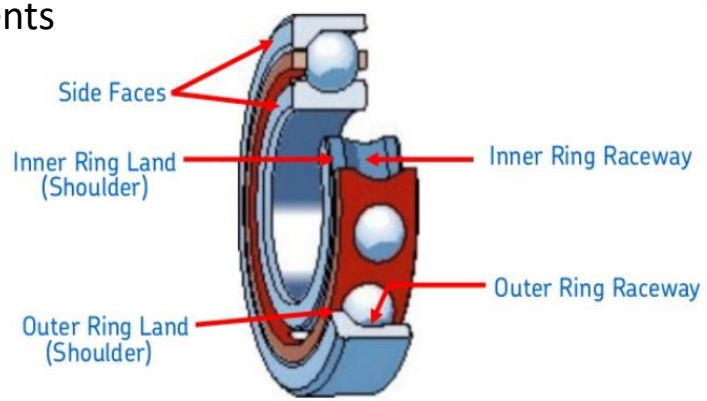
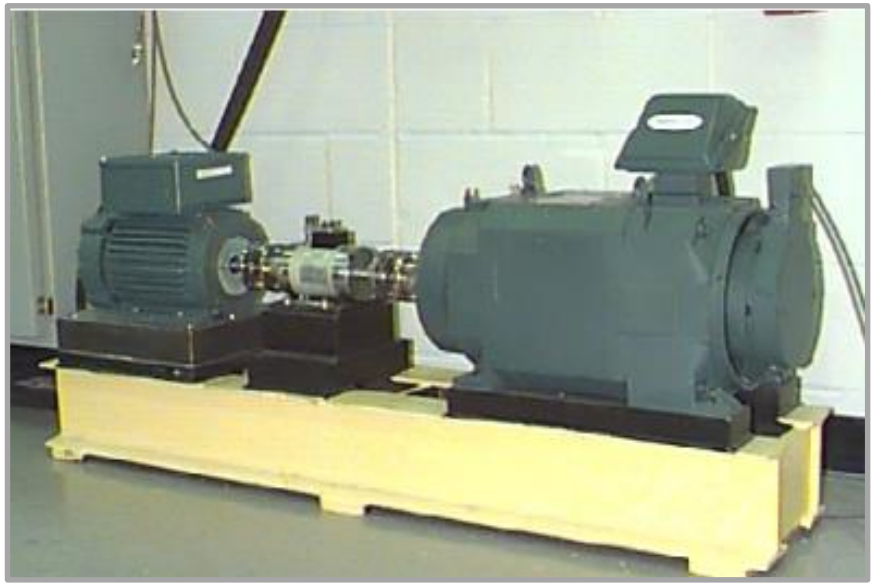
Summary of Project

- 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

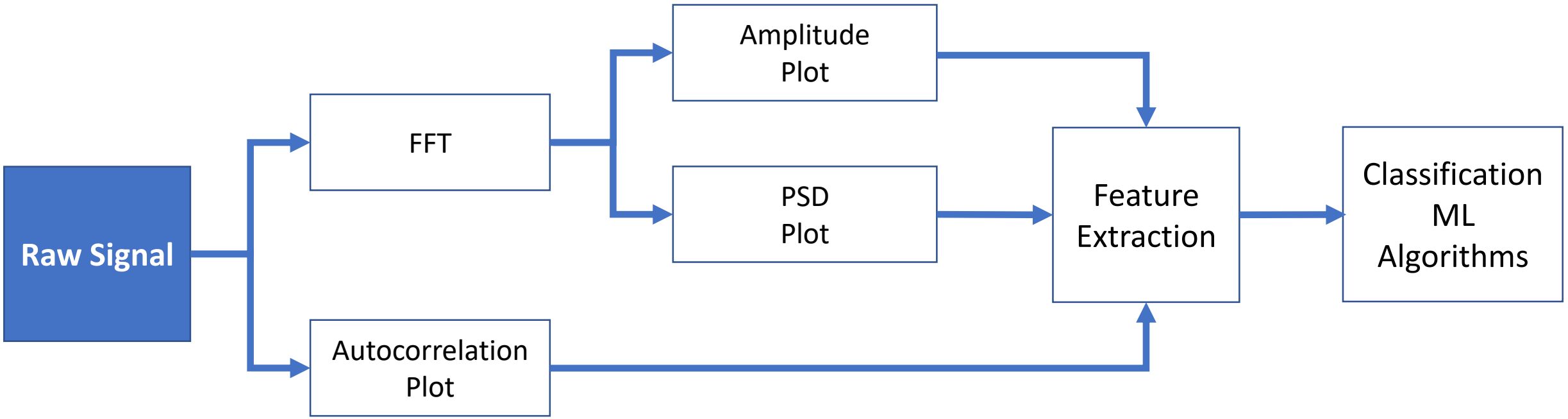
- Classic Approach : Engineered Features
  - Fast Fourier Transform
  - Discrete Wavelet Transform
  - Fast Fourier Transform + Discrete Wavelet Transform
  - SVM, XGBoost, Gradient Boosting, Random Forests

