Wafer Dataset

A collection of time-series data sets where each file contains the sequence of measurements recorded by one vacuum-chamber sensor during the etch process applied to one silicon wafer during the manufacture of semiconductor microelectronics.

Data Stats

Wafers

Total = 1194

- **Normal =** 89.3%
- **Abnormal =** 10.7%

Naming = <run>_<wafer>

Sensors

Number of sensors for each wafer = 6

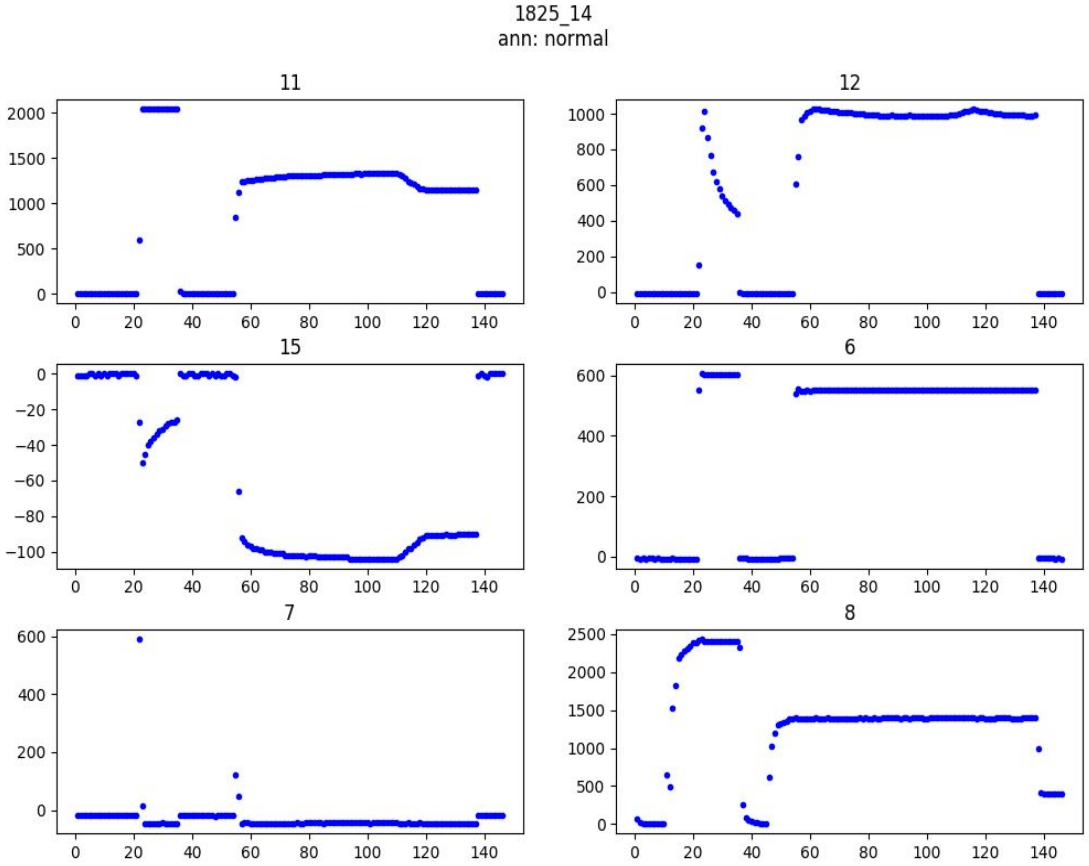
- **6** - radio frequency forward power sensor
- **7** - radio frequency reflected power sensor
- **8** - chamber pressure sensor
- **11** - 405 nm emission sensor
- **12** - 520 nm emission sensor
- **15** - direct current bias sensor

