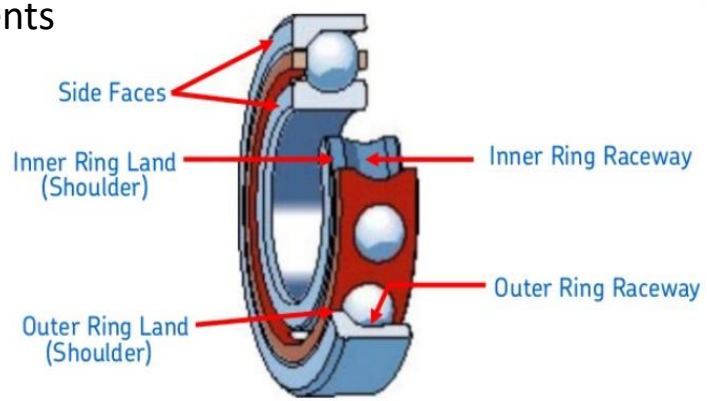
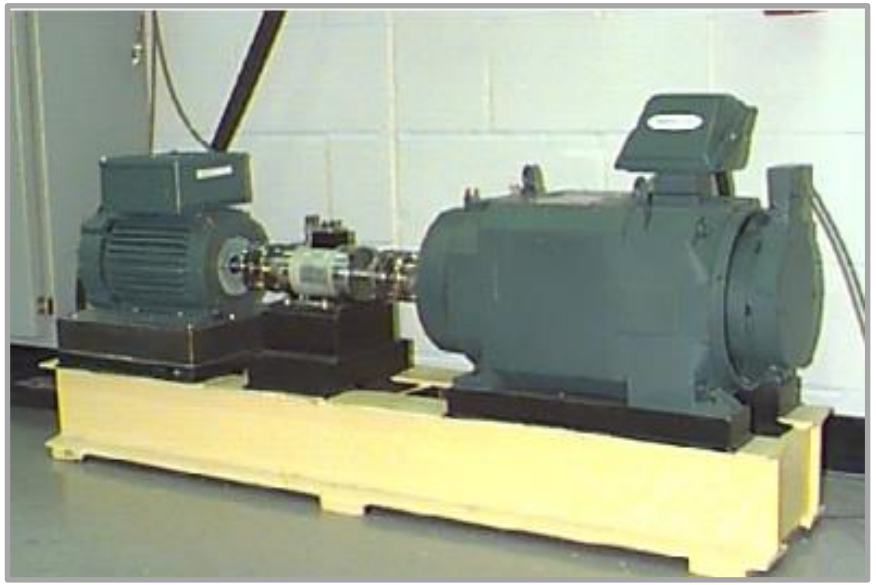
Summary of Project

- Accelerometer Sensor Data (Case Western Reserve University)
  - 12,000 samples per second
  - Inner raceway bearing sensor – drive end
  - Data segmented into fixed sizes of 256 samples
  - 14,234 segments total
  - 6,633 Baseline (normal) segments
  - 7,601 Faulty segments





- Classification Problem
  - 4 Baseline (normal) classes
  - 16 Faulty classes
  - 20 Total classes

- Contemporary Approach : 1D CNN

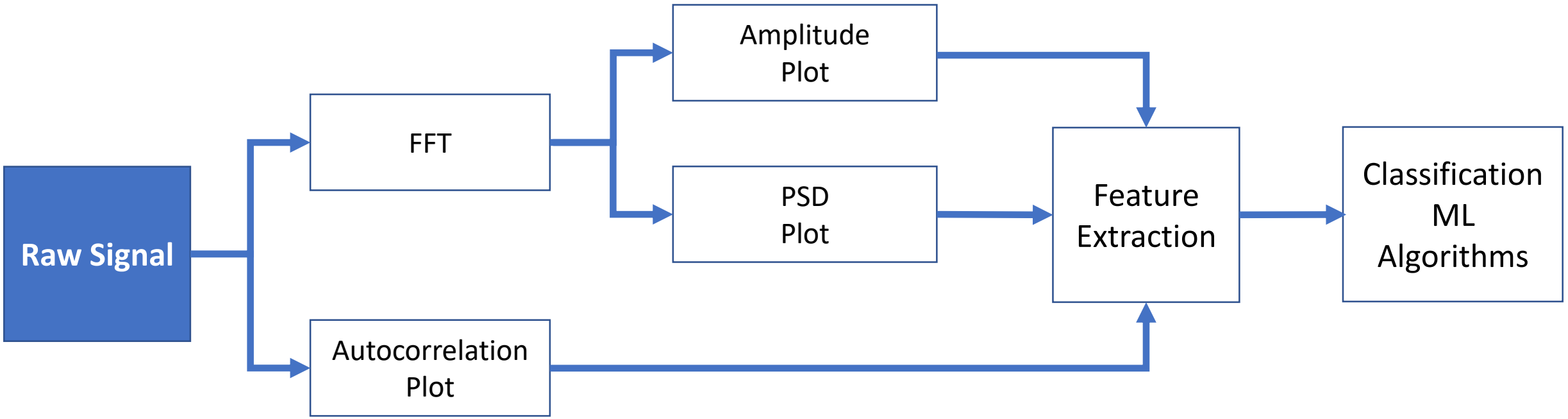
- Classic Approach : Engineered Features
  - Fast Fourier Transform
  - Discrete Wavelet Transform
  - Fast Fourier Transform + Discrete Wavelet Transform
  - SVM, XGBoost, Gradient Boosting, Random Forests

