepsy in comparison to the general population.

Related Prior Research – Types of Detections Methods



Related Prior Research

Several seizure detection methods have been proposed.

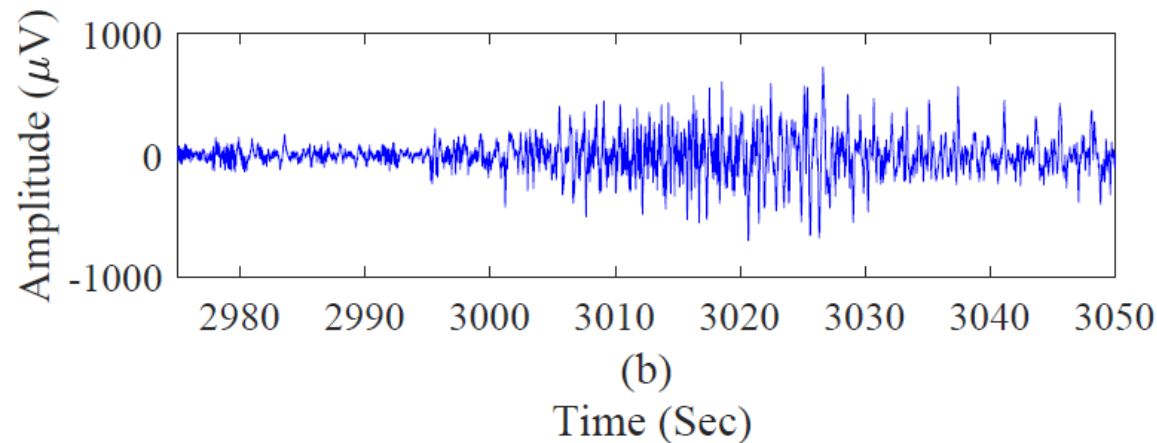
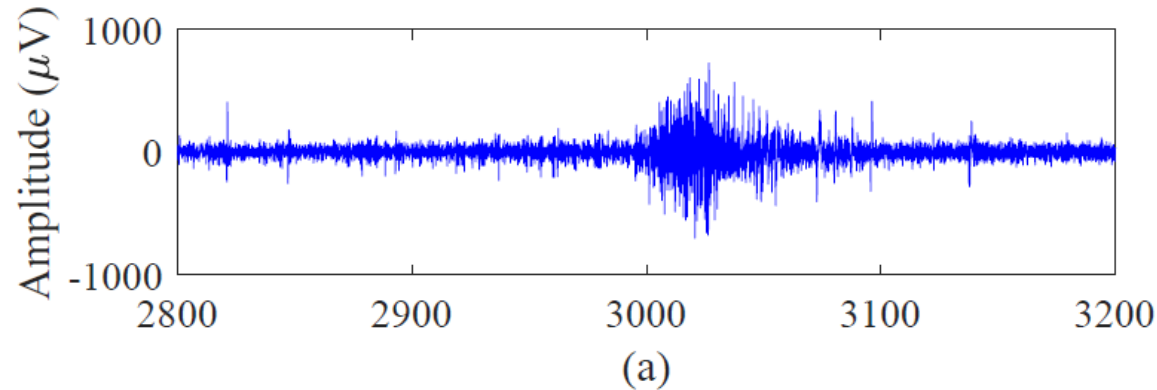
The algorithms are based on the following:

- ☐ Wavelet Transform Algorithm
- ☐ Support Vector Machine (SVM)
- ☐ Signal Rejection Algorithm (SRA)
- ☐ Wrist-worn accelerometer Device
- ☐ Local Mean Decomposition (LMD)
- ☐ Temporal Synchronization Approach