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

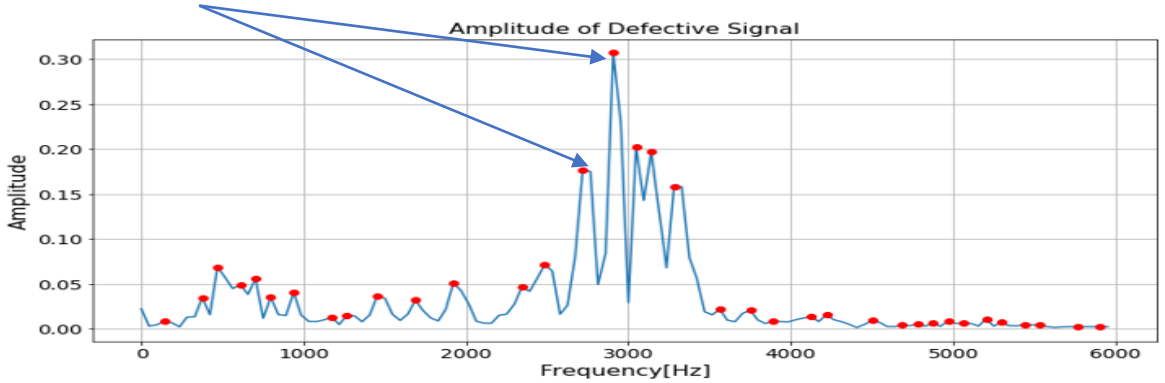
EDM - electro-discharge machining was used to create faulty bearings

