

ML for Apnea Prediction in Premature Infants

Apnea of Prematurity is a developmental condition affecting infants born before term. Apnea is defined as a temporary cessation of breathing for 20 seconds or longer or a shorter pause accompanied by bradycardia (heart rate <100 beats per minute), cyanosis, or pallor. The present study focuses on **detecting** and **forecasting** apnea occurrence in preterm infants with the aid of ML.

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Problem Statement

Apnea of Prematurity is a common condition observed in infants born preterm, hospitalized in Neonatal Intensive Care Units (NICUs). As a developmental disorder, it resolves when the babies grow and mature. However, some apnea events cause changes in heart rate (HR) and blood oxygen saturation (SpO2), which can damage vital organs. Studies indicate that apnea can have a detrimental effect on the neurodevelopment of affected babies. Thus, continuous and precise monitoring is essential to ensure timely intervention during apnea episodes. Detecting and forecasting apnea can reduce the workload of medical staff, and improve safety of hospitalized newborns. Furthermore, it can aid physicians in determining the appropriate time for a safe home discharge.



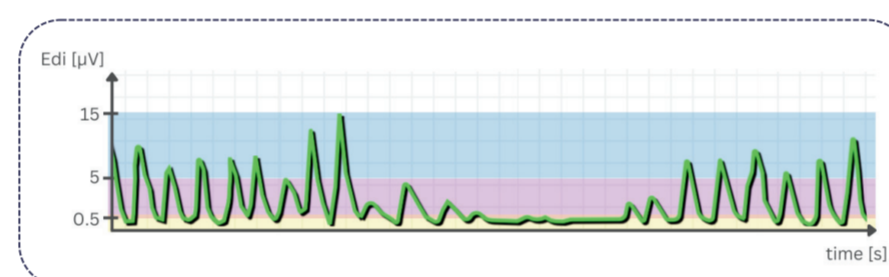
Primary objective

- Detect and forecast apnea occurrences in premature infants using electrical activity of the diaphragm (Edi) signal.

Secondary objectives

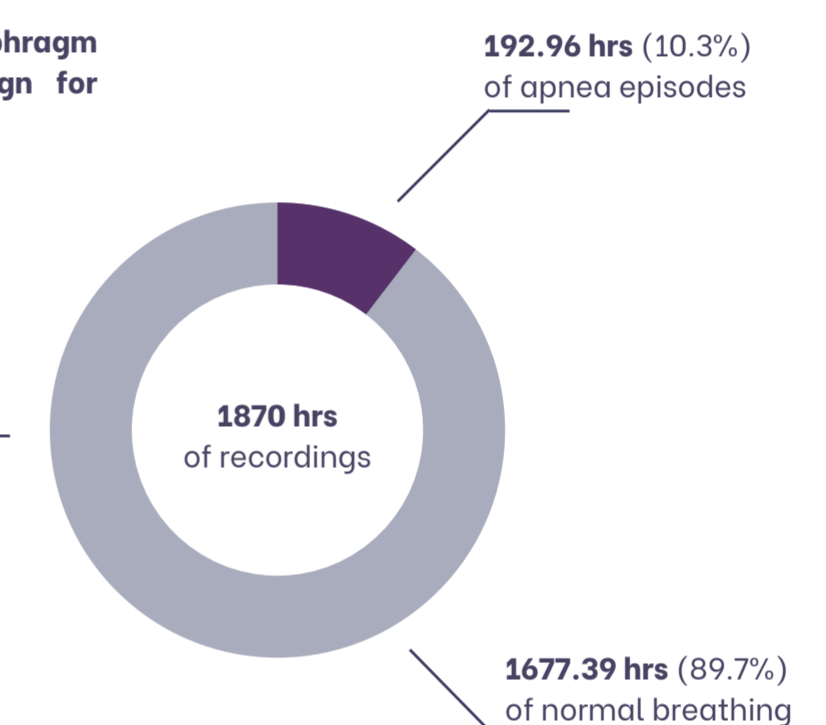
- Tag HR and blood SpO2 drop occurrences.
- Identify and isolate the occurrence of periodic breathing

