Robust and Fast Seizure Detection in the IoT Edge

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Outline of the talk

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

Introduction

- Epilepsy and Seizures
- Significance of Seizure Detection

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

Motivations: Seizure Detection

- Traditional healthcare is unable to accommodate the needs of the increasing world population.
- Anti-epileptic drugs are not an effective cure for refractory patients.
- Surgery is not an alternative to anti-epileptic drugs if the seizure focus is located on the eloquent area of the cortex.
- As a result, seizure detection is of high importance, as early detection leads to an appropriate and timely treatment.

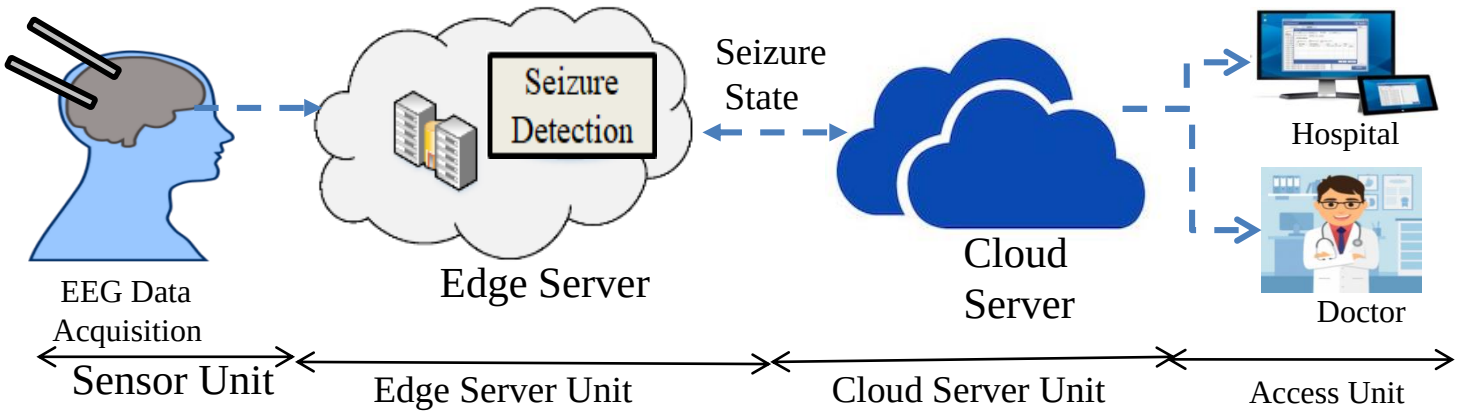
Novel Contributions

- Statistical features show considerable potential in distinguishing seizure and non-seizure behavior, and the use of a naïve Bayes classifier leads to improved classification accuracy.
- The proposed edge-IoT framework reduces latency compared to cloud-IoT frameworks and provides universal connectivity with ambient intelligence.