Time-Steps

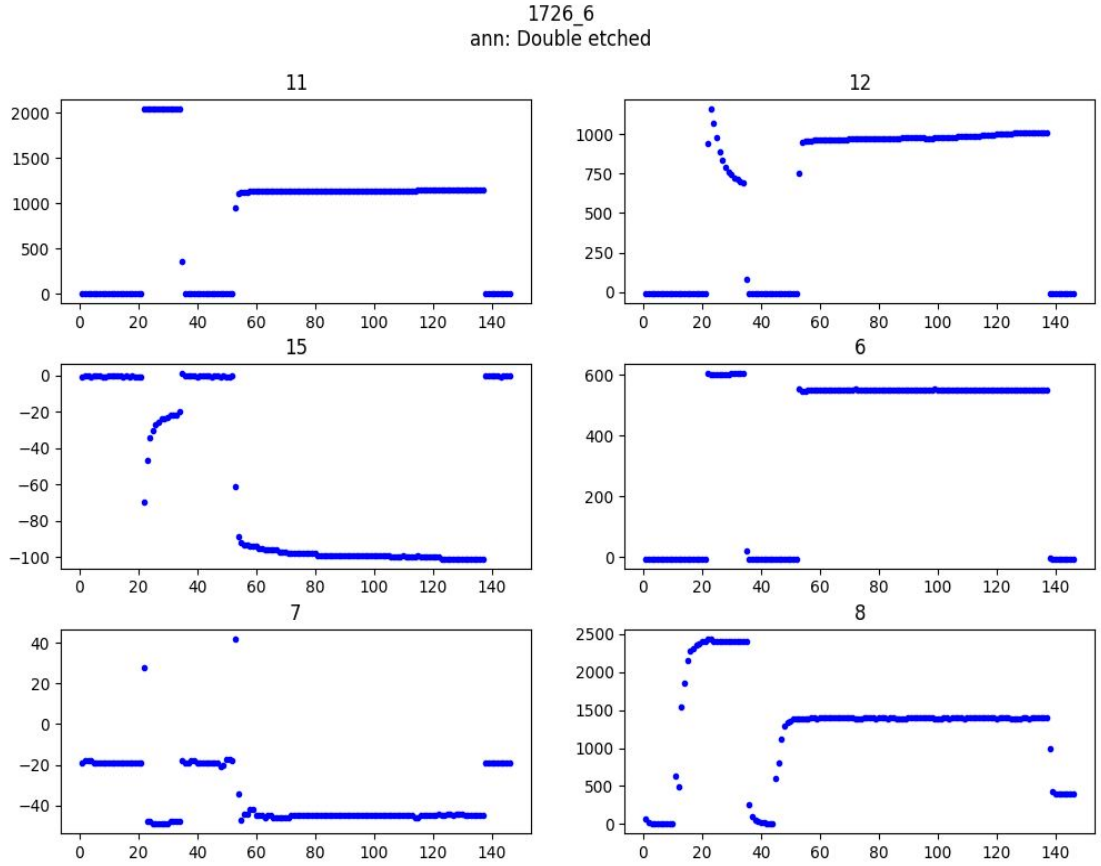
Number of time-steps:

- **Normal:** 114-152 (136 +/- 6)
- **Abnormal:** 104-198 (144 +/- 8)

Example: Normal



Example: Abnormal



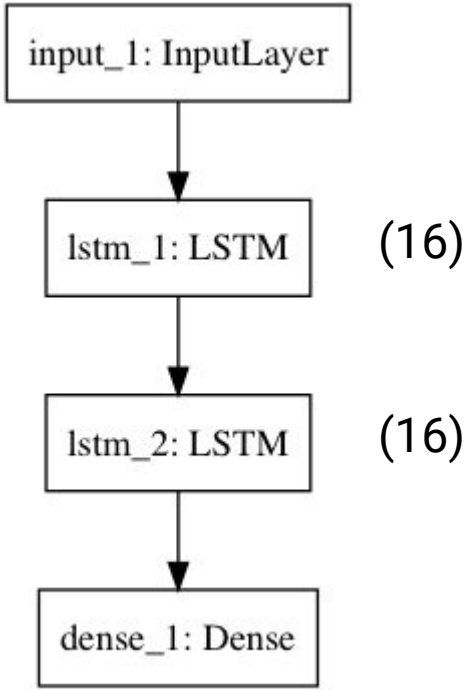
Preprocessing

- One hot coding
- Resampling timesteps to 140

Deep Learning Models

- Train : Validation : Test = 8:1:1
- Epochs = 40
- Output activation = softmax
- Optimizer = adam
- Loss = binary cross-entropy

LSTM



Confusion Matrix:

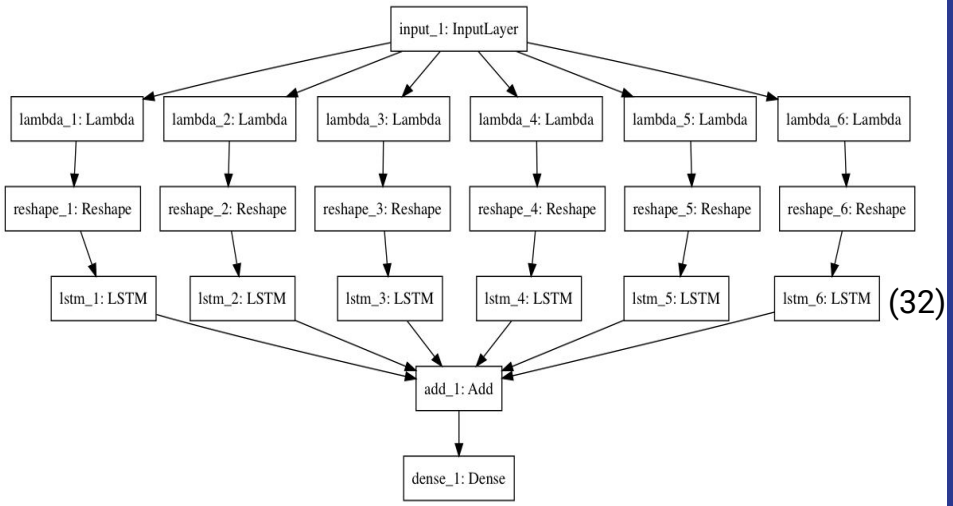
Actual/Predicted	Abnormal	Normal
Abnormal	12	1
Normal	0	107