Summary of Project – Data Class Descriptions

Label	Segments	Data Type	Data Description	File Name
0	952	Baseline Data	0 HP workload normal	97.mat
1	1890	Baseline Data	1 HP workload normal	98.mat
2	1894	Baseline Data	2 HP workload normal	99.mat
3	1897	Baseline Data	3 HP workload normal	100.mat
4	473	Faulty Data	0 HP workload .007 inches EDM	105.mat
5	475	Faulty Data	0 HP workload .014 inches EDM	169.mat
6	477	Faulty Data	0 HP workload .021 inches EDM	209.mat
7	471	Faulty Data	0 HP workload .028 inches EDM	3001.mat
8	476	Faulty Data	1 HP workload .007 inches EDM	106.mat
9	475	Faulty Data	1 HP workload .014 inches EDM	170.mat
10	474	Faulty Data	1 HP workload .021 inches EDM	210.mat
11	474	Faulty Data	1 HP workload .028 inches EDM	3002.mat
12	477	Faulty Data	2 HP workload .007 inches EDM	107.mat
13	475	Faulty Data	2 HP workload .014 inches EDM	171.mat
14	475	Faulty Data	2 HP workload .021 inches EDM	211.mat
15	474	Faulty Data	2 HP workload .028 inches EDM	3003.mat
16	480	Faulty Data	3 HP workload .007 inches EDM	108.mat
17	475	Faulty Data	3 HP workload .014 inches EDM	172.mat
18	476	Faulty Data	3 HP workload .021 inches EDM	212.mat
19	474	Faulty Data	3 HP workload .028 inches EDM	3004.mat

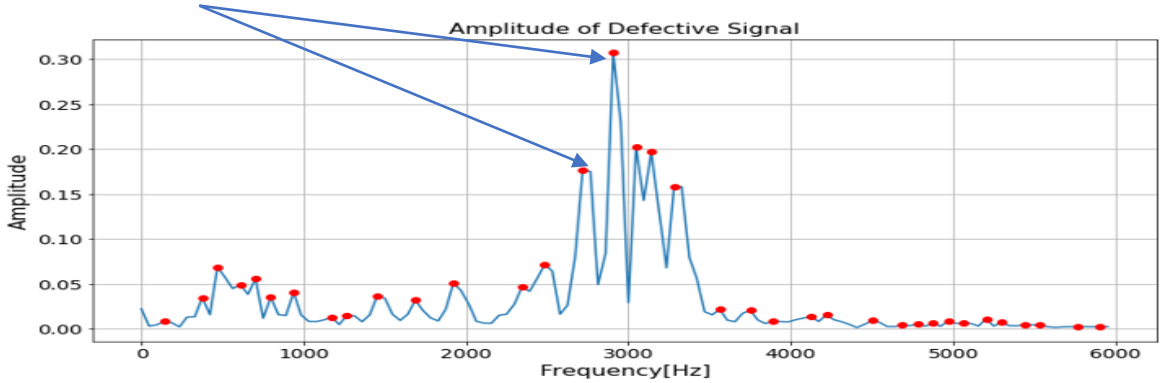
EDM - electro-discharge machining was used to create faulty bearings