Research Question Addressed in The Current Paper

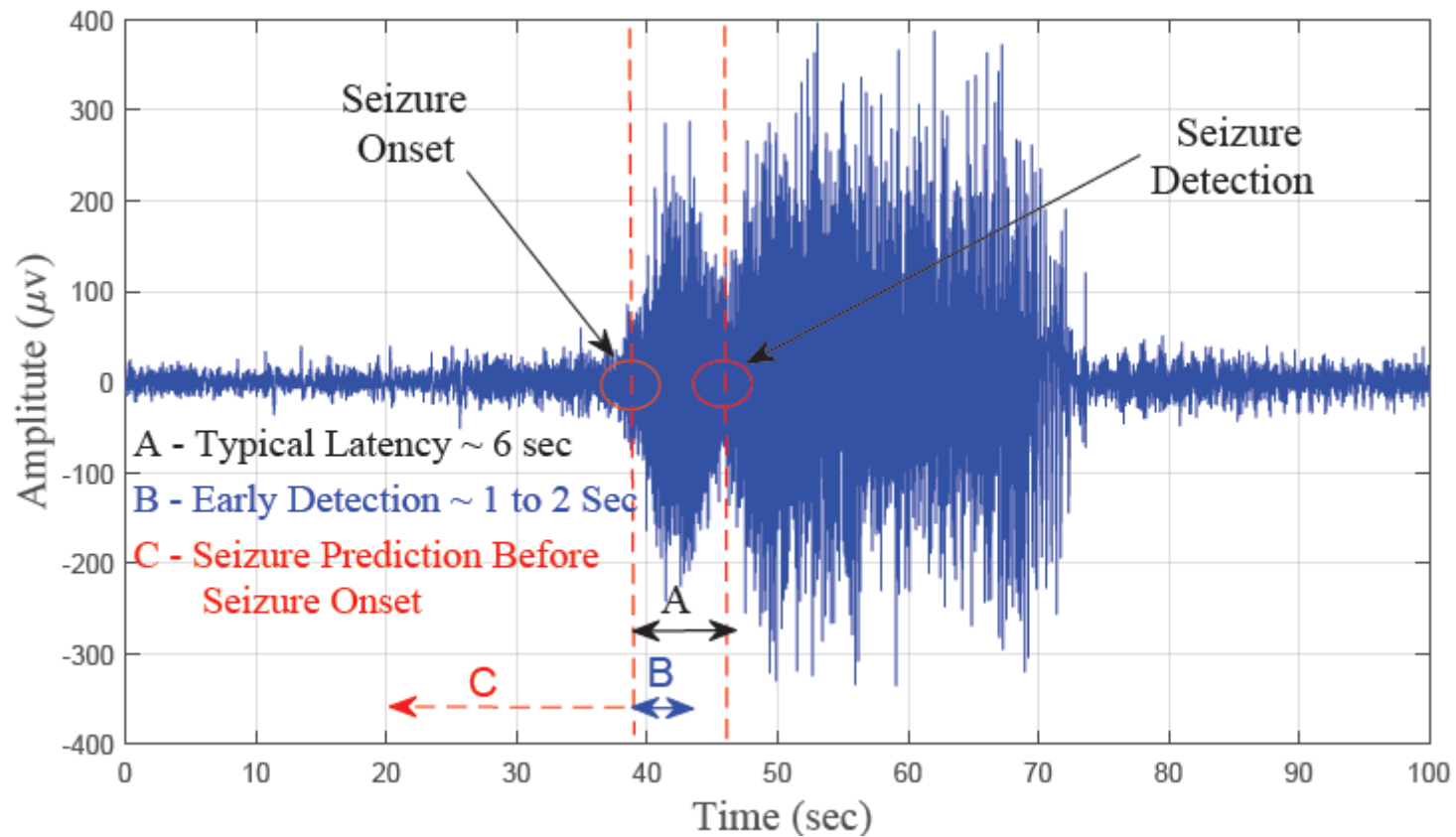
- ☐ Pattern detection for EEG abnormalities
- ☐ Early seizure detection
- ☐ Reduction in detection latency

EEG Signal – When a Seizure Occurs



Transient analysis (a) Input EEG signal of 2800-3200 seconds
(b) EEG signal of 2975-3050 seconds

Seizure Detection, Prediction, and Early Detection



Significance of Rapid Seizure Detection

- ❑ Smart healthcare is gaining considerable importance to meet the demand of mass population.
- ❑ Anti-epileptic drug and surgery can not be a universal choice to control epilepsy, which stipulates alternate methods.
- ❑ As a result, seizure detection is of high importance, as early detection leads to an appropriate and timely treatment.

