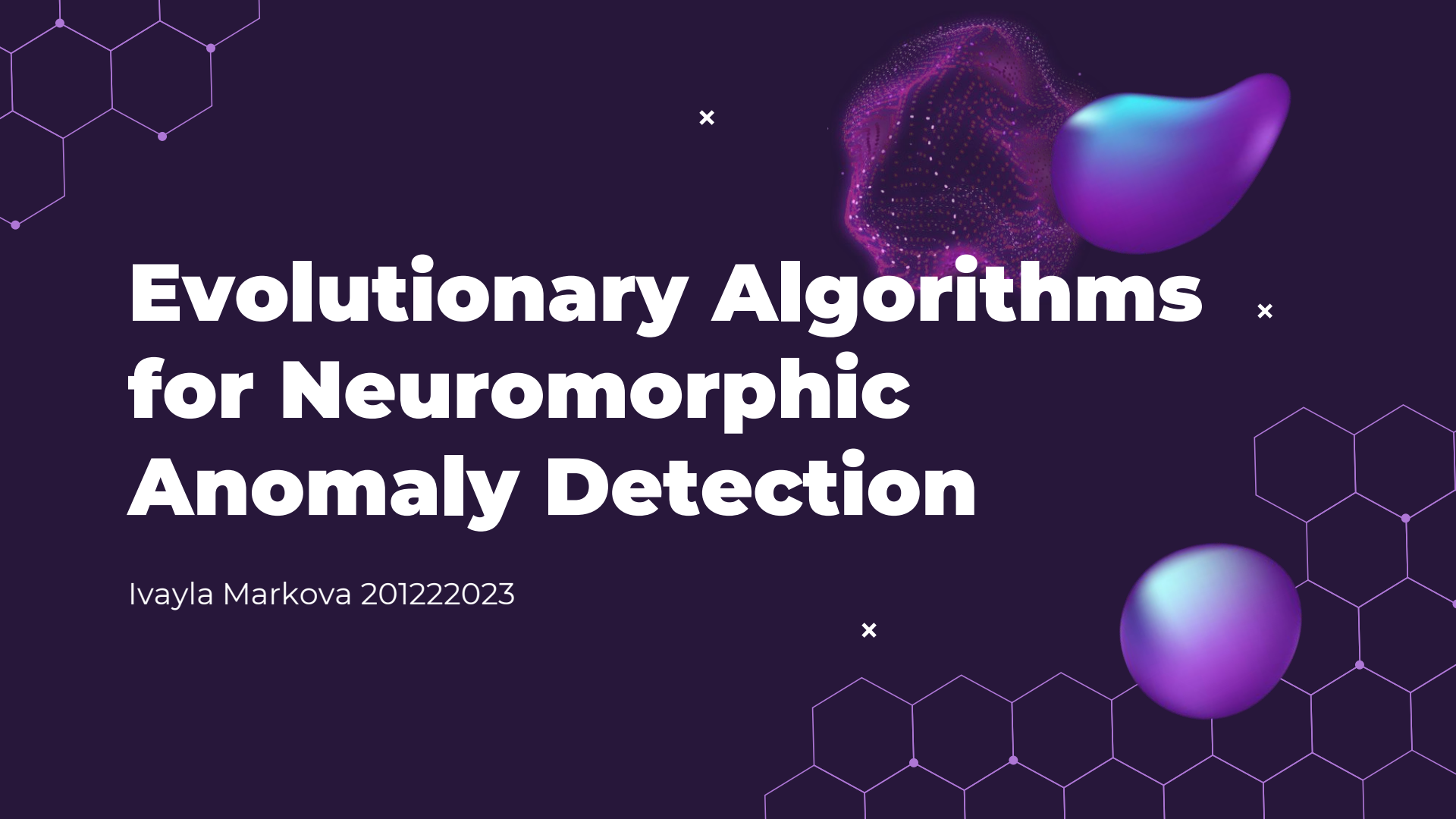
Evolutionary Algorithms for Neuromorphic Anomaly Detection
Ivayla Markova 201222023

