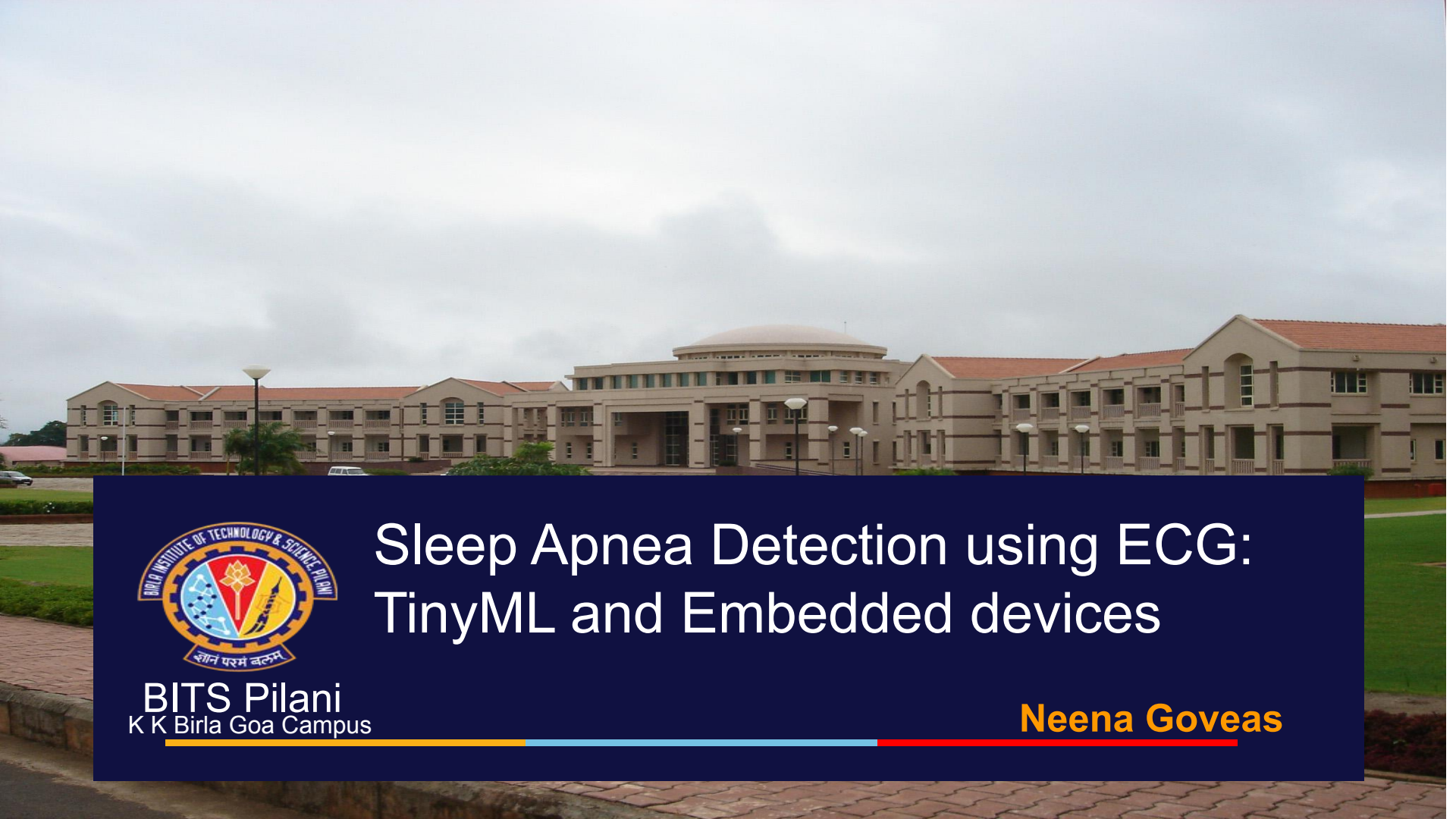

Sleep Apnea Detection using ECG: TinyML and Embedded devices

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Outline

- Motivation: Teaching large and mixed student set
- Results from research
- Conclusion
- References