Engineered Features using FFT

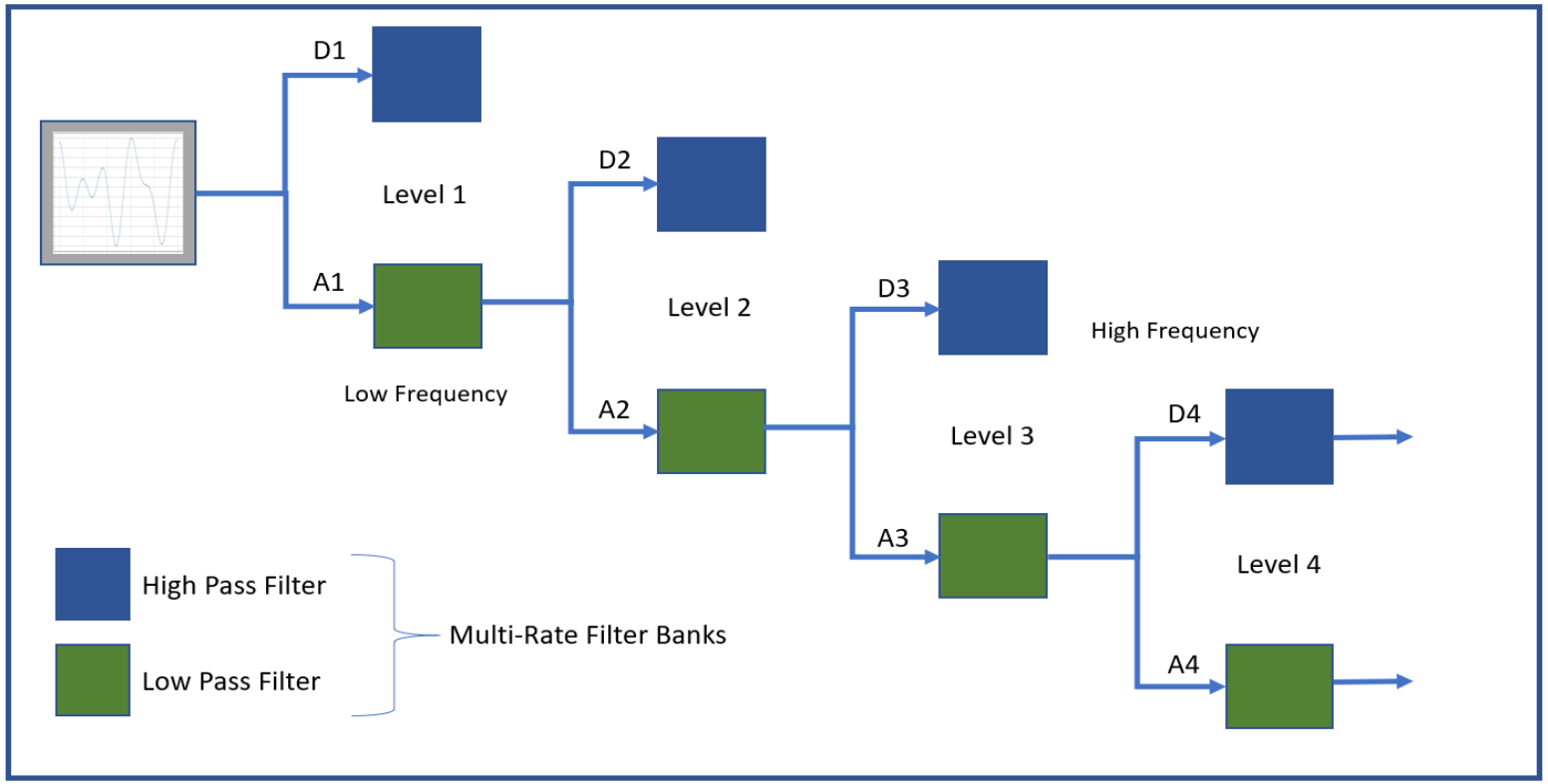


PSD – Power Spectral Density

Feature Extraction selects top n peaks of each plot

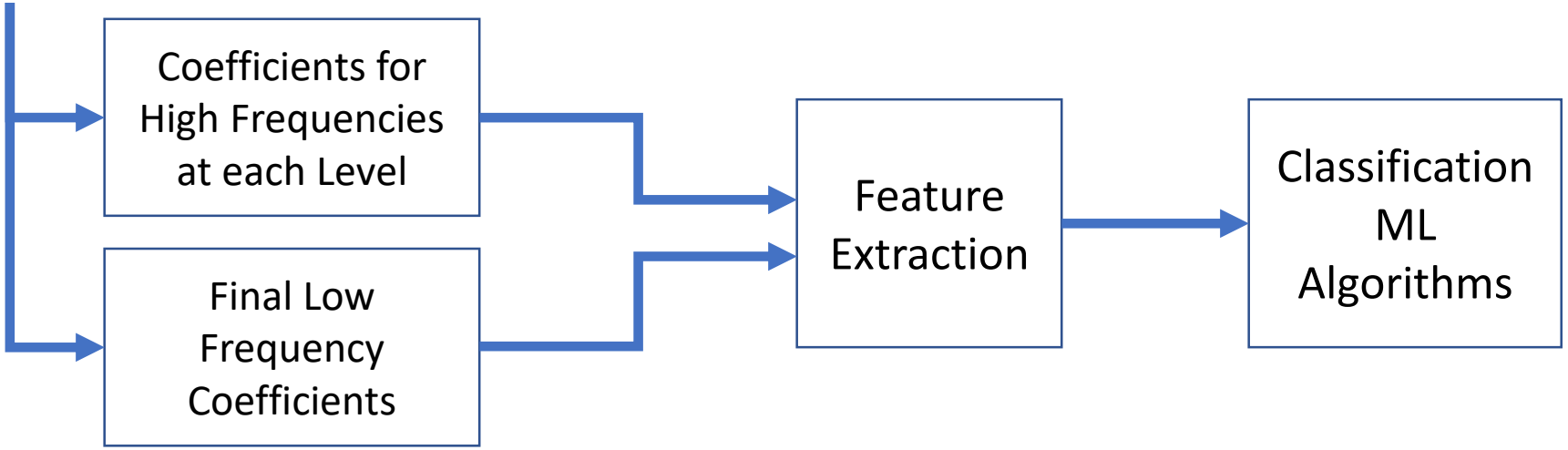