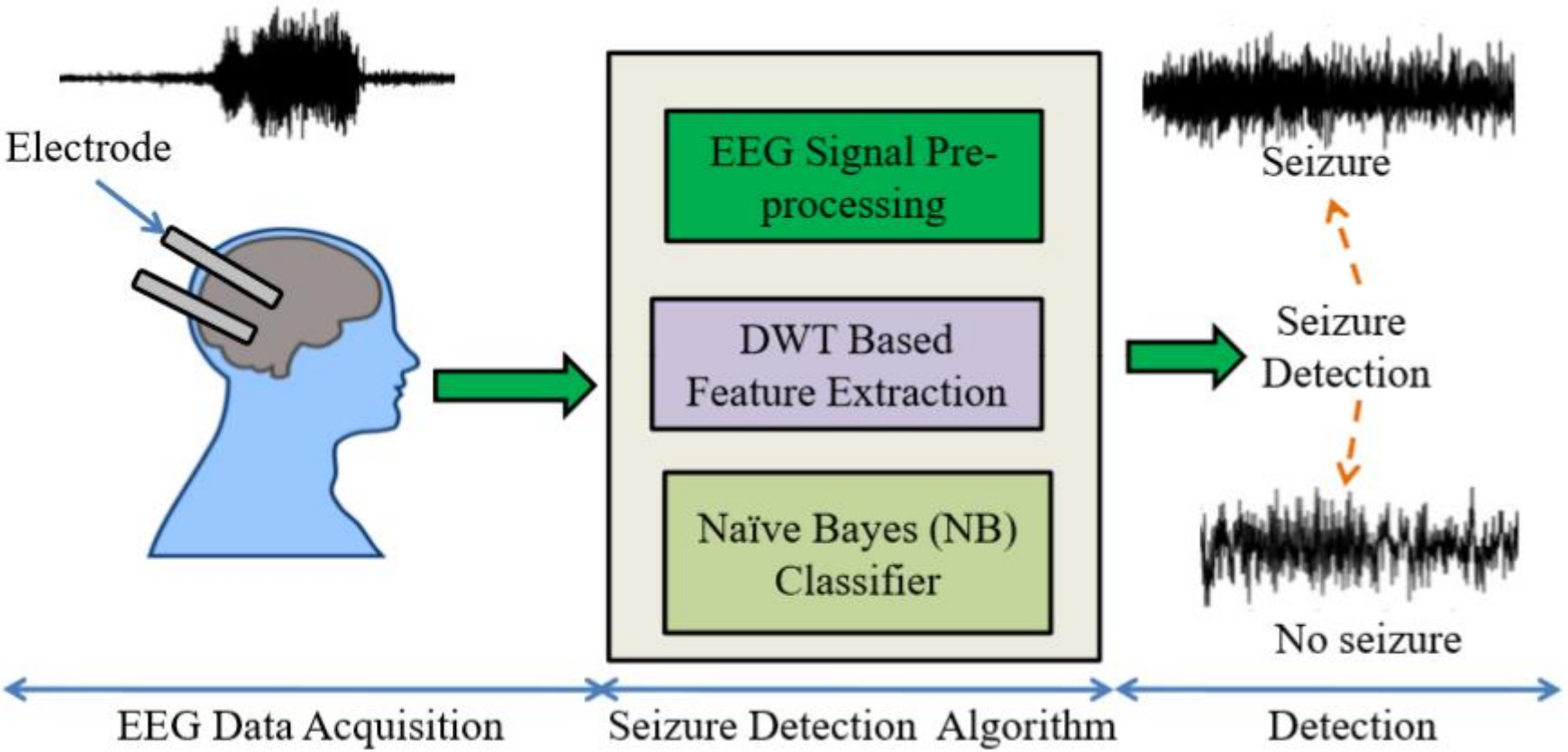
Design of the Proposed System

- Edge Computing: Edge-IoT perspective
- DWT-based Feature Extraction
- Naïve Bayes Classifier