Motivation: Large and mixed student set

- ~370+ in Computer Science
- Dual degree- Biology+CS, Chemistry+CS..
- Courses: Object Oriented Programming (Design),

  Software for Embedded Systems (elective)

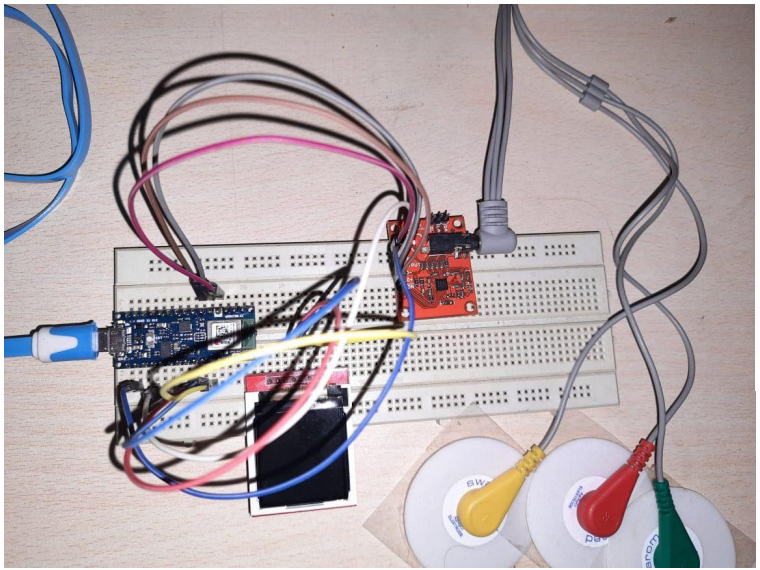
Sleep Apnea- Existing Solutions

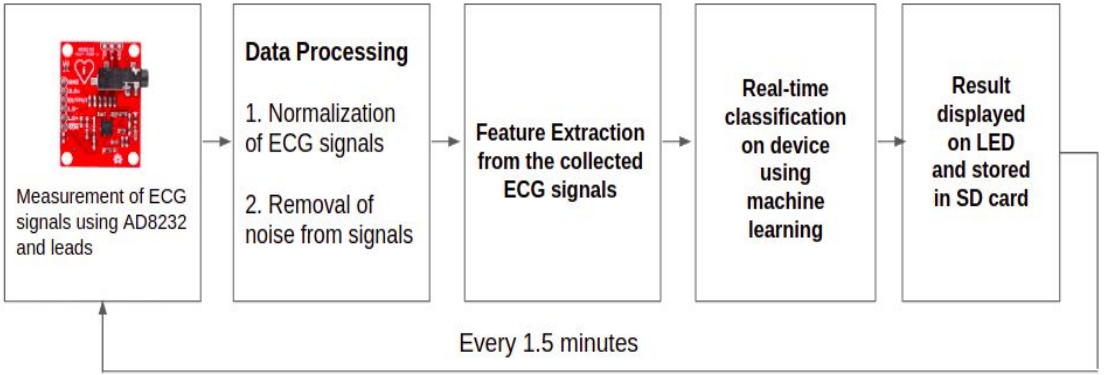
- Wang et. al. presented an AI based mechanism to detect Sleep Apnea from a single-line ECG.
- Khincha et. al.presented a low-cost solution on Raspberry Pi 3 Model B using Support Vector Machines.

Ideal Solution

- Cheaper
- Latency lower- real time, possible actuation
- Compact
- No Internet connectivity

Proposed System





Setup of the System

- Resource Constrained Devices:
  - ESP32 (6 USD)
  - Raspberry Pi Pico (8 USD)
  - Arduino Nano BLE (30 USD)

- Edge Impulse Platform: For training and deploying models on a resource-constrained devices. (https://www.edgeimpulse.com/)