Engineered Features using DWT

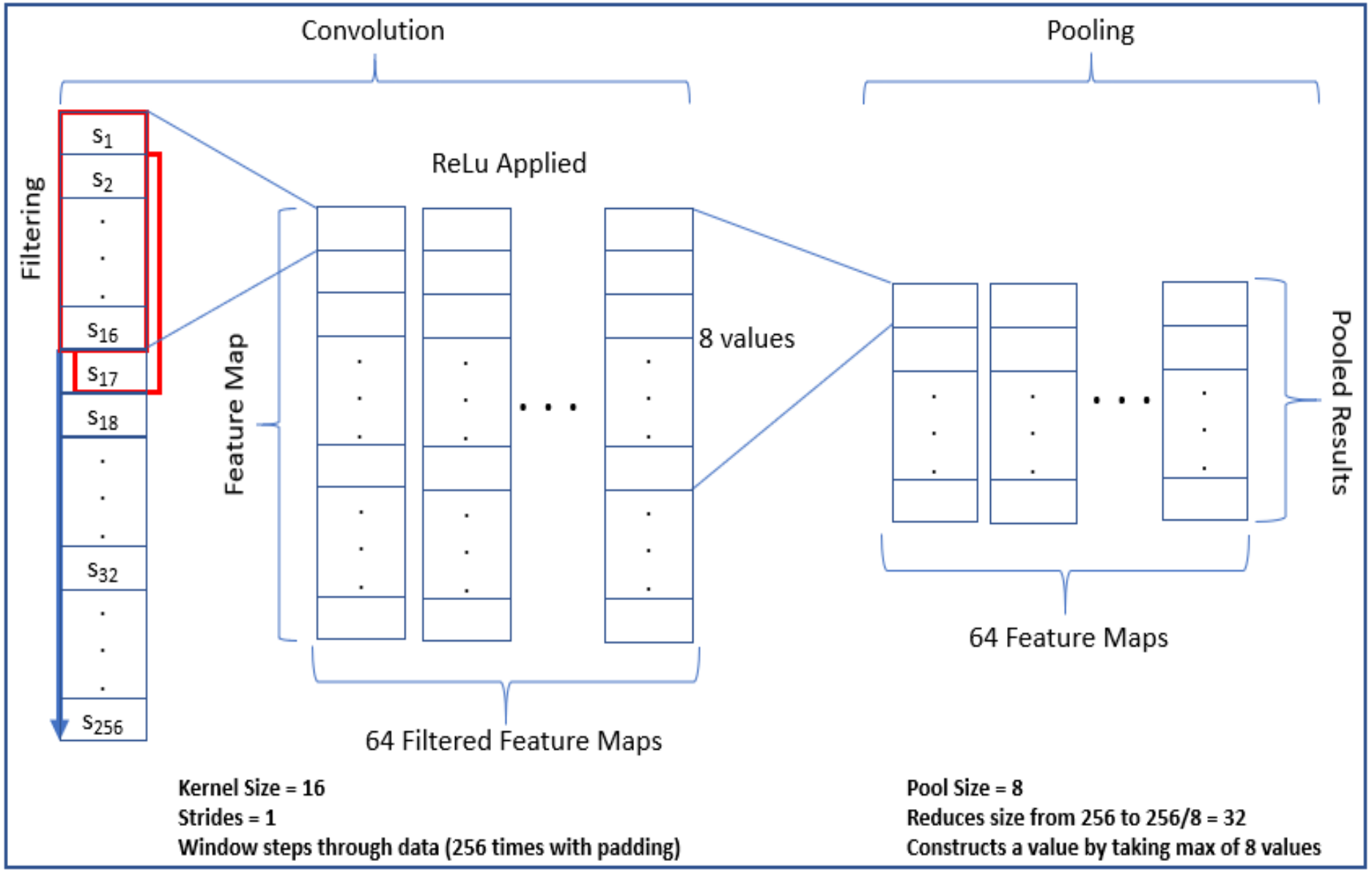


Feature Extraction

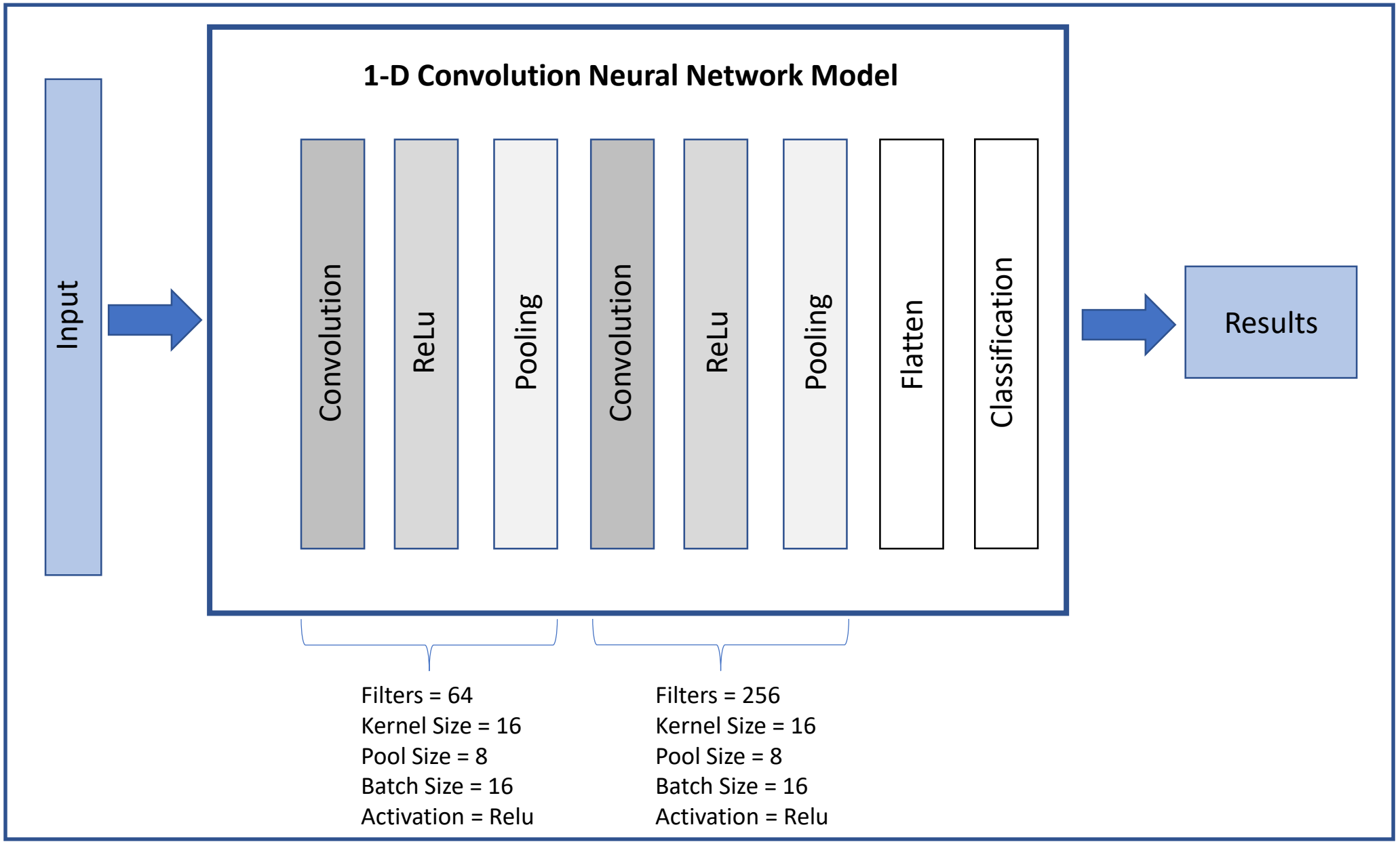
- Entropy
- Statistics
- Crossings



