
# Advanced Foundations for Machine Learning Course Project

## Neuro-Symbolic Optimization with Uncertainty Quantification for Atrial fibrillation

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# Advanced Foundations for Machine Learning

## Submission Checklist

| No | Feature Description | Drive Shared ( Y/N) |
|---|---|---|
| 1 | Code notebook | Y |
| 2 | Dataset or dataset source | Y |
| 3 | This PPT | Y |
| 4 | The 5 mins Video presenting your paper | Y |
| 5 | Brief Project Report in IEEE Format | Y |

**Email-id** we shared the drive with shusrith03@gmail.com

## Problem Statement

- A neuro-symbolic approach combining CRNN-Transformer feature extraction with Logic Neural Networks (LNN) can enable uncertainty quantification and transparent rule-based reasoning, bridging the gap between model performance and clinical trustworthiness helping doctors and medical researchers.

## Uniqueness

- Most healthcare ML models only focus on accuracy — not interpretability.
- Doctors need *explanations* and *confidence scores* before trusting AI.
- Neuro-symbolic AI combines **logic-based rules + neural networks**.
- Adding **uncertainty quantification** makes predictions safer.
- Novel intersection of symbolic AI, deep learning, and healthcare.

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## Dataset

### Size:

- Dataset explored in notebook: 8,000+ ECG waveform samples (PhysioNet)
- Duration per recording: 9–60 seconds
- Sampling rate: 300 Hz
- High-resolution time-series signals

### Attributes:

- Raw ECG waveform values
- R-peaks and RR-interval features (extracted in notebook)
- Metadata/labels depending on dataset (Normal / Other rhythms / Noise)
- Suitable for neural preprocessing and symbolic clinical rule mapping

### Source:

- PhysioNet: Public physiological signal repository

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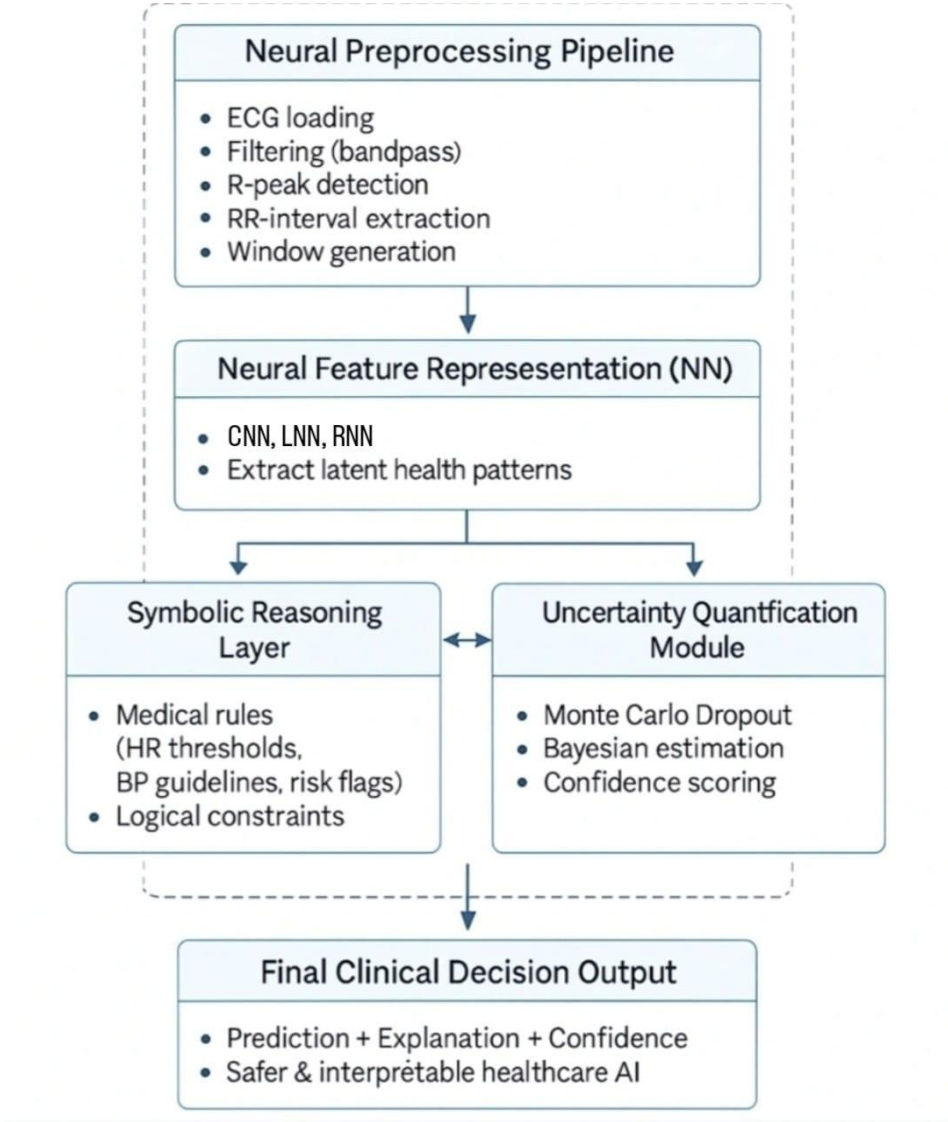
## Overall Design or Approach



## Final Results

Different type of neural networks are integrated with logical reasoning easier for doctors to know about the problem

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## Features : Done vs. Remaining to be done

| No | Description | Done or To be Done ? |
|---|---|---|
| 1 | Different types of neural are integrated | Done |
| 2 | Prediction of AF diseases | To be done |
| 3 | | |
| 4 | | |
| 5 | | |

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## Quantity and Quality of Work

| No | Code Functionality | % Complete | Runs w/o Issues ( Y /N) | State minor issues |
|---|---|---|---|---|
| 1 | ECG Loading | 100% | Y | None |
| 2 | Signal Filtering | 100% | Y | Slight waveform variation |
| 3 | R-Peak Detection | 95% | Y | Misses' peaks in noisy signals |
| 4 | RR Intervals | 100% | Y | Depends on R-peak accuracy |
| 5 | Window Generation | 90% | Y | Window tuning needed |
| 6 | Visualization | 100% | Y | None |
| 7 | Preprocessing Pipeline | 85% | Y | Slow on large data |

## Top Few Learnings from this Project

| No | Description |
|---|---|
| 1 | How neural and symbolic AI can be integrated |
| 2 | ECG signal analysis: filtering, peak detection |
| 3 | Handling noisy clinical data |
| 4 | Probabilistic modeling (Bayesian ideas, MC dropout) |
| 5 | Importance of interpretability in healthcare ML |

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## Top Unresolved Challenges

| No | Description |
|---|---|
| 1 | Combining symbolic rules with neural network outputs |
| 2 | Calibrating uncertainty reliably |
| 3 | Handling noisy or missing physiological signals |
| 4 | Ensuring clinically safe decision-making |
| 5 | Dataset constraints (access/security) |

## References, if any


| No | Paper title | Year of publication |
|---|---|---|
| 1 | Atrial Fibrillation Detection and ECG Classification based on Convolutional Recurrent Neural Network | 2017 |
| 2 | AFClassification from a Short Single Lead ECG Recording: the PhysioNet/Computing in Cardiology Challenge | 2017 |
| 3 | Automatic Detection of Atrial Fibrillation Based on CNN-LSTMandShortcut Connection | 2020 |


# THANK YOU

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