Dataset

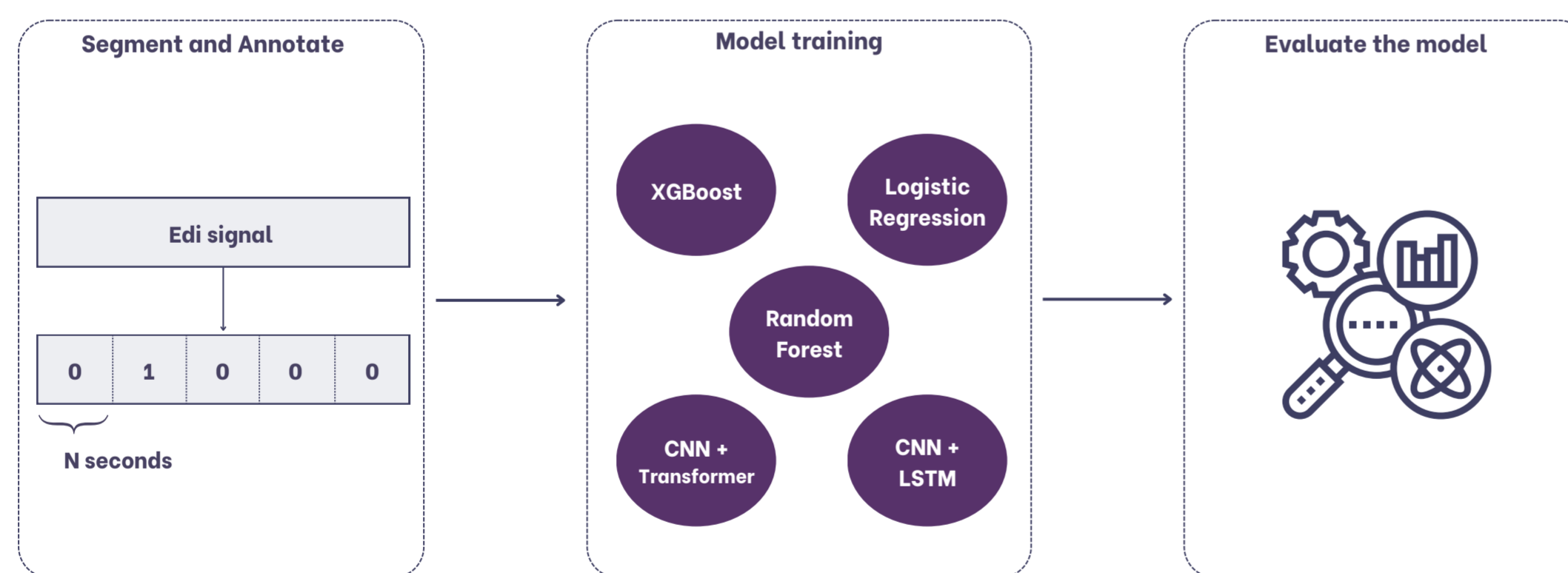


The electrical activity of the diaphragm (Edi) is a respiratory vital sign for monitoring breathing patterns.

- The dataset consists of the **Edi signal** and other physiological data (e.g. HR, SpO2)
- Recordings of **99 preterm infants**
- The apnea episodes are tagged on the Edi signal



Apnea detection pipeline



The signal was divided into chunks of N seconds and then each segment was annotated them as normal (0) or apnea (1). It was tested segments of 10, 20 and 30 seconds.