(I) ESP32

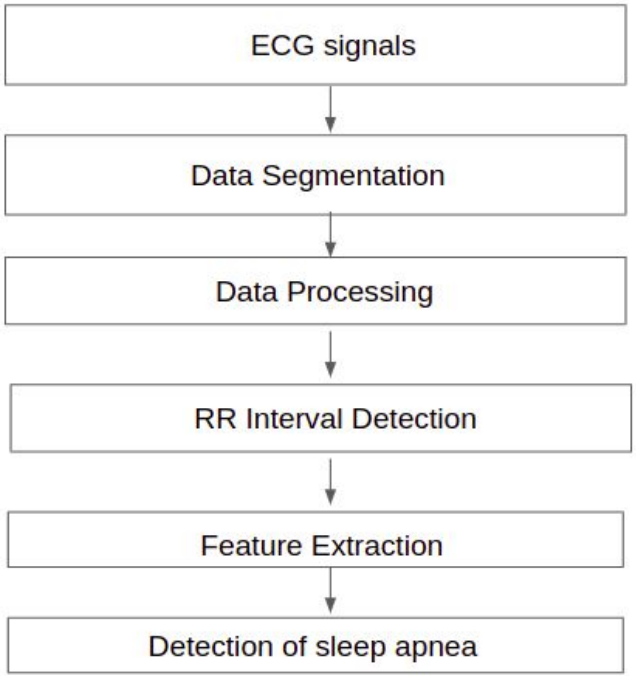
(II) Raspberry Pi Pico

(III) Arduino Nano 33 BLE Sense

Proposed Solution

- ECG signals- measured using AD8232
- ECG time series: segmented into few minute duration
- Features are then extracted from the ECG signals

Proposed Solution



ECG Signals segmented into block size of 1.5 minute; around 100 RR intervals.

The model uses four features extracted from the RR intervals: mean and standard deviation of heart rate and the NN50 measures.

Models were used to classify ECG signals into Apneatic and normal.

Deployment to Devices

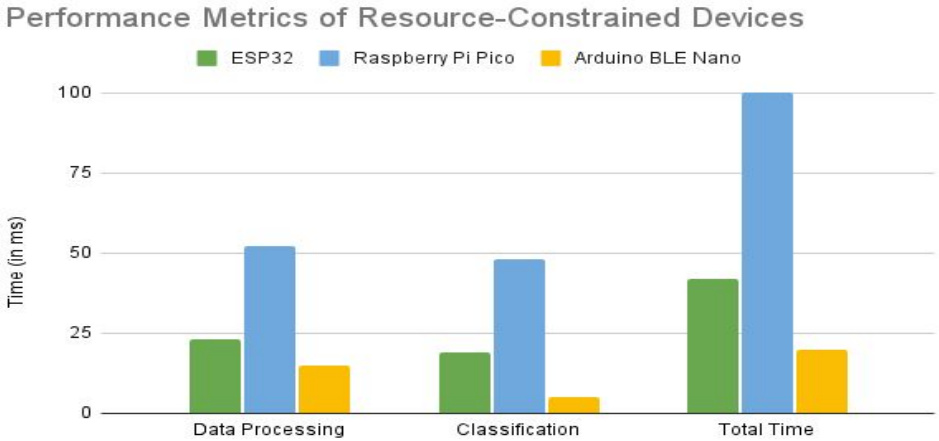
Two methods used for deployment:

- The data processing block and the neural network converted into a single Arduino library.
- The data processing block and the neural network converted into a single C++ library for each model with the help of the Edge Impulse platform. C++ libraries then deployed on the devices.

Second level of optimization provided by the EON Compiler tool of Edge Impulse which allowed 50% less RAM usage.

Results

Device	Data Preprocessing	Classification	Total Time
ESP32	23ms	19ms	42ms
Raspberry Pi Pico	52ms	48ms	100ms
Arduino BLE Nano	15ms	5ms	20ms



Conclusion

Resource-constrained devices: Arduino BLE Sense, ESP32 and Raspberry Pi Pico can be used for the detection of Sleep Apnea.

Internet connectivity not needed, within a few milliseconds, low cost.

Future:

- Can be used to detect other anomalies in ECG.
- Can be used for any time series data.
- Can be deployed on other devices.

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Thank you!