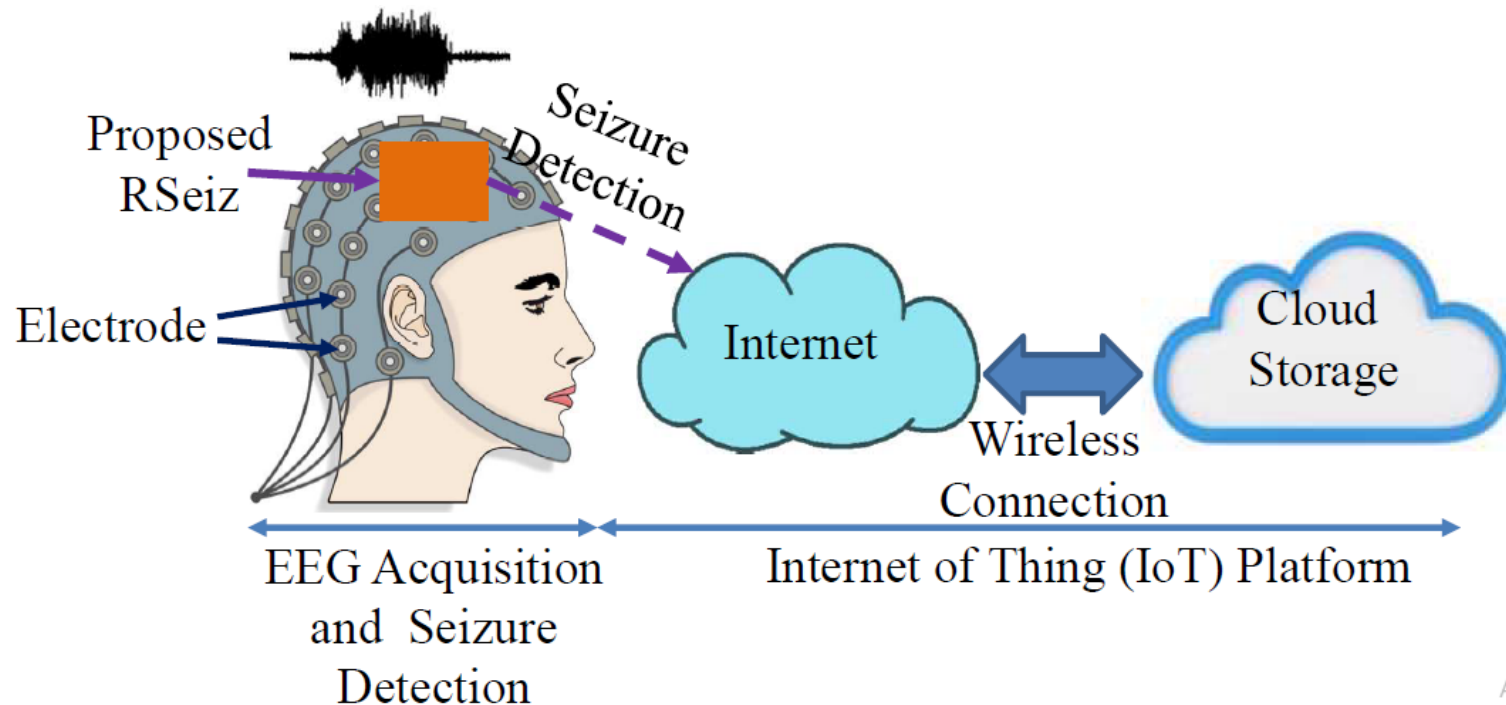
Novel Contributions

- ❖ The proposed algorithm removes unnecessary and less significant channels and features, which eliminates redundant computations and reduces the latency of the system.
- ❖ The proposed IoT framework provides remote connectivity, data sharing, and data storage.
- ❖ proposed system reduces detection latency considerably while maintaining high sensitivity, which makes it a suitable candidate for practical epilepsy treatment.

