# Deep Learning for Predicting Disease Progression of Clinical Endpoints in ALS

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## Motivation

- Amyotrophic Lateral Sclerosis (ALS) is a neurodegenerative disease.
- No cure and a short life expectancy following the start of symptoms.
- Most patients die of respiratory failure within 3-5 years.

## Problem

- ALS affects most muscles of the body.
- Several clinical conditions derive from it.
- Non-Invasive Ventilation showed the most promise in terms of extending life expectancy and improving quality of life.

## Objective

Our **main objective** is to increase life expectancy and improve quality of life. For that we propose the use of Deep Learning to:

- Predict ALS disease progression within a predefined time window (90, 180 and 365 Days).

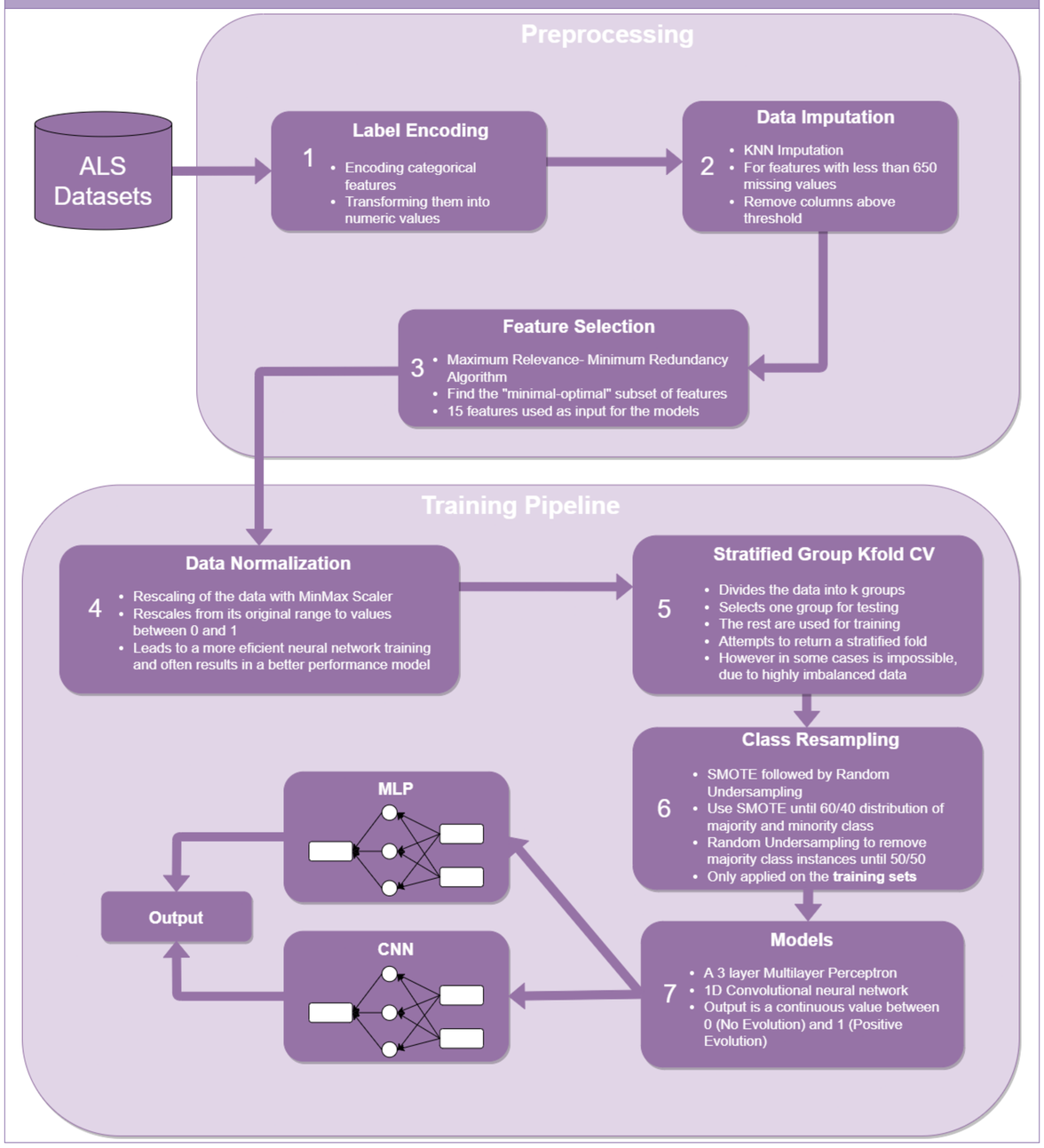
## Background

- Prognostic models based on predefined time windows to predict the disease progression and the need of NIV treatment in ALS.
- Categorization of patients depending on their stage of disease progression, stratifying them in 3 groups, slow, neutral and fast.
- Use of neural networks (mainly LSTM) to predict the disease progression of the patients in the various time windows.
- Shapley Additive Explanations (SHAP) explaining the deep model was helpful to determine the influence of certain features for the overall prediction.

## Data

- Tabular Data from the ALS clinic of Centro Hospitalar Universitário de Lisboa Norte, Hospital Santa Maria [1].
- Static information
  - Demographic information about the patient.
- Temporal information – Multivariate Time Series
  - Results of a series of clinical assessments of specific tests:
    - Respiratory tests;
    - Neurophysiological data;
    - Questionnaire answers to the ALS Functional Rating Scale.