Engineered Features using FFT

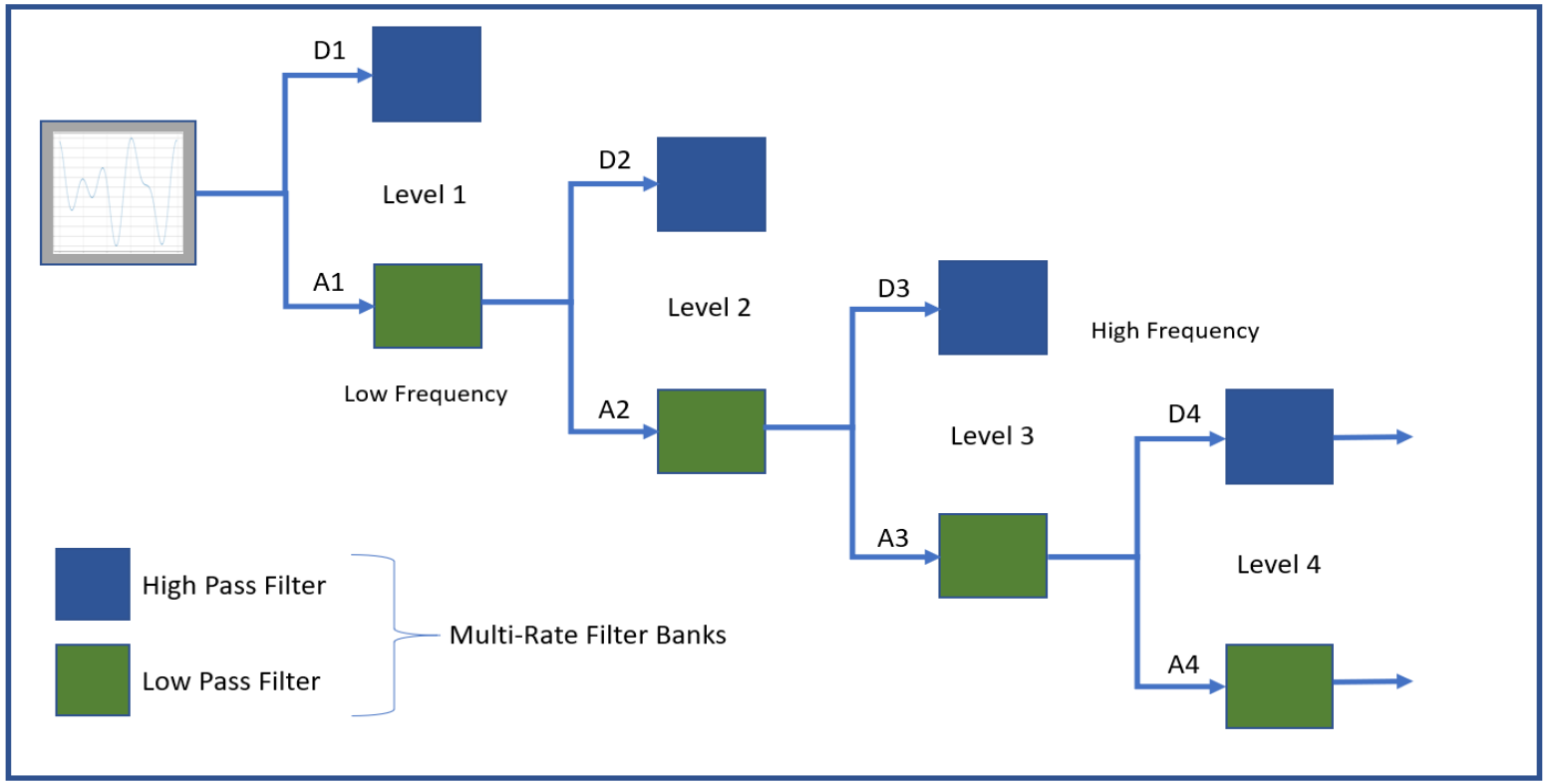


PSD – Power Spectral Density

Feature Extraction selects top n peaks of each plot

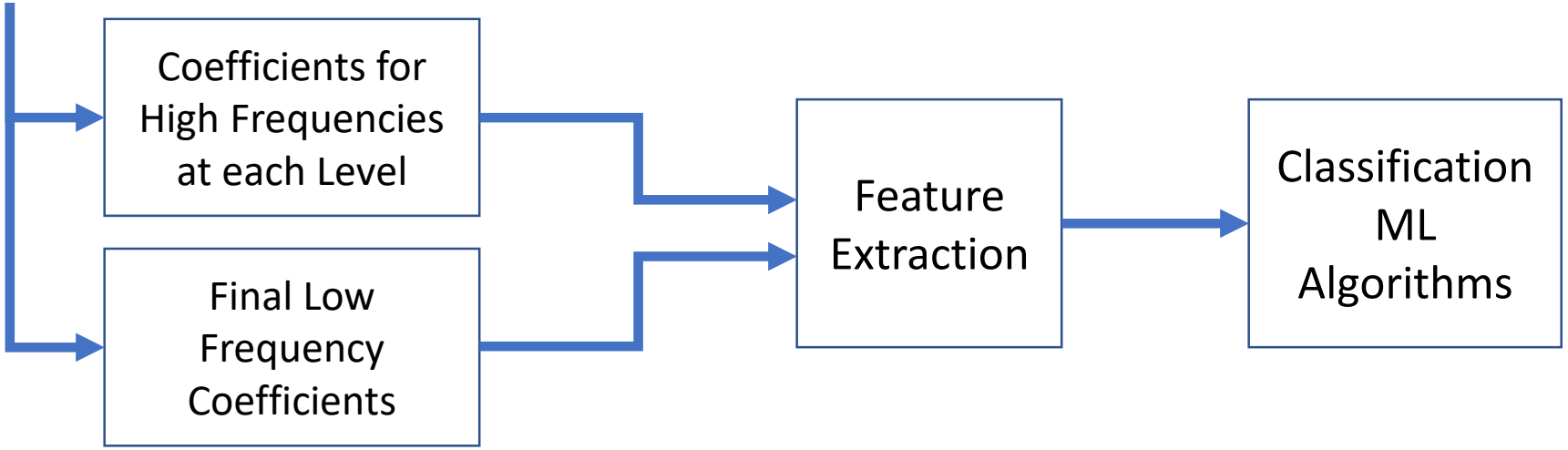