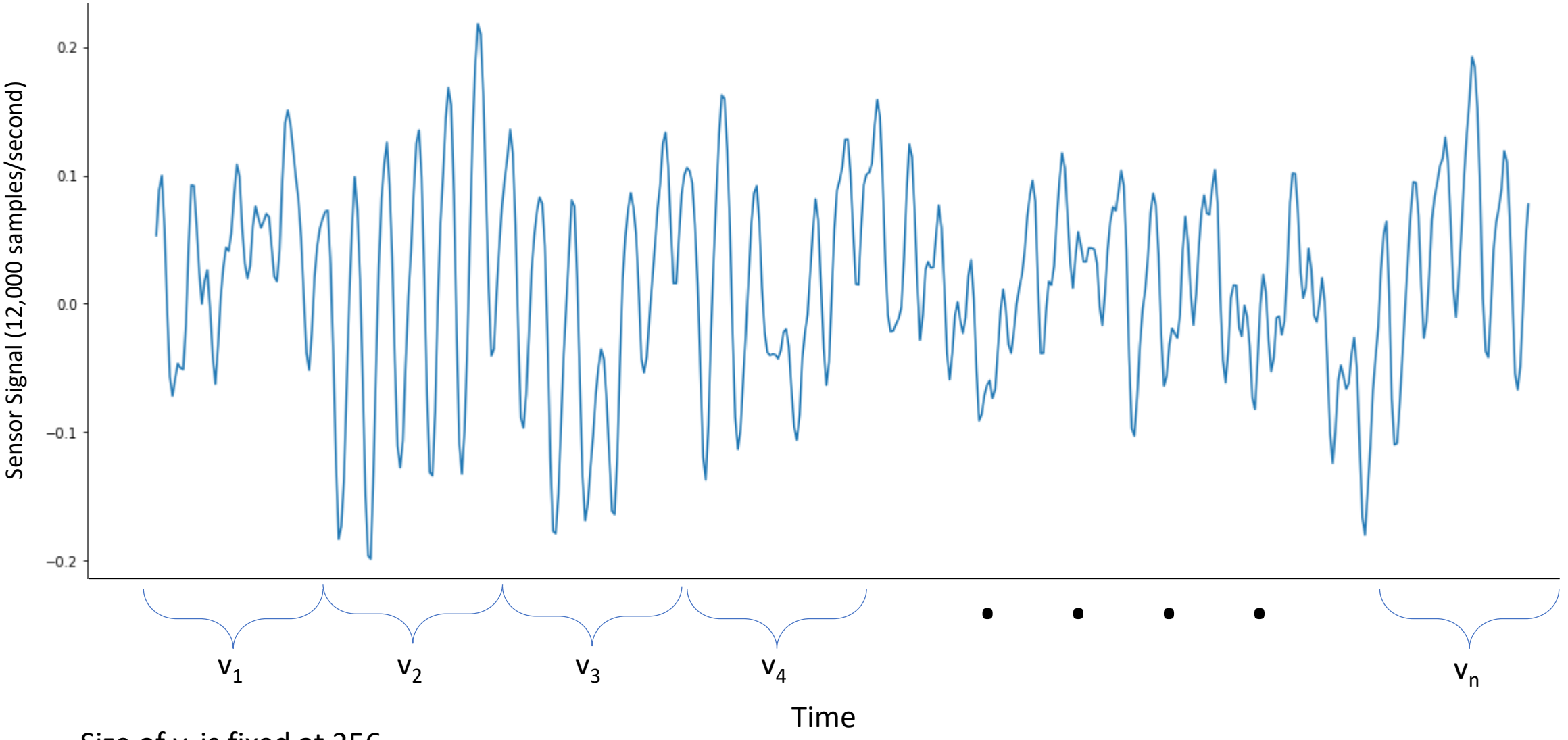
CNN 1D Architecture



CNN 1D Architecture – Sensor Data



Data Preparation: Training Set

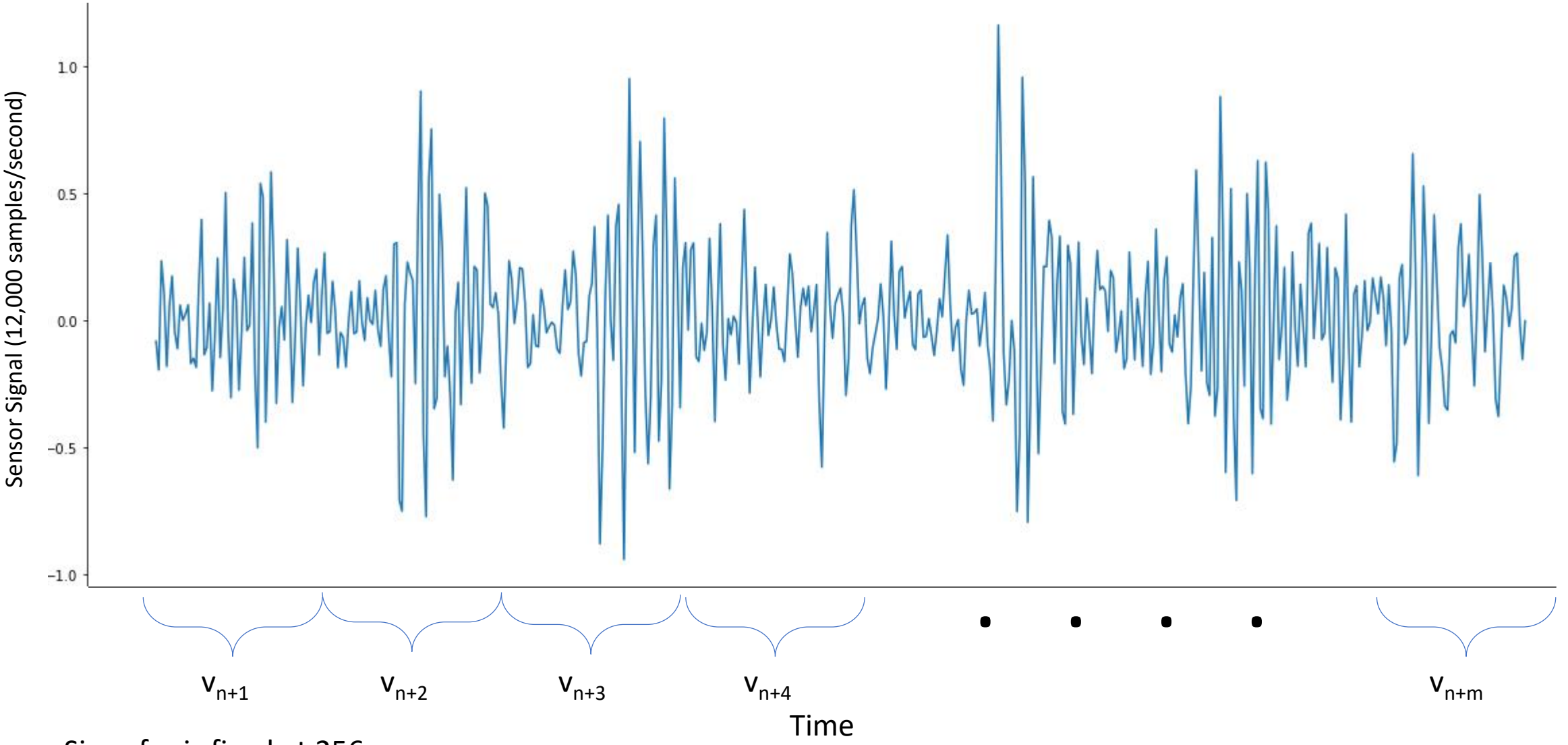


Size of v_i is fixed at 256.

