ECE12: Team Sleep – ML Sleep Apnea Detection using PPG

We design, implement, and benchmark a complete PPG-based apnea detection pipeline across six ML architectures using the DREAMT dataset.

By: Noah Cauchi, Jonathan Moses, Benjamin Saenz

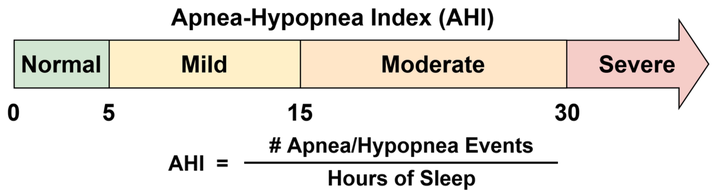
DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

A. JAMES CLARK SCHOOL OF ENGINEERING

INTRODUCTION

Sleep Apnea:

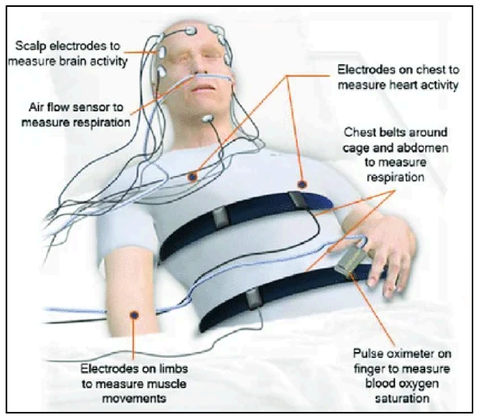
- Repeated breathing interruptions during sleep → stresses the heart and brain
- Affects 26% of adults aged 30-69[1] yet 80% remain undiagnosed
- Linked to hypertension, stroke, and Type 2 diabetes when left untreated



Diagnosis:

	PPG	PSG
Cost	Cheap	Expensive
Patient Experience	Seemless	Invasive
Collection Method	Wearable	Clinical Study

Photoplythsmography (PSG) vs Polysomnography (PSG)



PSG Sleep Study[2]

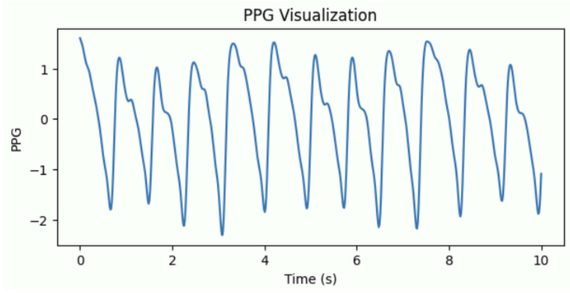
OBJECTIVES

1. Develop a machine learning model for detecting sleep apnea events from PPG.
2. Calculate a patient's AHI.
3. Compile prediction pipeline into a seemless user interface.

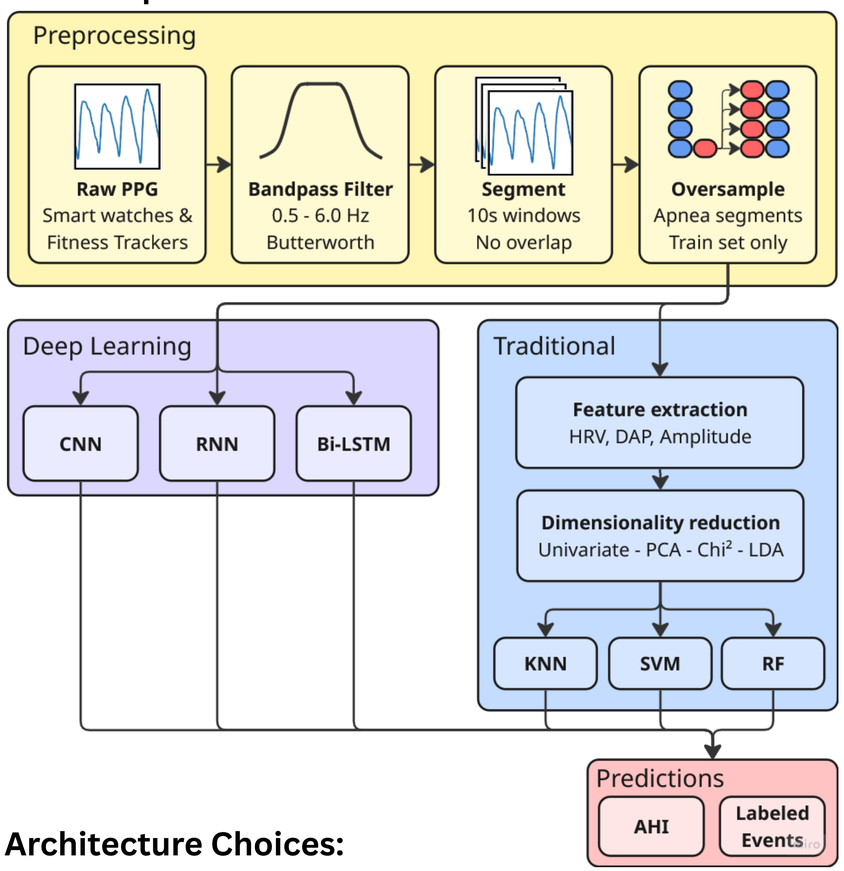
METHODS

Dataset:

- *DREAMT*[3]
- 100 overnight PPG measurements
- Labeled apnea events



Model Pipeline:



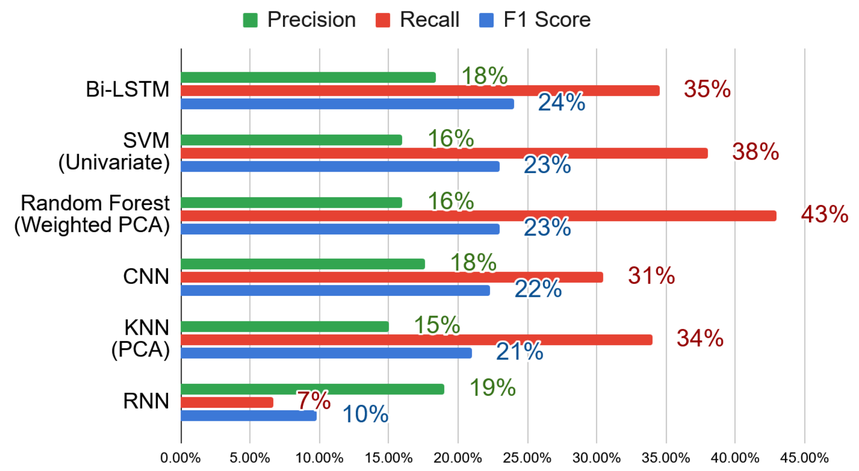
Architecture Choices:

- **Traditional**:
  - Most important features learned through simple algorithms.
  - Team Apnea from Sp25 showed success with KNN in a related problem.
- **Deep Learning:**
  - RNN and Bi-LSTM memory units enable learning historical features.
  - Learn complicated feature dependencies.

User Interface:

- Web application deployment.
- Provides insights on sleep apnea and AHI with models as backend.

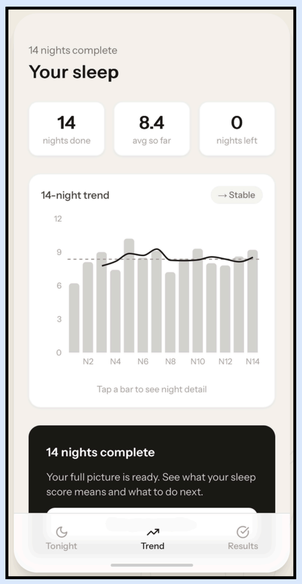
RESULTS

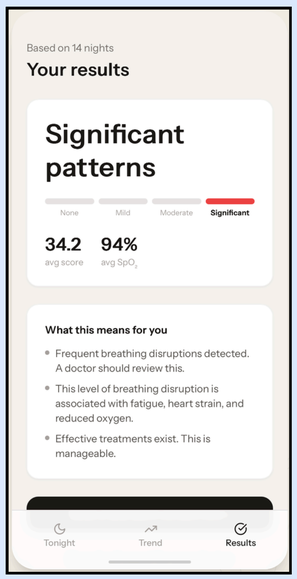


- Recall is more critical than precision since a 4:1 class imbalance makes missed apnea events more costly than false alarms.
- RF: Best recall and one of the best F1 scores.
- RNN: Weakest; strength of learning vanishes with long signals.
- PPG could be a viable option for sleep apnea detection.

FUTURE WORK

- Neighborhood prediction:
  - Adjacent 10s segments are highly correlated
- Transformer architecture: attention mechanism better suited to long-range PPG dependencies than RNN
- Reframe as anomaly detection:
  - Recast as one-class classification to handle 4:1 imbalance natively





[1] Cleveland Clinic, "Sleep Apnea," https://my.clevelandclinic.org/health/diseases/8718-sleep-apnea.

[2] Kwon and Kim, "Recent Advances in Wearable Sensors and Portable Electronics for Sleep Monitoring," *iScience*, vol. 24, 04 2021.

[3] K. Wang, J. Yang, A. Shetty, and J. Dunn, "DREAMT: Dataset for Real-time sleep stage EstimAtion using Multisensor wearable Technology," *PhysioNet*, Apr. 2025.