Engineered Features using DWT

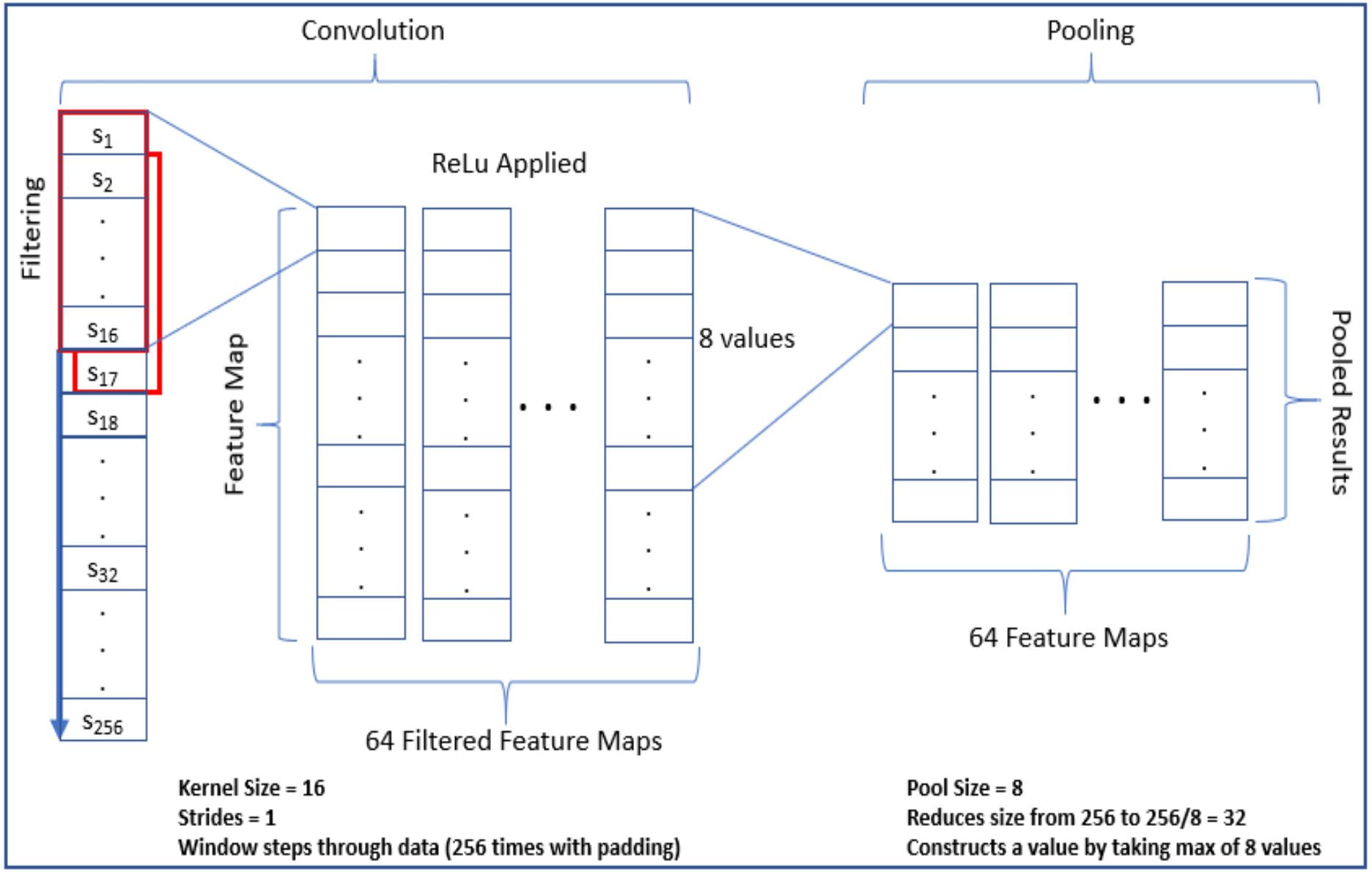


Feature Extraction

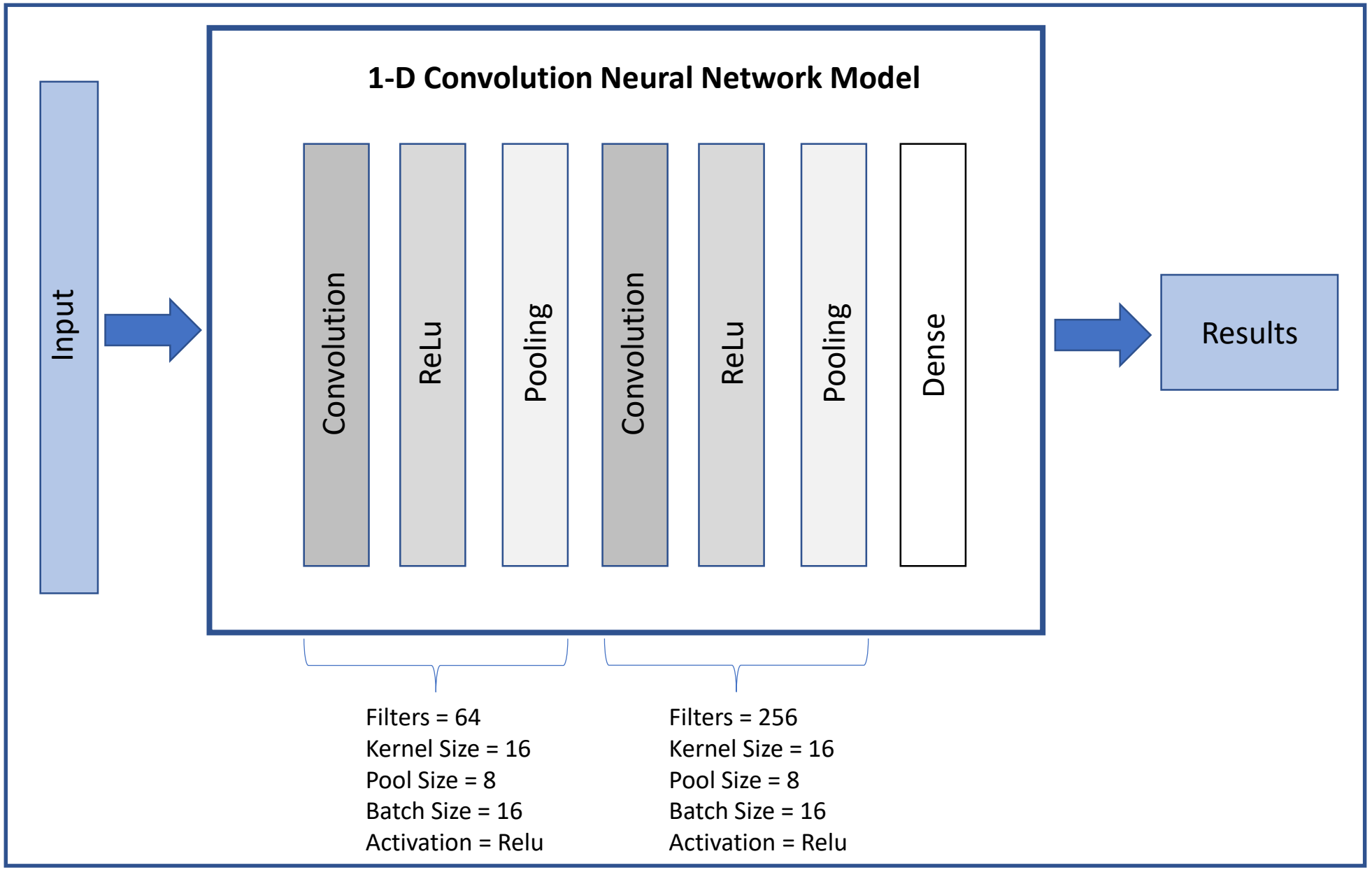
- Entropy
- Statistics
- Crossings



