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ALSNET: A DILATED 1-D CNN FOR IDENTIFYING ALS FROM RAW EMG SIGNAL

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Introduction

- **Amyotrophic Lateral Sclerosis (ALS) -**
  - One of the most common neuromuscular diseases
  - Affects both lower and upper **motor neurons**
  - Development of symptoms over a long period of time
  - Early diagnosis needed for prevention of the disease and improvement of quality of life for ALS patients
- **Electromyography (EMG) -**
  - Bio-signals consisting of several **motor unit action potentials (MUAPs)**
  - Various time and frequency domain features explored to identify ALS from EMG signals

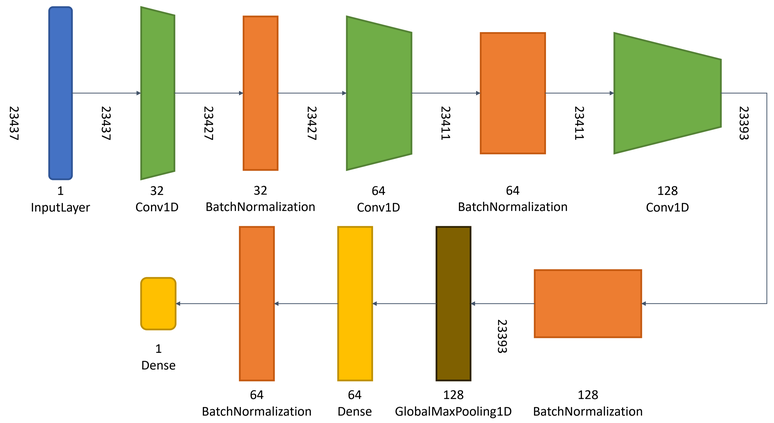
Existing Research

❑ Traditional approaches involving manual feature extraction

Feature Extraction Method		Classifier
Hand-crafted feature extraction	Mel-frequency cepstral coefficient (MFCC)	K-nearest neighbors (KNN)
	Discrete cosine transform (DCT)	KNN
	Spectral feature extraction from dominant MUAP of EMG	KNN
	Intrinsic mode functions (IMFs) using empirical mode decomposition (EMD)	Least square support ve ctor machine (LS-SVM)
Time-frequency (T-F) representation of EMG signal	Short time Fourier transform (STFT)	Convolutional neural network (CNN)
	Spectrogram	CNN
	Continuous wavelet transform (CWT)	CNN
	Smoothed pseudo Wigner-Ville distribution (SPWVD)	CNN

- A classifier taking **raw EMG signal as input** not considered in previous research works
- **Motivation behind proposed method -**
  - Reduction in computational cost by eliminating manual feature extraction step
  - Faster and more suitable practical implementation

Proposed System

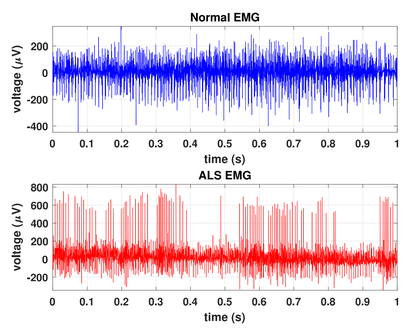


Network Architecture of ALSNet

- **Increase in dilation rate** of each of the three convolution layers widens the gap between two kernels and helps to integrate more information from a wider context –
  - Previously applied successfully in biomedical image segmentation, speech synthesis and sound source localization frow raw audio data
- **Binary classification** performed by final dense layer with Sigmoid activation – 1 for ALS EMG and 0 for normal EMG

Dataset

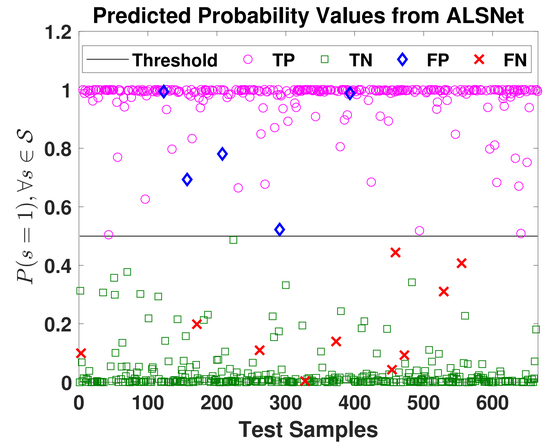
- **N2001 EMGLAB open access dataset** consisting of three groups – Normal, Myopathy and ALS
- **Normal** and **ALS** groups used in the experiment
- 302 EMG signals (sampled at 24kHz frequency with duration of about 11s each



- Each EMG signal segmented into 11 segments with time duration of 1s
- Total 3322 data samples split into train, validation and test sets by a ratio of 80:20:25

Experimental Results

- **Output of ALSNet** - probability value indicating the probability of a segment belonging to the ALS EMG class
- Threshold for binary classification set to 0.5



❑ Performance comparison of ALSNet with existing methods

Method	Overall Accuracy (%)	Sensitivity (%)	Specificity (%)	Balanced Accuracy (%)
MFCC + KNN	92.50	76.00	98.00	87.00
DCT + KNN	95.00	86.00	98.00	92.00
IMF + LS-SVM	95.00	93.00	92.54	92.75
MUAP + KNN	96.5	88.00	99.33	93.67
Deepemgnet	96.69	94.24	97.59	95.92
T-F + CNN	96.80	94.80	98.80	96.80
ALSNet	**97.74**	**96.77**	**98.59**	**97.68**

Conclusion

- **A 1D dilated CNN** based approach proposed in this research work
- No hand-crafted feature extraction needed to identify ALS from raw EMG signal
- Better performance than existing approach and reduced computational complexity