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

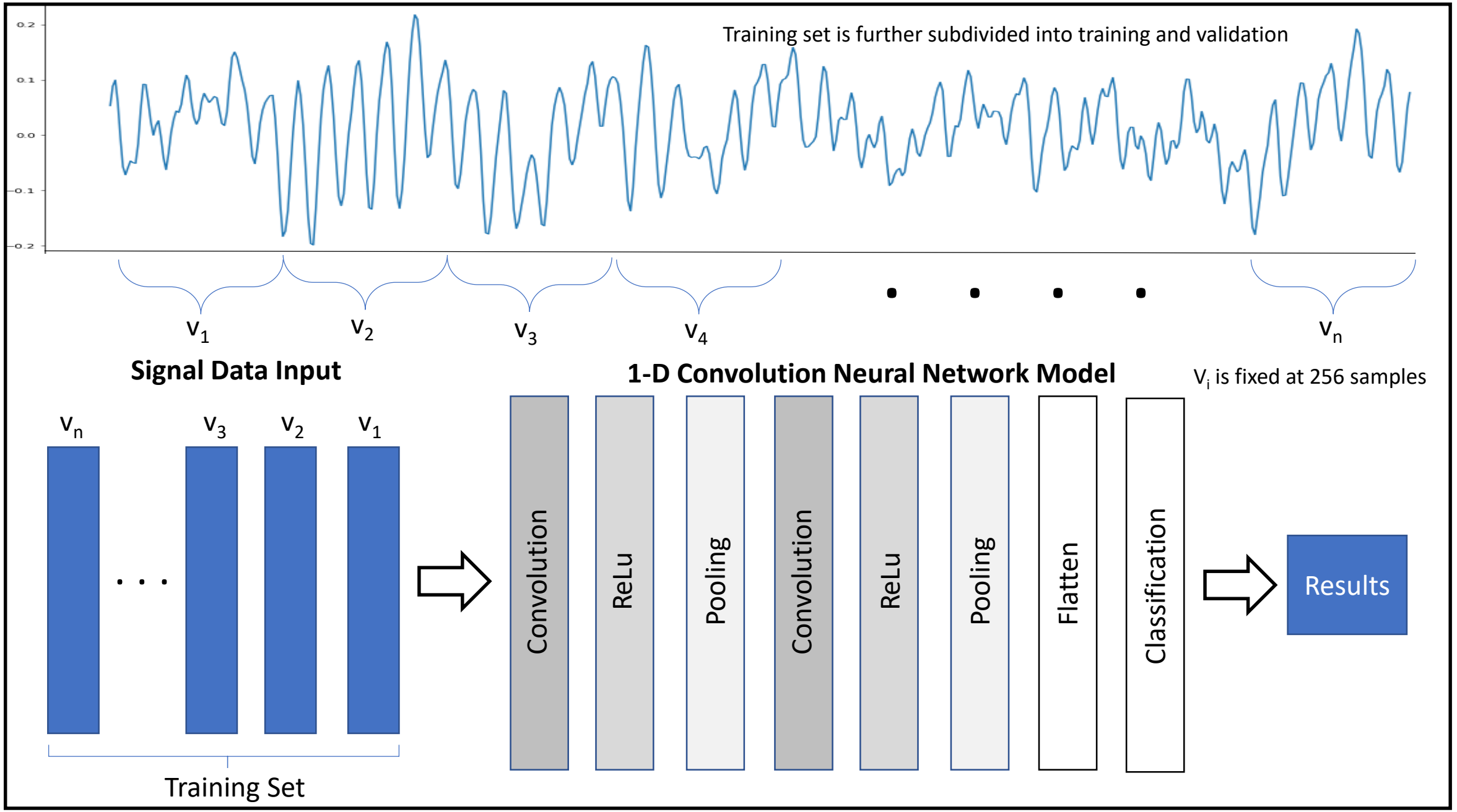


Size of v_i is fixed at 256.