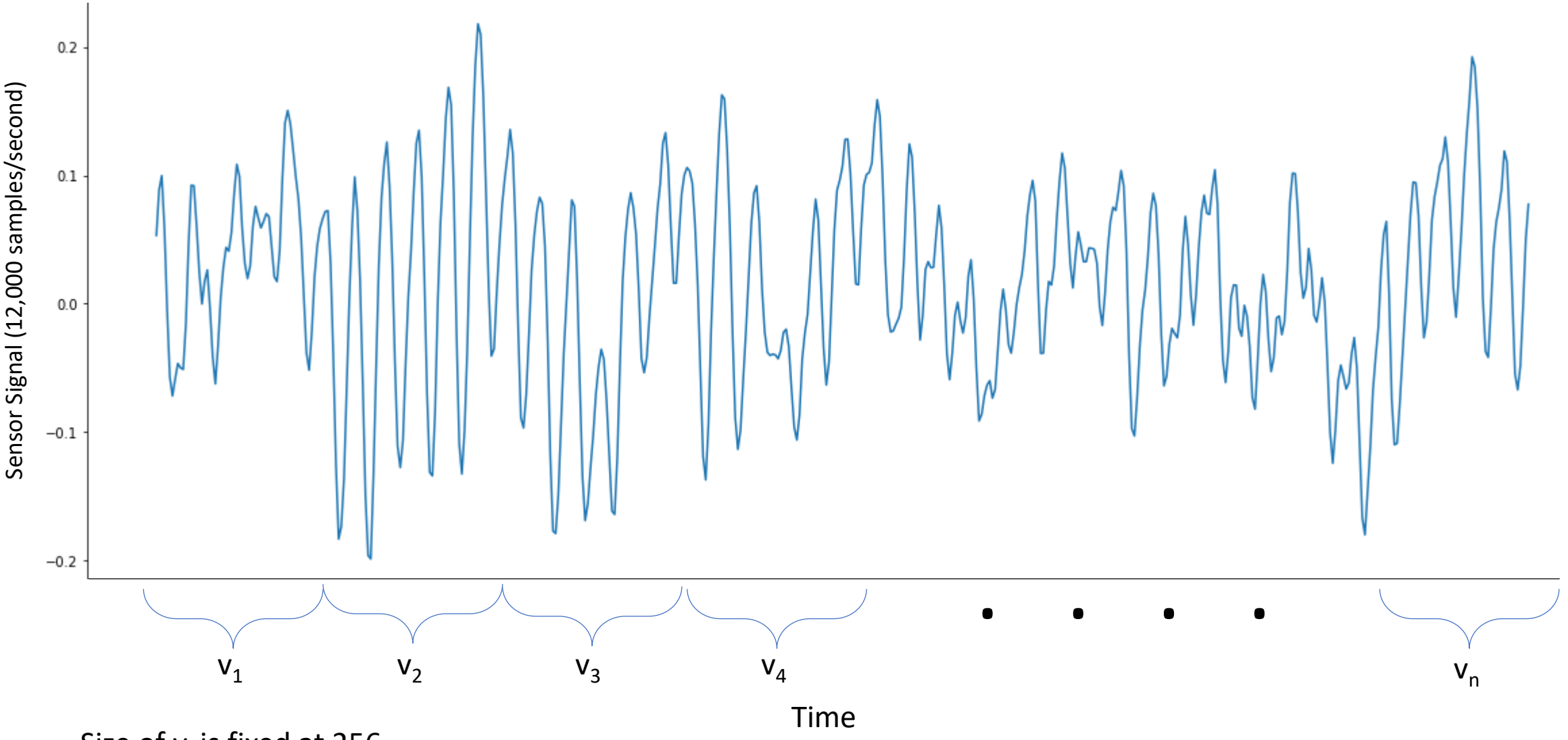
CNN 1D Architecture



CNN 1D Architecture – Sensor Data



Data Preparation: Training Set

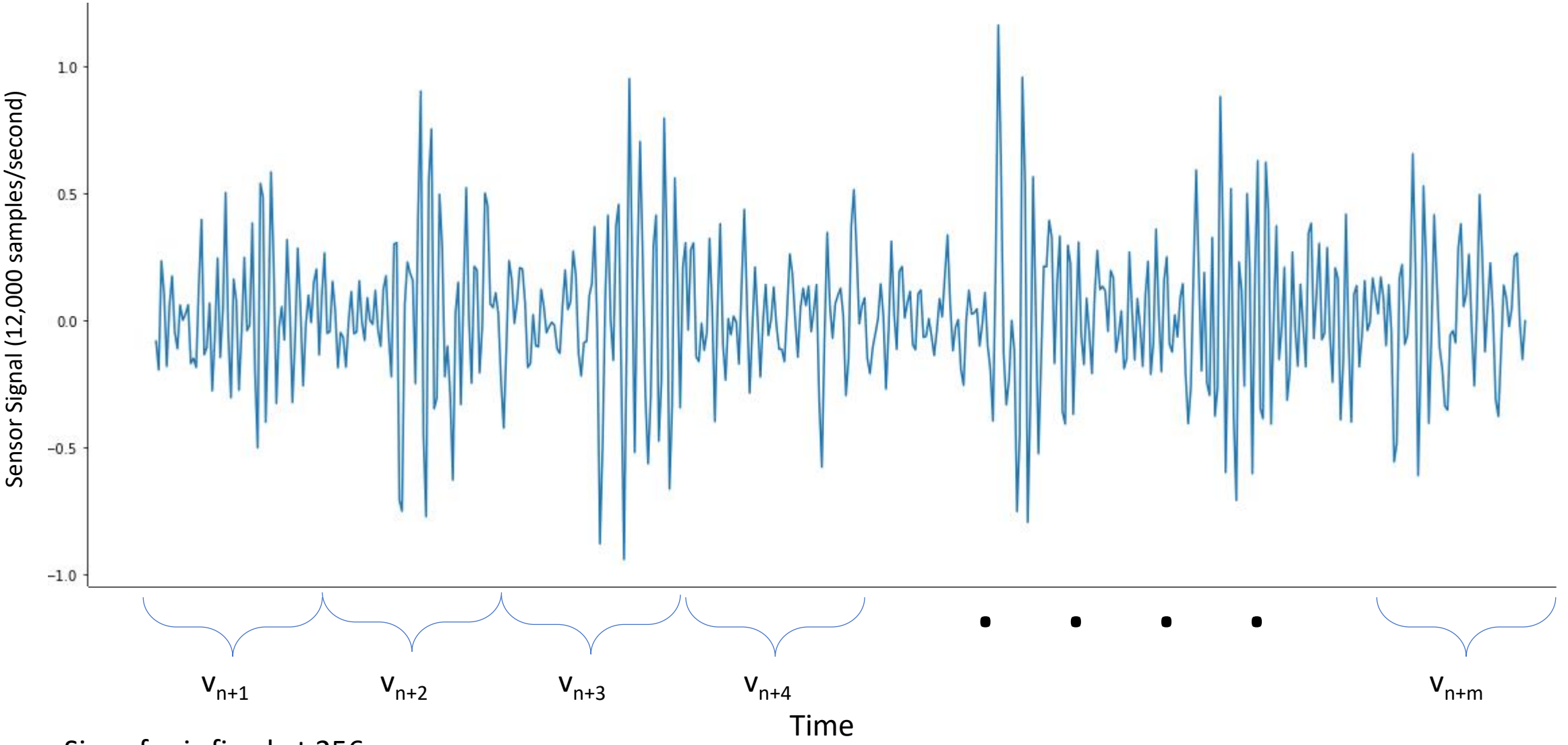


Size of v_i is fixed at 256.