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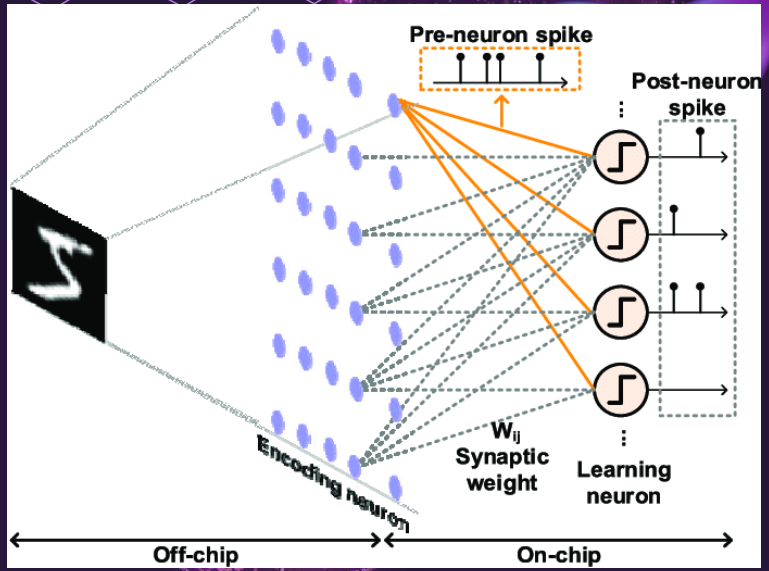
Neuromorphic computing and Evolutionary algorithms



Concept of SNN and its structure.

Neuromorphic computing:
an approach to computing that mimics the way the human brain works. It entails designing hardware and software that simulate the neural and synaptic structures and functions of the brain to process information.

Neuromorphic anomaly detection:
uses biologically inspired computing and hardware to detect unusual patterns in data with low power consumption and real-time processing. It combines techniques like Spiking Neural Networks (SNNs) and event-based sensors to analyze data from sources

Evolutionary algorithms:
stochastic search methods that are inspired by biology. They operate on a population of potential solutions applying the principle of survival of the fittest to produce approximations that converge to a solution

Problem & Dataset Description

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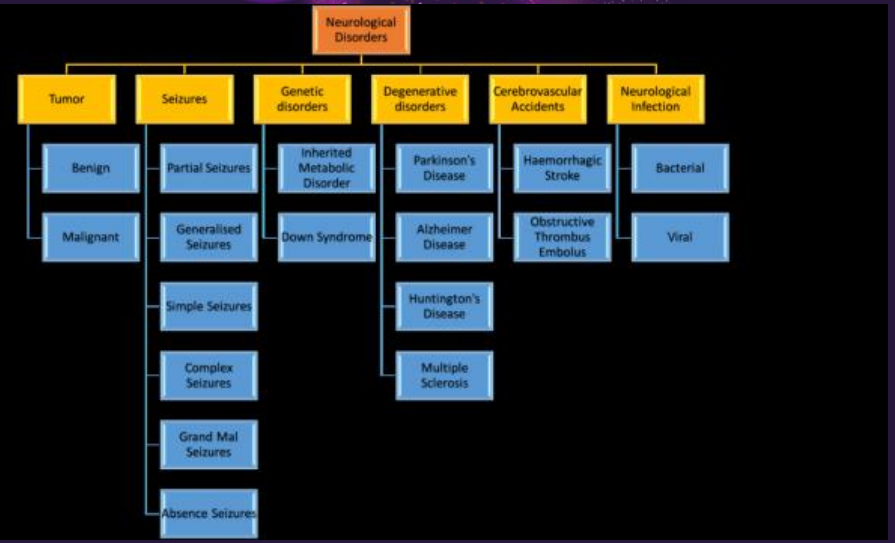
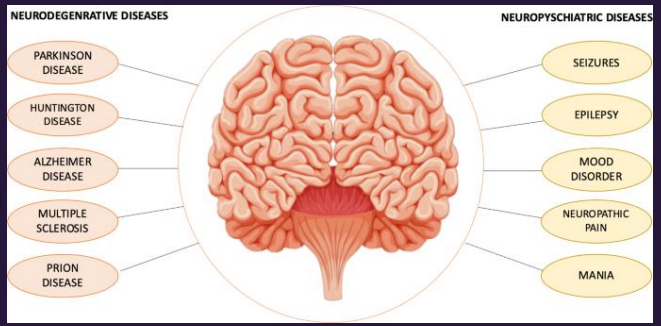
- Why epilepsy?
- 50 Million people globally
- Rare abnormal patterns
- Neuromorphic anomaly- detection
- My approach: automatic real-time recognition

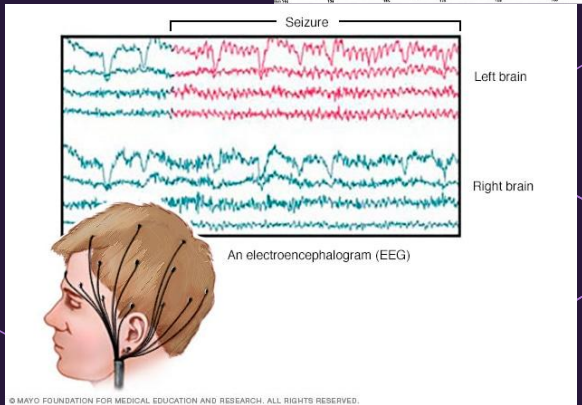




↑Major human neurodegenerative and neuropsychiatric diseases

<-Classification of neurological disorders

Epileptic spike and wave discharges monitored EEG ->



Methodology

Dataset

EEG recordings containing annotated seizure and non-seizure periods

Encoding

Conversion of EEG into spike-based or feature vectors suitable for neuromorphic processing