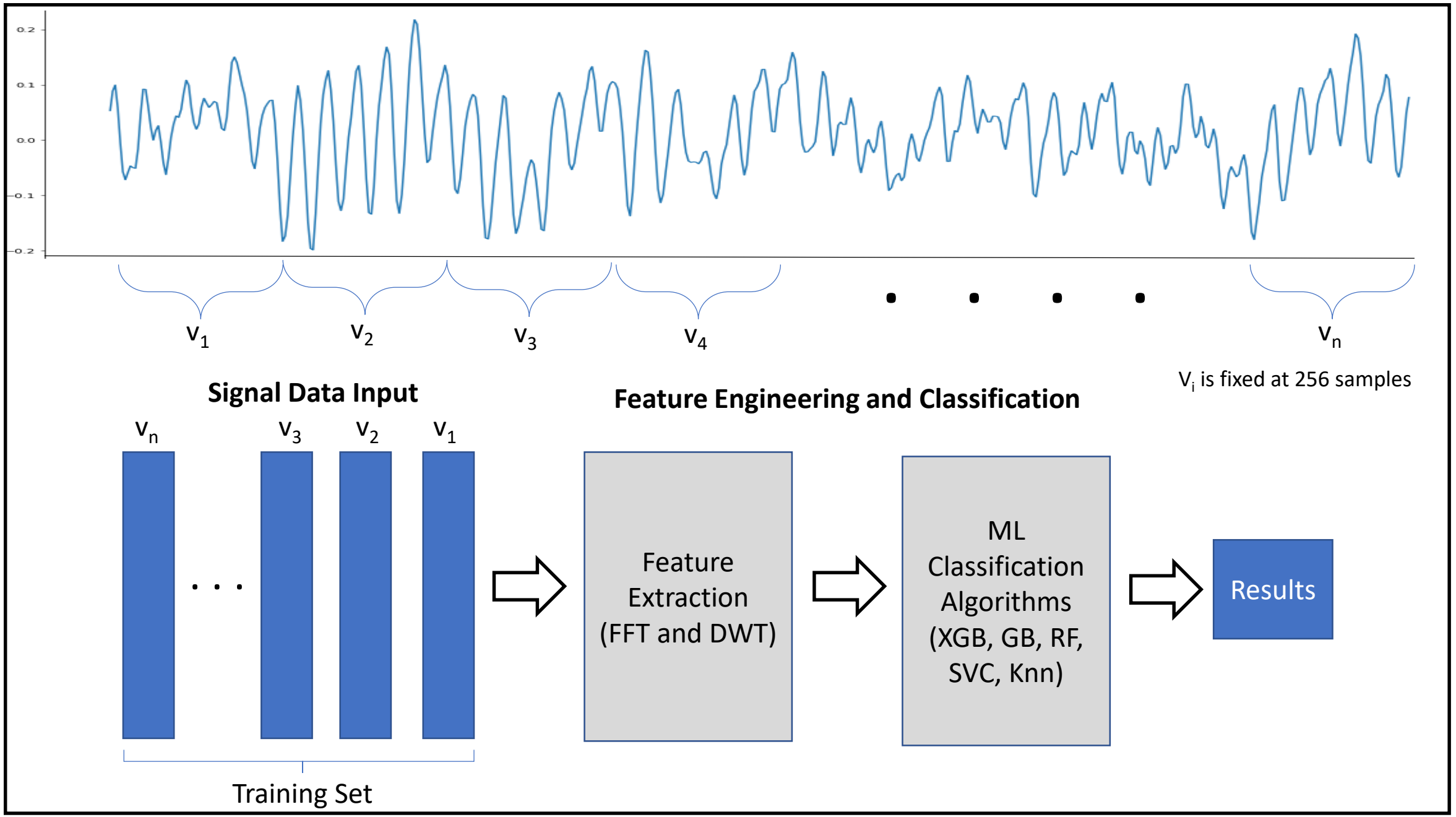
Where m is the number of fixed sample vectors of size 256

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)