Where n is the number of fixed sample vectors of size 256

y_i is the label for signal vector v_i. y_i in (0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19)

Data Preparation: Test Set

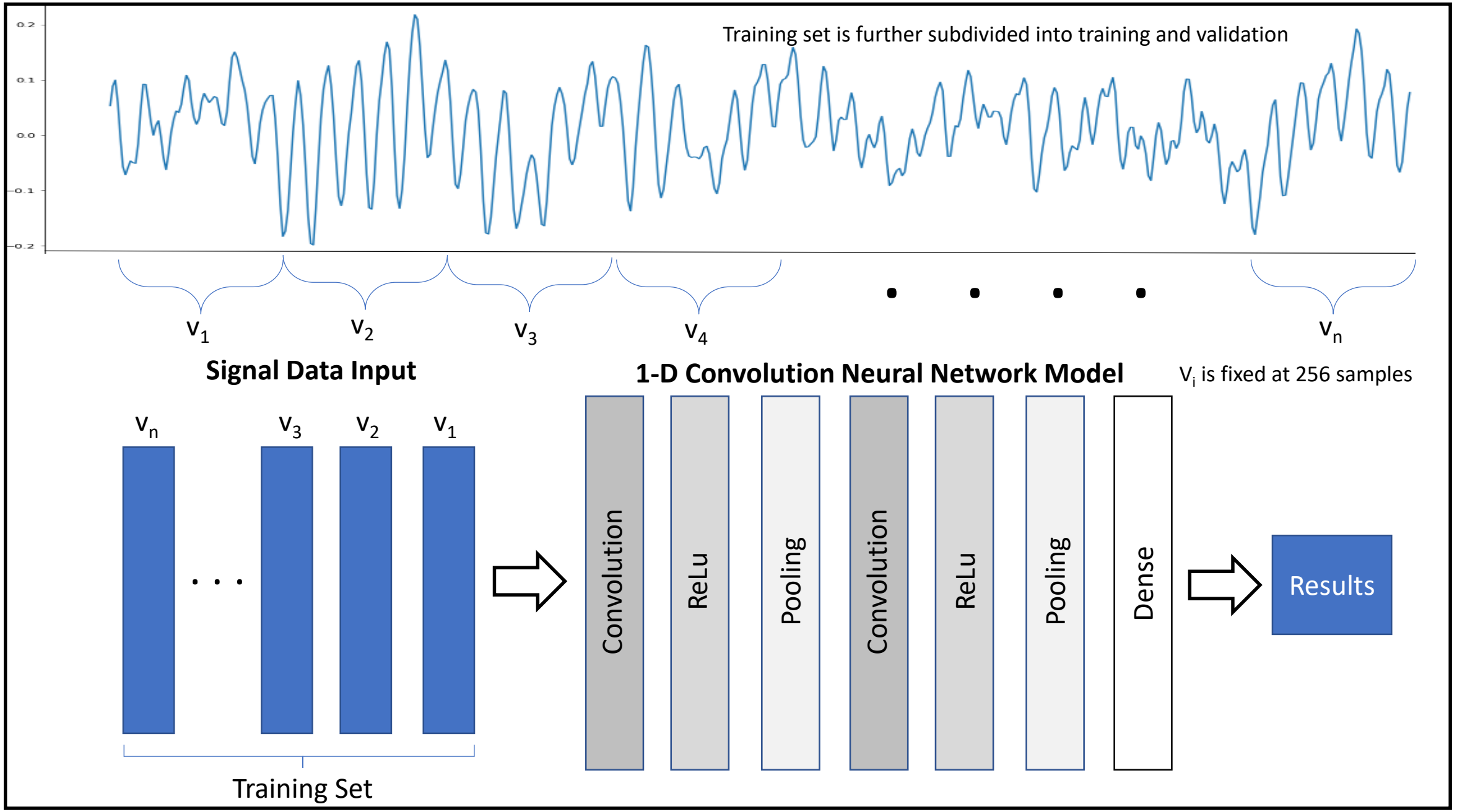


Size of v_i is fixed at 256.