Design of the Proposed System

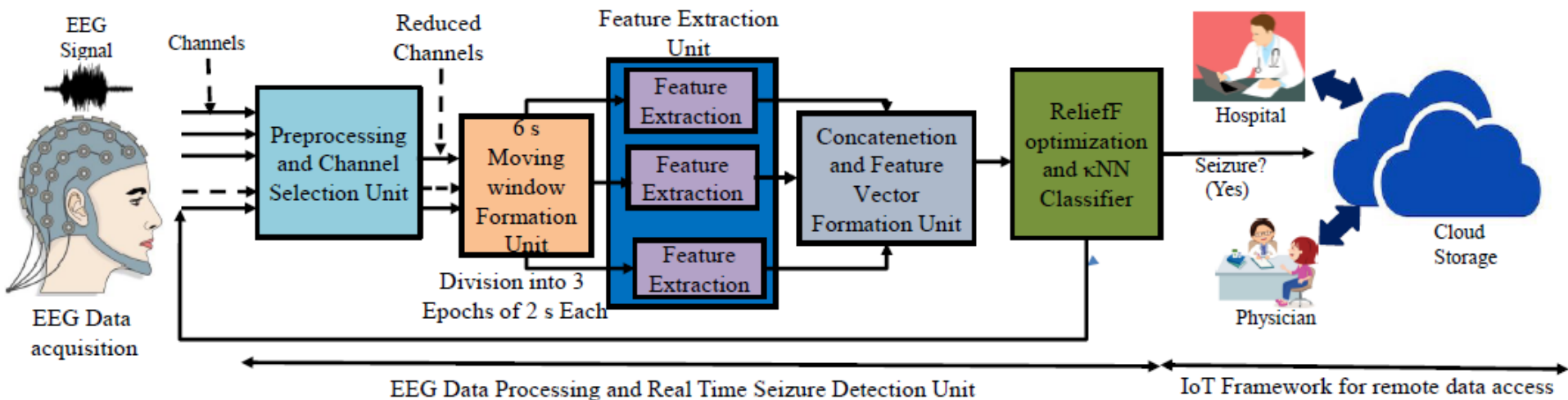
- ❑ Channel Selection: Neighborhood Component Analysis (NCA).
- ❑ Statistical Feature Extraction
- ❑ ReliefF optimized k -NN classifier