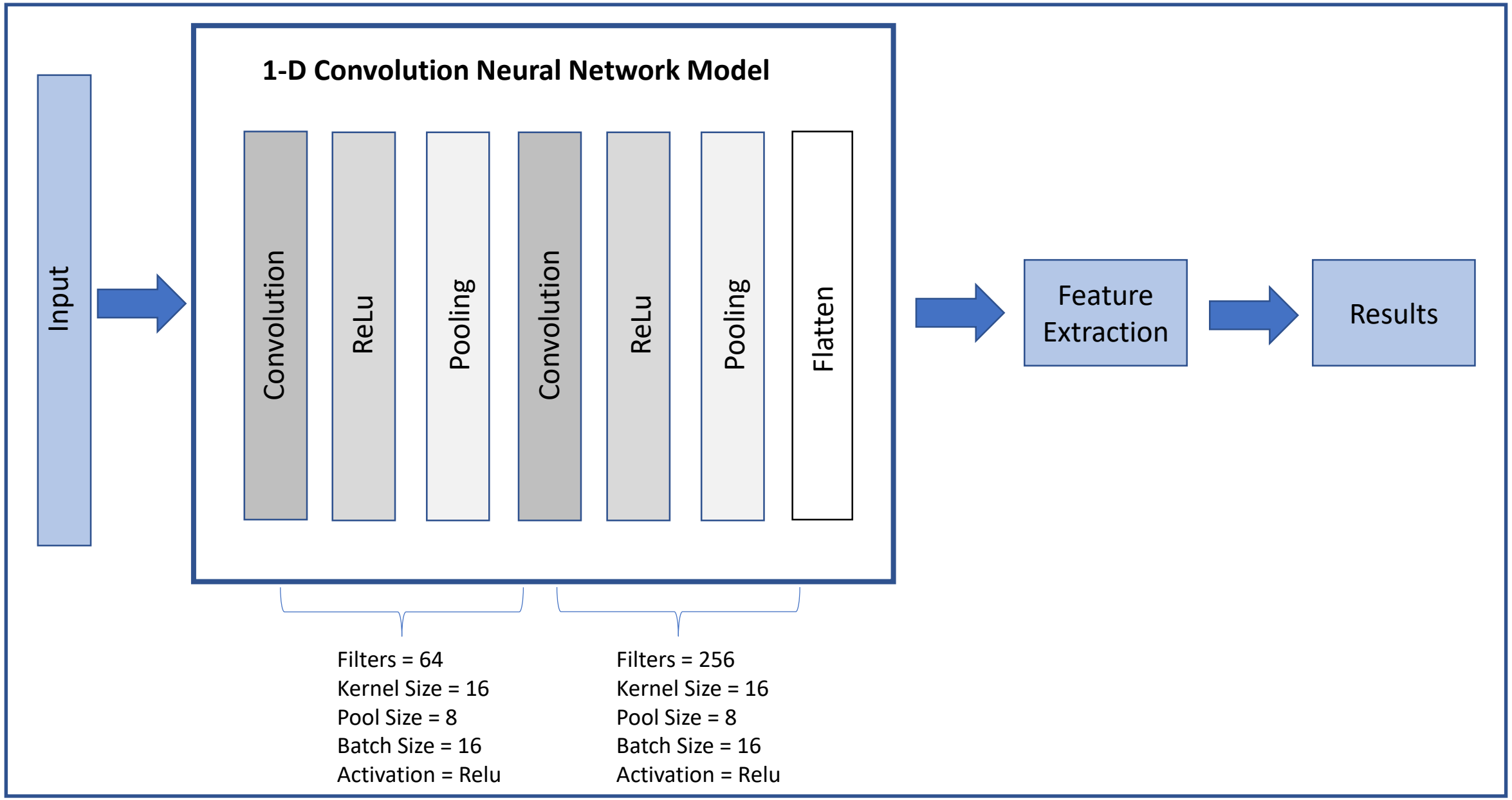
Contemporary Approach - Training



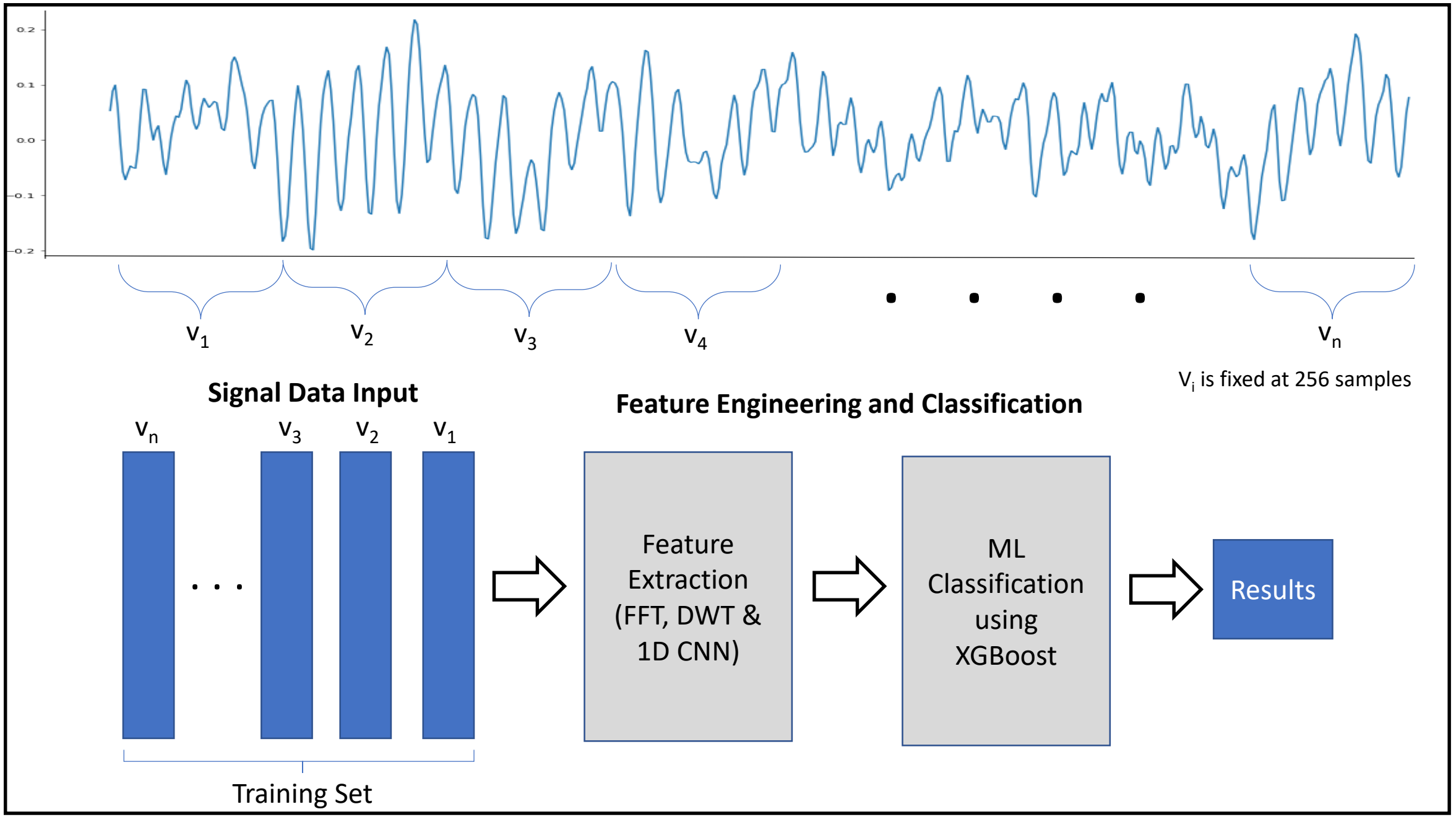
Classic Approach- Training



CNN 1D Feature Extraction



Classic and Contemporary Approach Together



Prediction and Results using Testing Data

Approach	Engineered Features Source	Algorithm	Training Accuracy	Testing Accuracy	Execution Time (minutes)
Contemporary	N/A	1D CNN	0.97	0.94	23
Classic	FFT	XGBoost	1.00	0.87	8
Classic	FFT	Gradient Boosting	1.00	0.81	5
Classic	FFT	Random Forests	1.00	0.81	6
Classic	FFT	Knn	0.63	0.54	1
Classic	FFT	SVCLinear	0.70	0.54	1
Classic	DWT	XGBoost	1.00	0.81	13
Classic	DWT	Gradient Boosting	1.00	0.79	4
Classic	DWT	Random Forests	1.00	0.80	7
Classic	DWT	Knn	0.63	0.53	2
Classic	DWT	SVCLinear	0.72	0.43	1
Classic	FFT & DWT	XGBoost	1.00	0.90	17
Classic	FFT & DWT	Gradient Boosting	1.00	0.87	4
Classic	FFT & DWT	Random Forests	1.00	0.86	10
Classic	FFT & DWT	Knn	0.65	0.56	3
Classic	FFT & DWT	SVCLinear	0.83	0.53	1
Both	FFT, DWT & 1D CNN	XGBoost	1.00	0.95	36