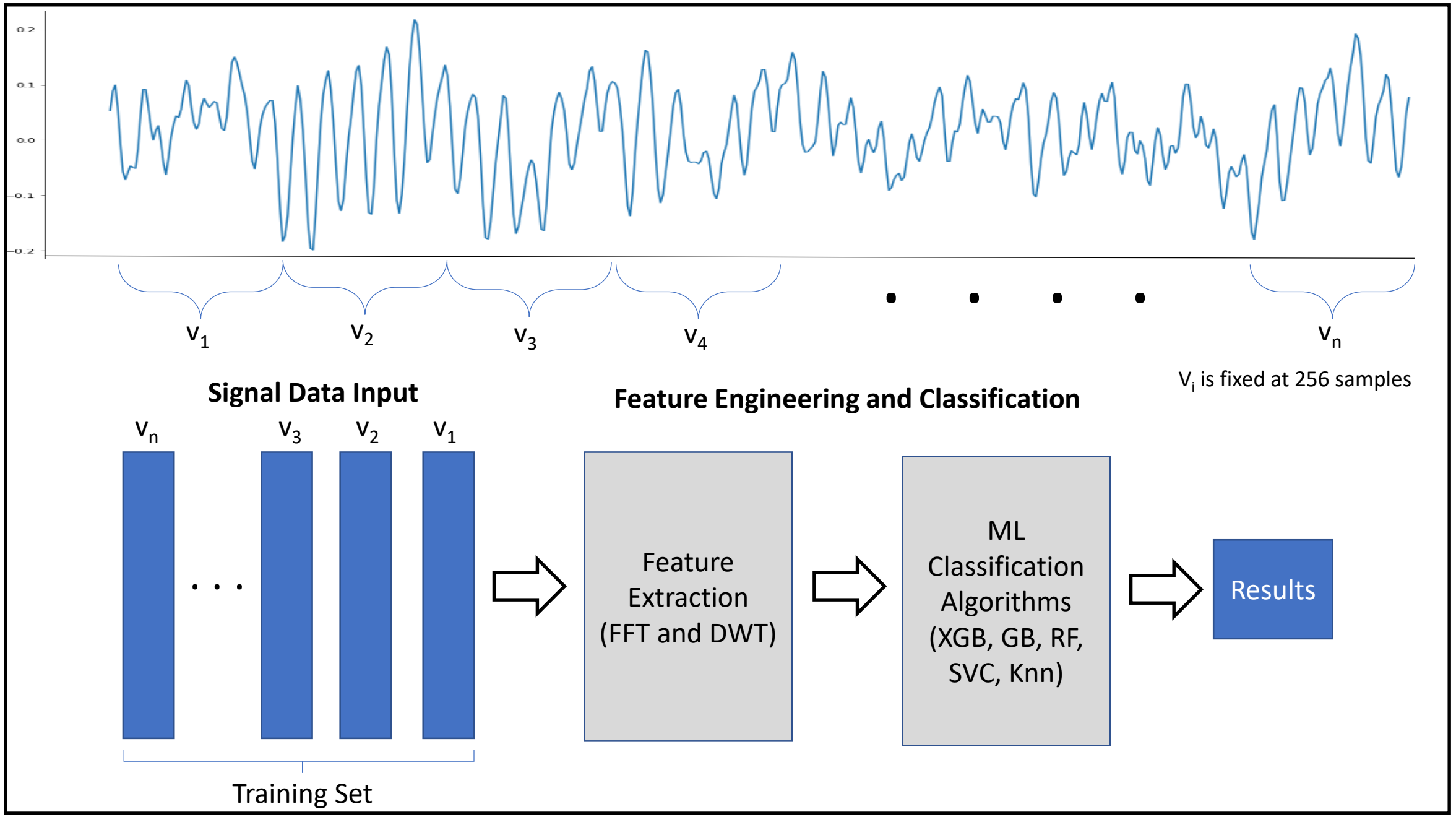
Where m is the number of fixed sample vectors of size 256

y_i is the label for signal vector v_i. y_i in (0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19)