Module of the Proposed Rseiz in the IoT

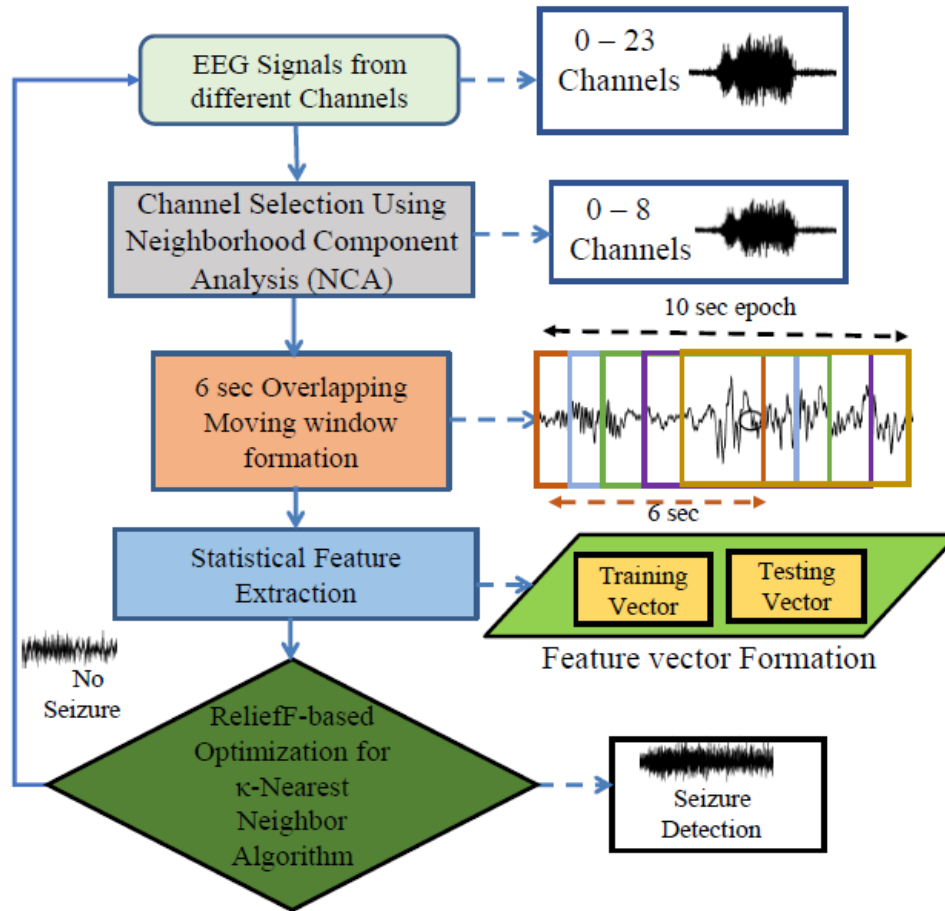


A

Architecture of the Proposed RSeiz



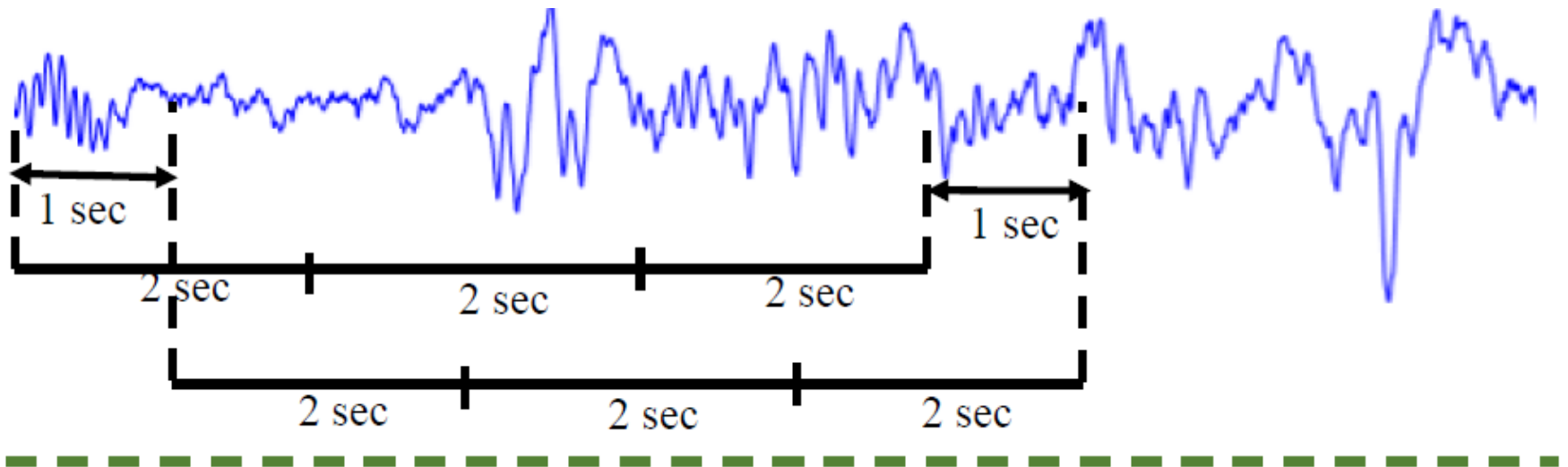
Flowchart of the RSeiz



Channel Selection: Neighborhood Component Analysis (NCA)

- ❖ Band Pass filter of frequency range 0-32 Hz retains signals of desired range.
- ❖ NCA analyzes all the channels and keeps only useful channels.
- ❖ The reduction in channels reduces latency associated with the proposed Rseiz.