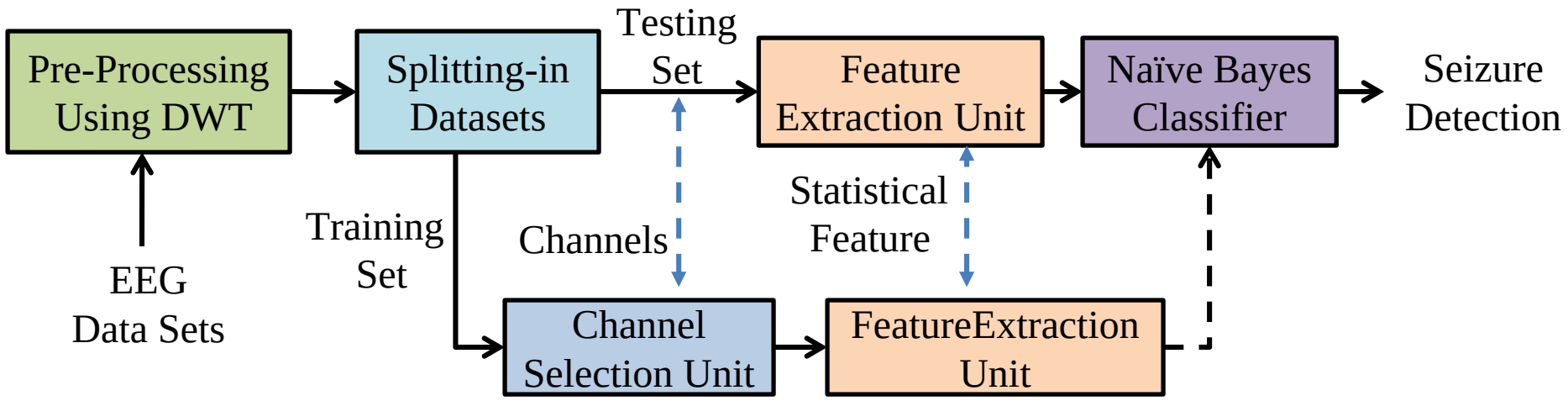
Edge Computing: Edge-IoT perspective



Seizure Detection Paradigm



Architecture: Epileptic Seizure Detection



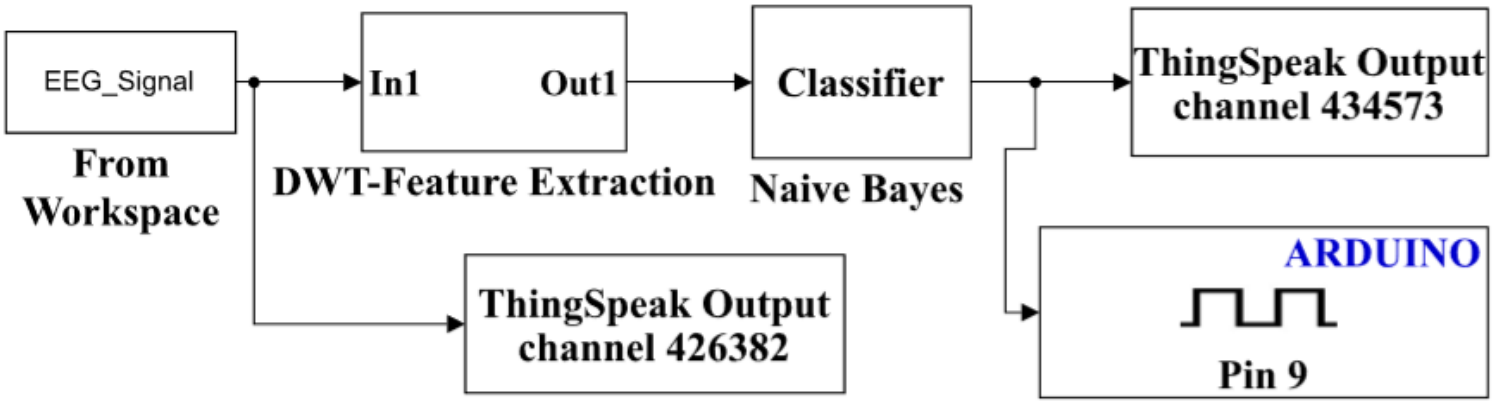
Feature Extraction From Discrete Wavelet Transform (DWT)

- Analysis of the EEG signals requires time-frequency (TF) decomposition to capture both low and high frequency information.
- The sub-band frequency ranges are: D1 (43.486.8Hz), D2 (21.7-43.4Hz), D3 (10.85-21.7Hz), D4 (5.4310.85Hz), and A4 (0-5.43Hz).
- The following statistical parameters are extracted from the decomposed EEG signals: variance, standard deviation, and energy.