- For each of the following clinical endpoints, there is predefined time windows (90, 180 and 365 days).


## Methods




## Class Distribution

| Dataset | Evolution | # Patients for the Time Windows in k Days | | |
|---|---|---|---|---|
| | | k=90 | k=180 | k=365 |
| C1 – Need for NIV | Yes | 217 | 740 | 1394 |
| | No | 4178 | 3655 | 3001 |
| C2 – Need for na Auxiliary Communication Device | Yes | 159 | 454 | 859 |
| | No | 5237 | 4942 | 4537 |
| C3 – Need for PEG | Yes | 68 | 267 | 605 |
| | No | 5983 | 5784 | 5446 |
| C4 – Need for a Caregiver | Yes | 341 | 837 | 1437 |
| | No | 2750 | 2254 | 1654 |
| C5 – Need for a Wheelchair | Yes | 202 | 589 | 1242 |
| | No | 4928 | 4541 | 3888 |

## Results

| Dataset | Model | AUC ROC Mean | | |
|---|---|---|---|---|
| | | k=90 | k=180 | k=365 |
| C1 – Need for NIV | MLP | 0.761 | 0.746 | **0.792** |
| | CNN | 0.768 | 0.766 | 0.762 |
| C2 – Need for na Auxiliary Communication Device | MLP | X | **0.924** | **0.924** |
| | CNN | X | 0.921 | 0.906 |
| C3 – Need for PEG | MLP | X | X | X |
| | CNN | X | X | X |
| C4 – Need for a Caregiver | MLP | 0.834 | 0.797 | 0.824 |
| | CNN | **0.850** | 0.782 | 0.800 |
| C5 – Need for a Wheelchair | MLP | X | **0.840** | 0.833 |
| | CNN | X | 0.827 | 0.823 |

**References:**

[1] André V. Carreiro, Pedro M.T. Amaral, Susana Pinto, Pedro Tomás, Mamede de Carvalho, and Sara C. Madeira. 2015. Prognostic models based on patient snapshots and time windows: Predicting disease progression to assisted ventilation in Amyotrophic Lateral Sclerosis. Journal of Biomedical Informatics 58 (2015), 133–144.

**Acknowledgments:** This work was supported by the Fundação para a Ciência e a Tecnologia (FCT) under LASIGE Strategic Project UIDB/00408/2020 and UIDP/00408/2020, through the AIpALS – Advanced learnIng models using Patient profiles and disease progression patterns for prognostic prediction in ALS (PTDC/CCI-CIF/4613/2020)