Moving Window Formation Unit



Feature Extraction Unit

- ❖ The statistical features can quantify complex behavior of the EEG signals.
- ❖ The extracted feature values for seizure and non-seizure activity are different, which is effective for identification of biomedical abnormalities.
- ❖ Level of variations along a signal can be used as statistical features such as : variance, complexity.

EEG Features

- ❖ Variance
- ❖ Standard deviation
- ❖ Signal Activity
- ❖ Signal Complexity

Concatenation and Feature Vector Formation Unit

- ❖ Extracted features from non-overlapping segments are concatenated and form the feature vector.
- ❖ During offline training, features are concatenated to form a training feature vector.
- ❖ In the online classification phase, features are concatenated to form testing feature vectors continuously from the moving window and applied to the machine learning classifier for further analysis

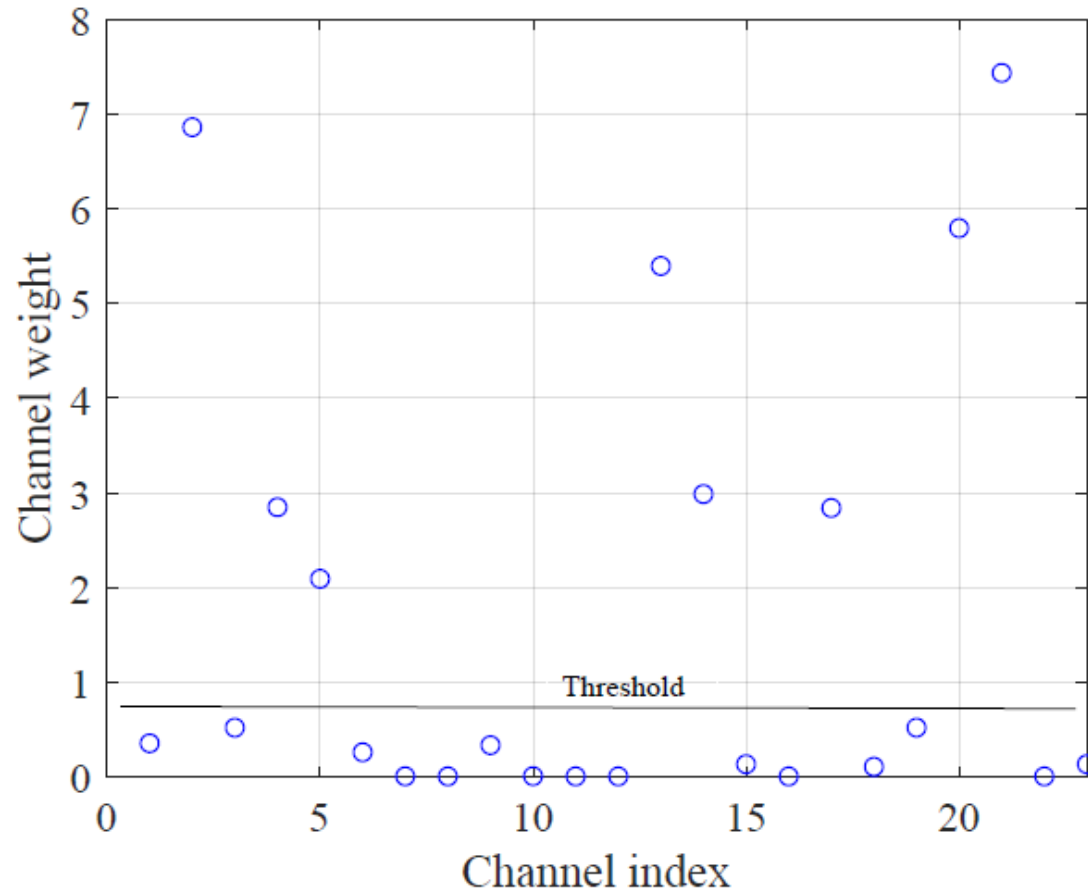
ReliefF Optimized k -NN Algorithm

- ❖ (RBO) discards irrelevant features and reduces the size of the training and testing feature vectors.
- ❖ In the offline training, the training feature vector is given to the k -NN classifier and the classifier is trained.
- ❖ In the real time classification phase, the system continuously forms testing feature vectors from the moving window and passes them to the classifier.
- ❖ The classifier analyzes the feature vectors and determines the nearest neighbors and finally, a class is assigned to the testing vector by voting among the neighbors.