Naïve Bayes Classifier

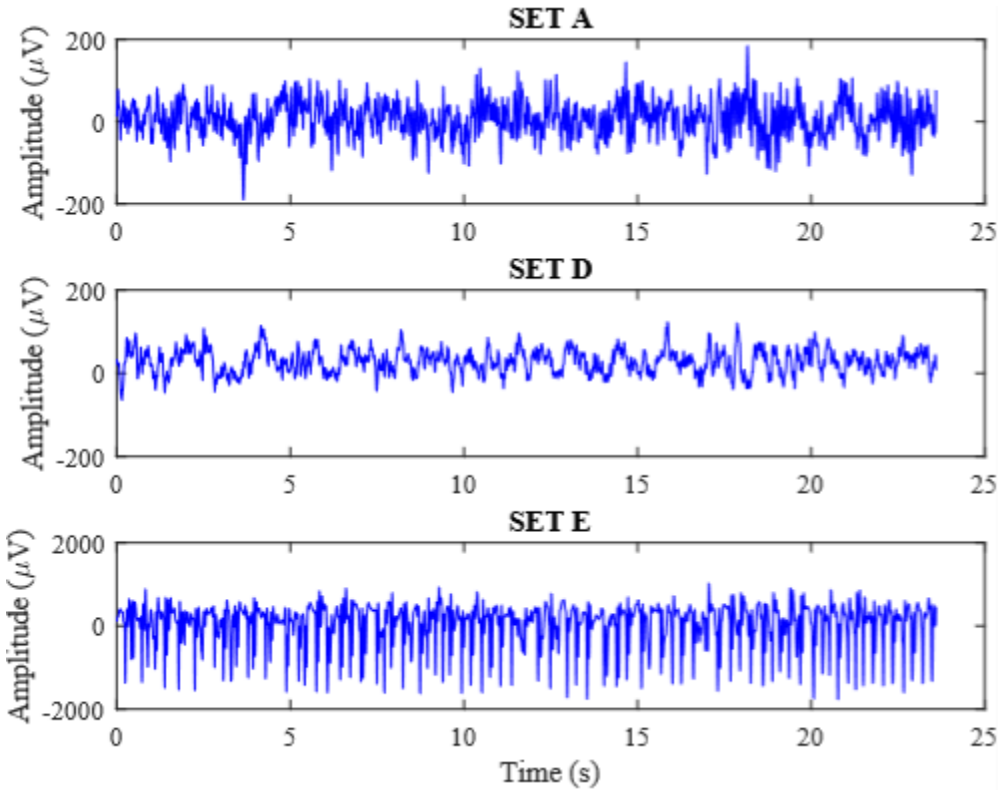
- A naïve Bayes classifier is based on Bayesian theory and requires fewer data for training.
- A class label is given to the attribute based on the highest posterior probability.

Implementation of the Proposed System..



- The proposed system was implemented using Simulink and the Arduino UNO R3 microcontroller board.
- ThingSpeak, an open data platform, was utilized to gather data in the cloud.

Results-EEG Waveforms



Results…

Extracted feature coefficients for dataset A

Coefficients	Variance	Standard Deviation	Energy
D1	25.21	5.02	2.85e+04
D2	587.55	24.23	3.04e+05
D3	5.39e+03	73.45	1.44e+06
D4	9.90e+03	99.52	1.98e+06
A4	1.54e+04	124.25	4.05e+06

Results…

Extracted feature coefficients for dataset E

Coefficients	Variance	Standard Deviation	Energy
D1	1.42e+03	37.98	1.89e+06
D2	6.43e+04	253.73	4.87e+07
D3	7.01e+05	837.56	3.06e+08
D4	6.96e+05	834.76	1.88e+08
A4	1.71e+06	1.31e+03	4.08e+08

Results: Cloud-IoT VS Edge-IoT

System Details	Latency
Clod-IoT Framework	2.5 sec
Edge-IoT Framework	1.4 sec

- Latency includes both computation time as well transmission delay.
- Edge-based IoT provides 44% reduction in latency which is highly important for critical biomedical applications.

Results- Comparison

Author	Methods	Accuracy (%)
Shoeb et al. [2009]	Support Vector Machines	78.74
Kumar et al. [2014]	Neural Network	95
Tawfiq et al. [2016]	Weighted Permutation Entropy	96.5
Sharmila et al. [2016]	Feature Extraction and k-NN classifier	97.08
Proposed System [2018]	DWT and naïve Bayes Classifier	98.65

Conclusion and Future Research

- The proposed edge-IoT framework reduces latency significantly while maintaining high classification accuracy.
- Future research includes implementing a drug delivery system with the proposed system for seizure detection and simultaneous drug injection.

Thank You !!!

Slides Will Be Available at:

http://www.smohanty.org