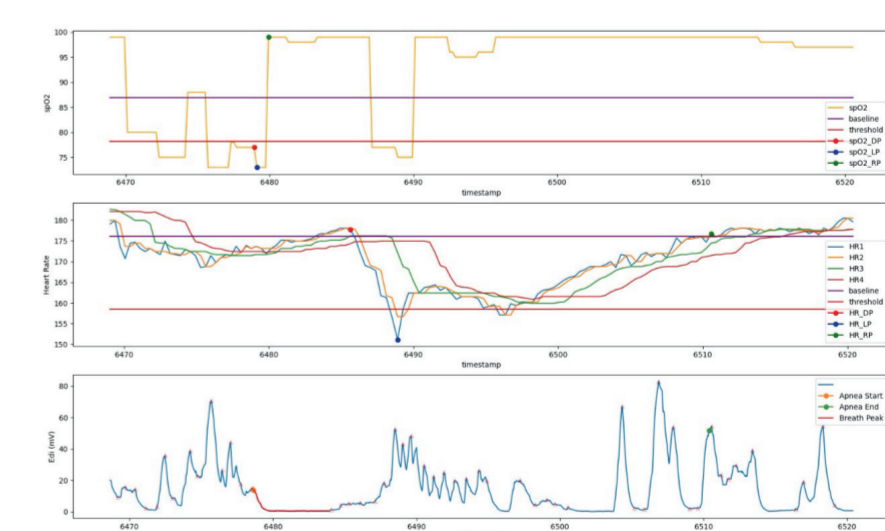
In this step, different ML models are trained in order to understand which model algorithm performs better the detection task.

Different metrics were utilized to evaluate the model: Accuracy, Precision, Recall and AUC.

HR and SpO2 tagging

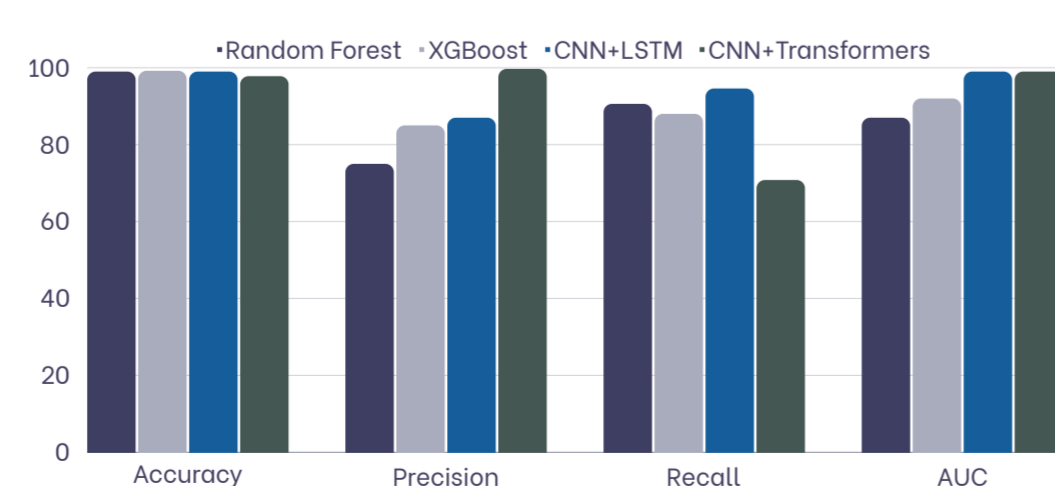
The taggings of the HR and SpO2 drops are not directly connected to the apnea detection task. However, they are instrumental in understanding the effect of apnea episodes on babies. Two approaches were attempted:

- Mean
- Moving Average



Example of HR and SpO2 tagging using the mean approach

Results



Results for apnea detection using 10 seconds segments

- The best models were CNN+LSTM and CNN+Transformers in all the segment sizes tested (10, 20, and 30s).
- The data imbalance poses a challenge in achieving good results in precision and recall.

Future works

- Experiment with some techniques to overcome the data imbalance.
- Attempt to apply the knowledge of apnea detection to apnea forecast.

References

Kesavan, K. and J. Parga (2017). "Apnea of Prematurity: Current Practices and Future Directions." *NeoReviews* 18(3): e149-158.
 Eichenwald, E. C., et al. (2016). "Apnea of Prematurity." *Pediatrics* 137(1): e20153757.