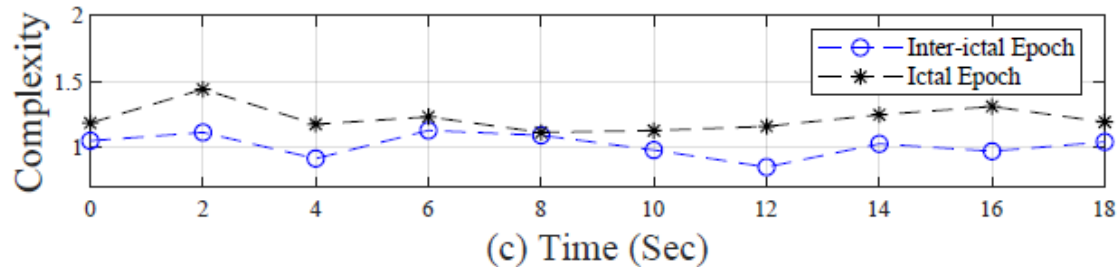
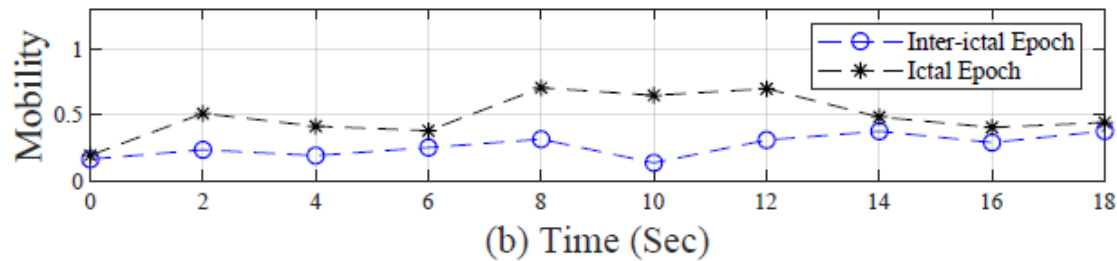
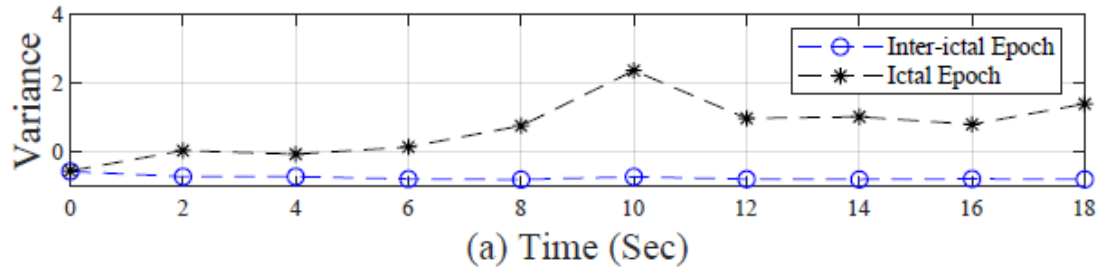
Characterization of the Proposed System

Parameter	Value
Sampling Frequency	256 Hz
Low cut-off Frequency	0 Hz
High cut-off Frequency	32 HZ
Best Lamda (NCA)	0.000264 (varies)
<i>K</i> value	2
Distance Metric	Euclidean
Sensitivity	100%
Latency	1.49 sec