SNN

for seizure anomaly detection

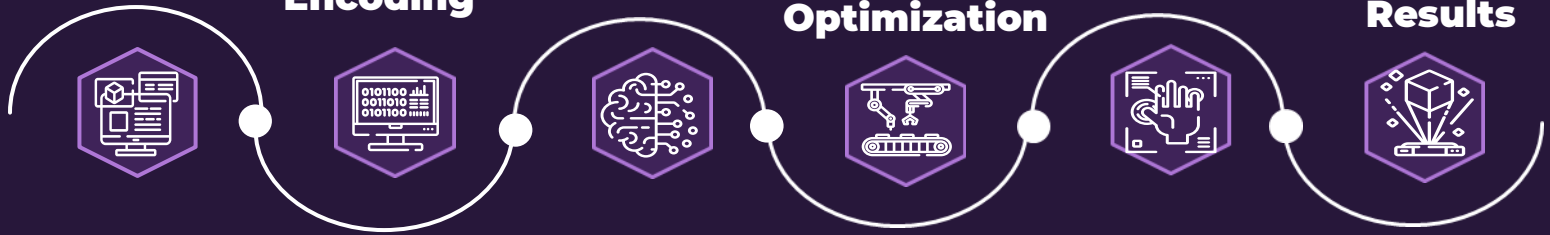
Evolutionary Optimization

of model structure and parameters

Evaluate

using standard metrics: sensitivity, specificity, latency

Results



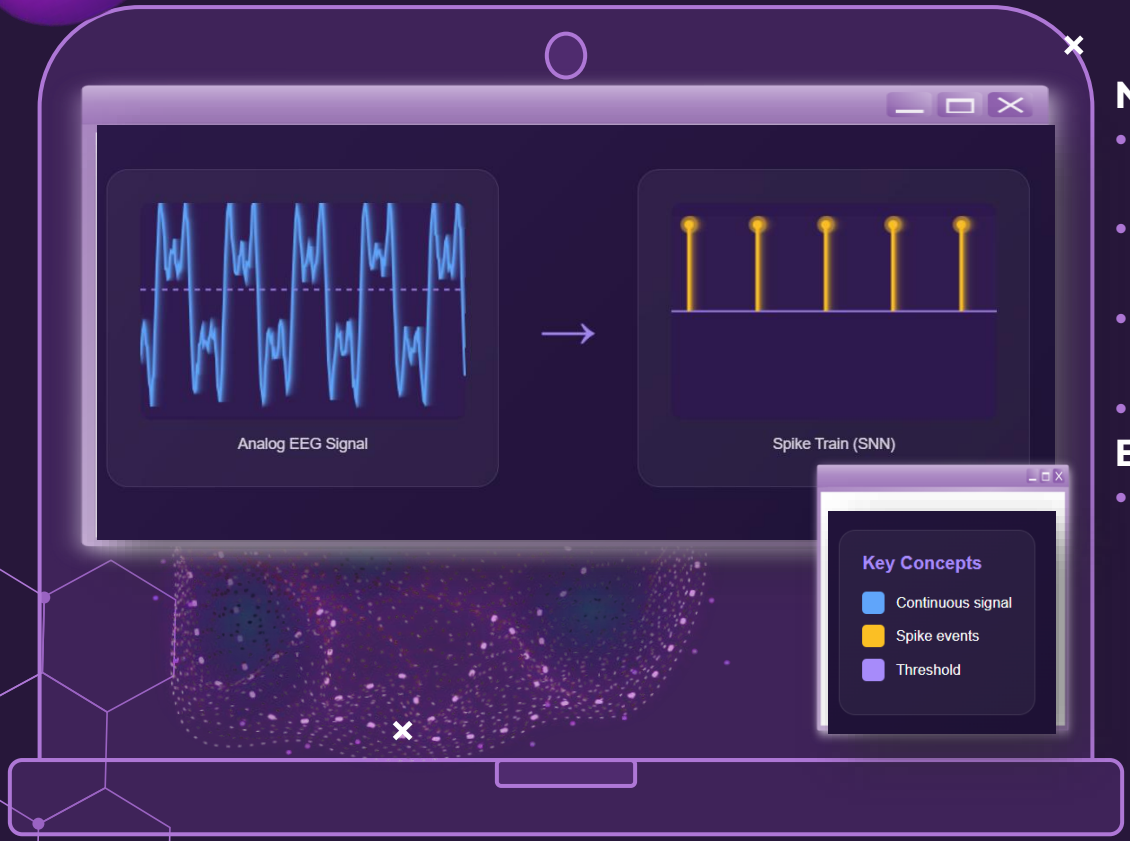
Experimental Setup

Dataset	• collected at the Children's Hospital Boston • EEG recordings from pediatric subjects **with intractable seizures**. Subjects were monitored for up to several days following withdrawal **of anti-seizure medication** in order to characterize their seizures and assess their candidacy for surgical intervention.
Software/ Tools	Google Colab, ipynb libraries such as: • **Pyedflib** – reading EDF files; **Scipy.stats** – statistics; **Pywt** – Wavalet transformations and more
Model Details	Finds epileptic seizures in EEG brain signals - 3 Main steps: : 1. Data Preparation: Get full EGG record -> cut on 5-sec windows -> mark seizure=1, normal=0 2. Features extraction for each 5 sec piece: energy – how strong is the signal; line length – how complicated is form is; entropy – how chaotic/ irregular it is 3. Genetic algorithm for optimization: Start [random weights] -> bad results **-> EVOLUTION** (30 gen.): - Selection: Take the best ones; - Crossover: Combine them; - Mutation: Make little changes -> END:[optimal weights] -> best results

EA Setup

https://colab.research.google.com/drive/171wQ0EloviycEShdyJU3i0Neeh139xKb?usp=sharing
Each individual has 4 numbers:
w1,w2,w3 – weights for the characteristics, threshold – classification threshold

Neuromorphic Model & Encoding



Neuromorphic Computing

- Mimics the workings of the human brain
- Uses spiking neural networks (SNN)
- Spikes instead of continuous signals
- Energy efficient

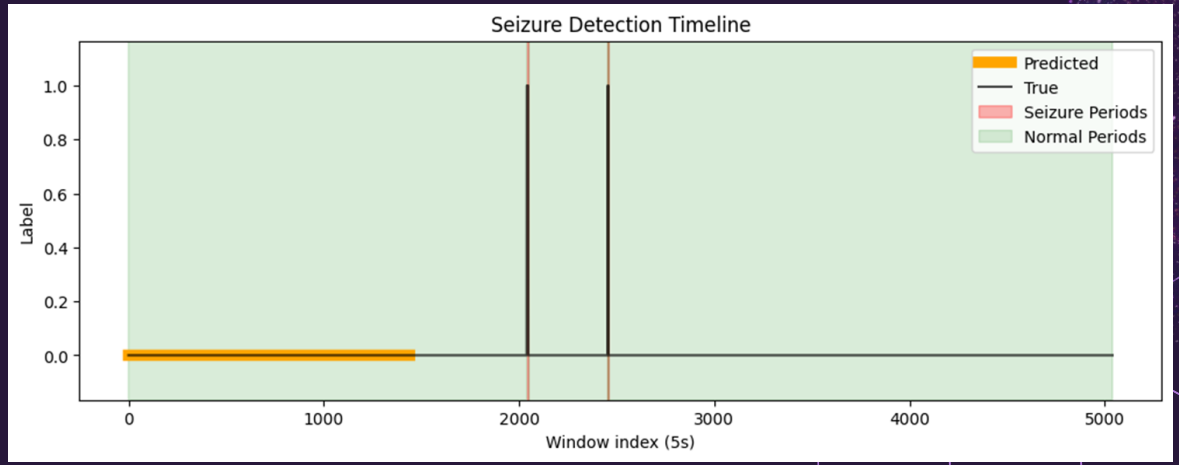
Encoding for EEG

- Converting analog EEG signals into spikes

Results & Evaluation

Timeline of Seizure Detection: Over 5,040 Windows (7 hours of EEG data)
Key Results: Orange Line: EA-optimized predictions; Black Line: Actual seizure events; Red Zones: True seizure periods (11 windows); Green Zones: Normal brain activity (5,029 windows)
Performance Metrics: Successfully detected rare events (0.2% of data)
-> Meaning:

- EA found optimal feature weights automatically
- System balances catching seizures vs. avoiding false alarms
- Challenge: Highly imbalanced dataset (1:457 ratio)



Conclusion

- ✓ Evolutionary algorithms can optimize neuromorphic anomaly detection
- ✓ Time-domain features are sufficient for basic seizure detection
- ✓ Automated weight optimization eliminates manual tuning

Future Applications:

Medical

- Real-time seizure prediction devices
- Personalised epilepsy monitoring systems
- Automatic medication adjustment

Other:

- Anomaly detection in financial systems
- Cybersecurity intrusion detection

SOURCES

https://www.ibm.com/think/topics/neuromorphic-computing
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Thank you for your attention!