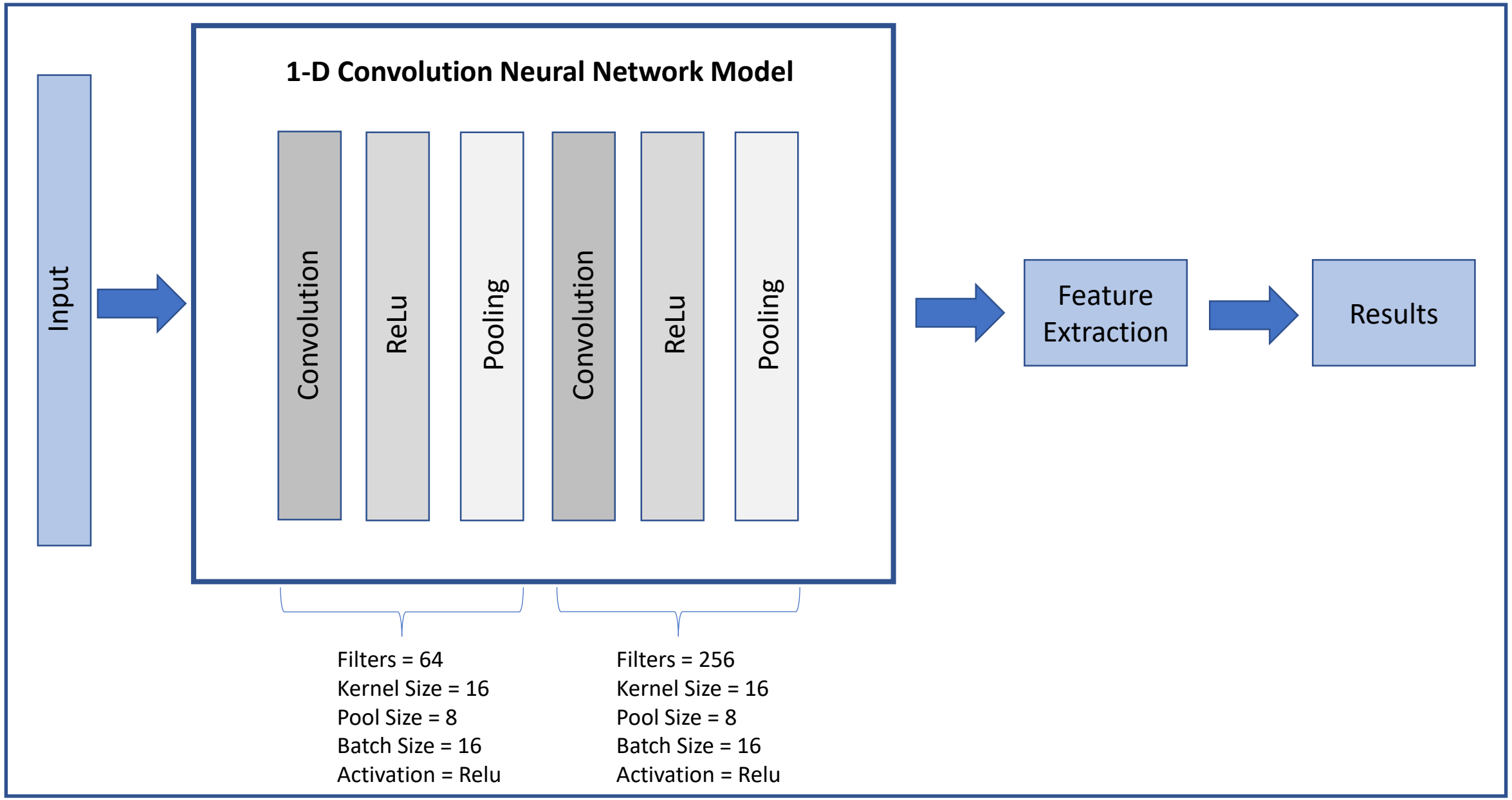
Contemporary Approach - Training



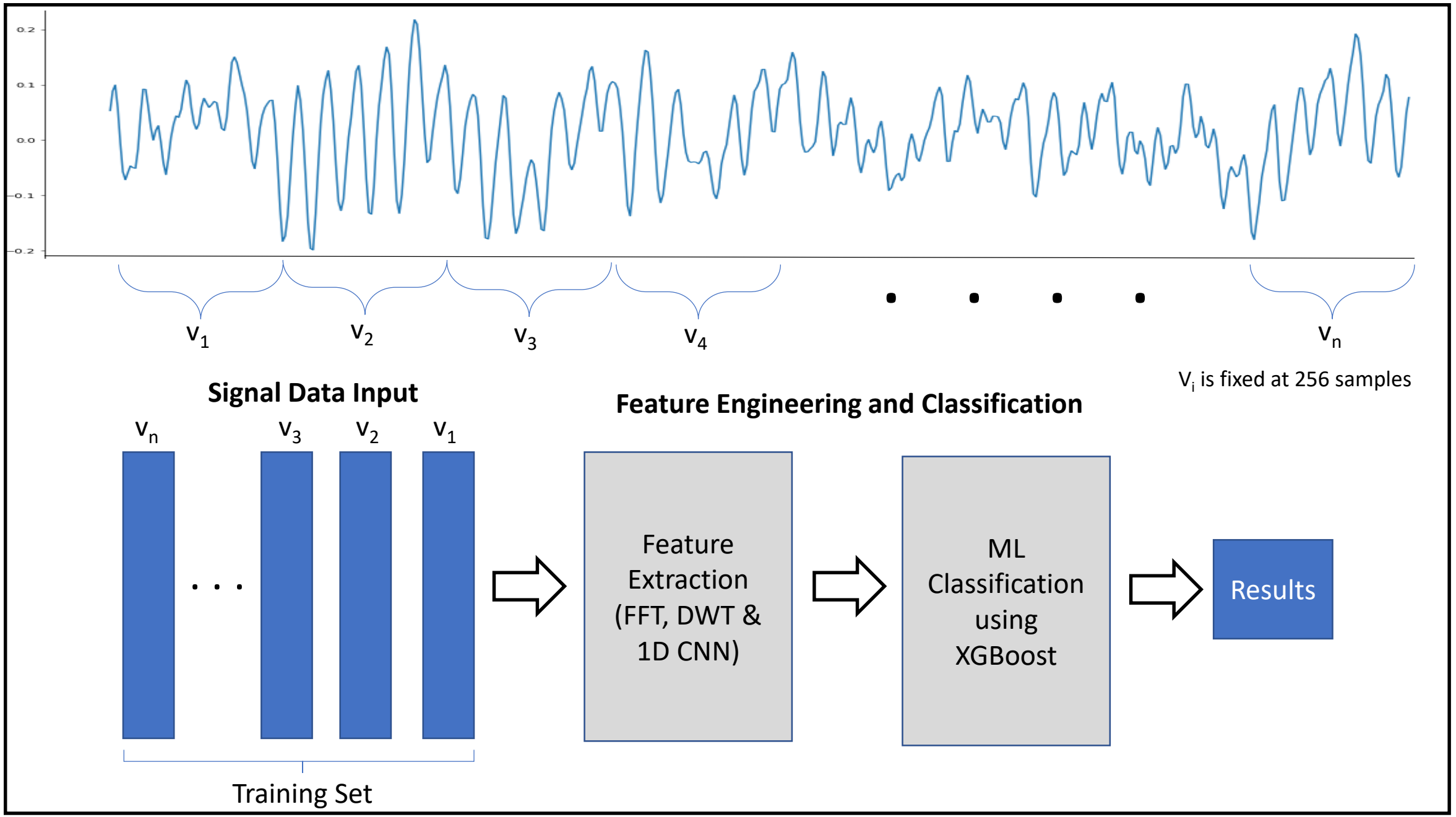
Classic Approach- Training



CNN 1D Feature Extraction



Classic and Contemporary Approach Together



Prediction and Results using Testing Data

Approach	Engineered Features Source	Algorithm	Training Accuracy	Testing Accuracy
Contemporary	N/A	1D CNN	0.97	0.94
Classic	FFT	XGBoost	1.00	0.87
Classic	FFT	Gradient Boosting	1.00	0.81
Classic	FFT	Random Forests	1.00	0.81
Classic	FFT	Knn	0.63	0.54
Classic	FFT	SVCLinear	0.70	0.54
Classic	DWT	XGBoost	1.00	0.81
Classic	DWT	Gradient Boosting	1.00	0.79
Classic	DWT	Random Forests	1.00	0.80
Classic	DWT	Knn	0.63	0.53
Classic	DWT	SVCLinear	0.72	0.43
Classic	FFT & DWT	XGBoost	1.00	0.90
Classic	FFT & DWT	Gradient Boosting	1.00	0.87
Classic	FFT & DWT	Random Forests	1.00	0.86
Classic	FFT & DWT	Knn	0.65	0.56
Classic	FFT & DWT	SVCLinear	0.83	0.53