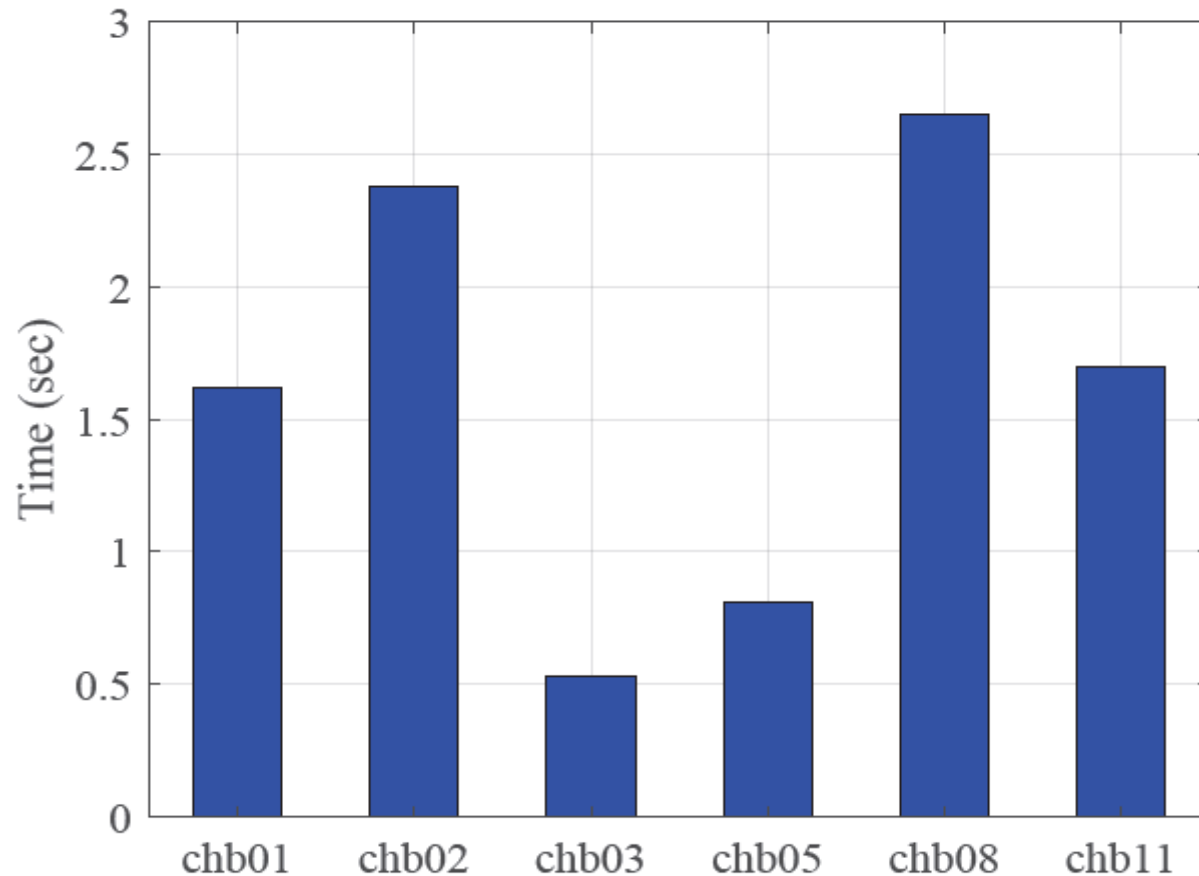
Experimental Results...



Experimental Results....



Experimental Results...



Comparison with Related Research

Existing Works	Sensitivity	Latency	Power Consumption
Salam, et al. 2012	100%	13.5 sec	51 μ W
Yoo, et al. 2013	84.4%	2 sec	1.49 μ j/class
Altaf, et al. 2015	95.7%	1 sce	2.73 μ j/class
Fan, et al. 2019	96.7%	6 sce	NA
Propoed RSeiz	100%	1.49 sec	~(30-40) μ W

Conclusions

- ❑ The proposed IoT based framework reduces latency significantly by eliminating redundant channels and features, while maintaining high classification accuracy.
- ❑ The reduction in computational burden makes it suitable for low latency biomedical applications.

Future Research

- ❑ Future research includes implementing a drug delivery system with the proposed system for seizure detection and simultaneous drug injection.
- ❑ Proposed idea can be combined with advanced machine learning algorithms to explore seizure prediction before the occurrence of seizure.

Thank You !!!

Slides Will Be Available at:
<http://www.smohanty.org>