Classification Report:

	Precision	recall	f1-score	support
Abnormal	1.00	0.92	0.96	13
Normal	0.99	1.00	1.00	107
Avg / Total	0.99	0.99	0.99	120

Cross Validation: 99.33% (+/- 0.97%)

LSTM_6



Confusion Matrix:

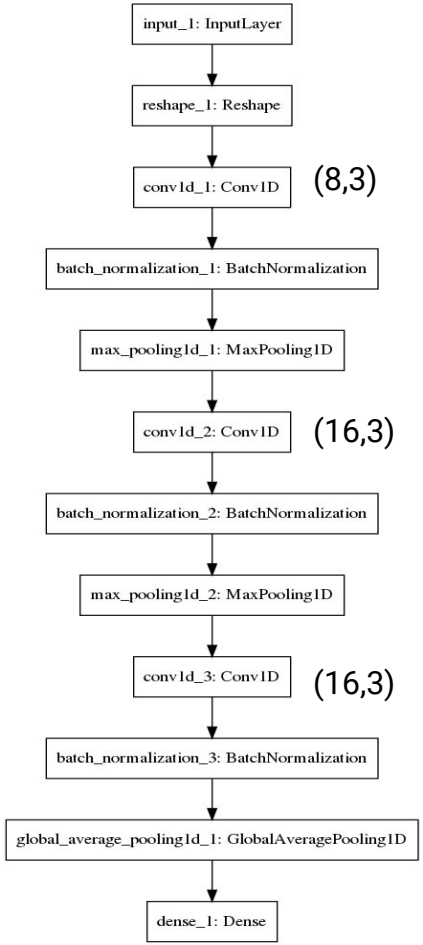
Actual/Predicted	Abnormal	Normal
Abnormal	8	5
Normal	2	105

Classification Report:

	Precision	recall	f1-score	support
Abnormal	0.80	0.62	0.70	13
Normal	0.95	0.98	0.97	107
Avg / Total	0.94	0.94	0.94	120

Cross Validation: 98.49% (+/- 1.04%)

1D-CNN



Confusion Matrix:

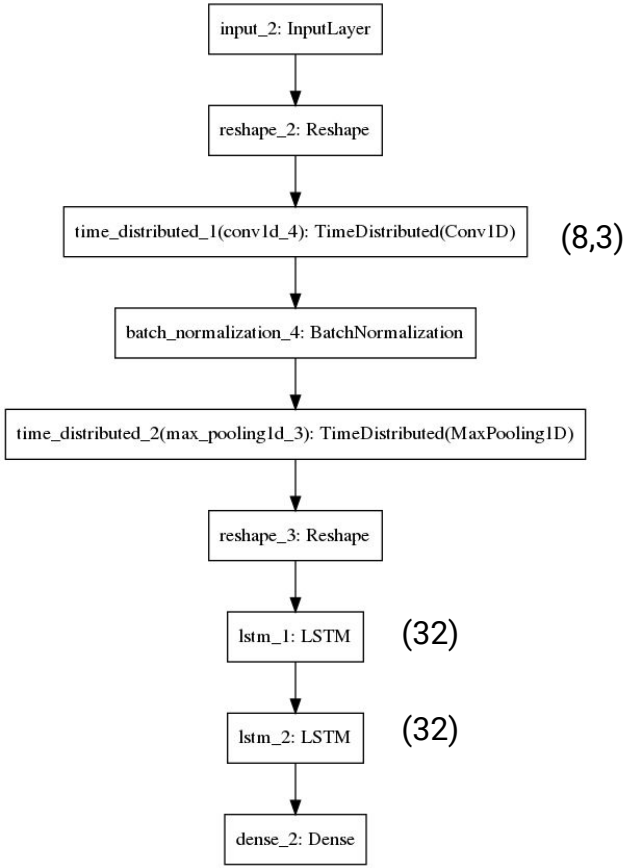
Actual/Predicted	Abnormal	Normal
Abnormal	12	1
Normal	0	107

Classification Report:

	Precision	recall	f1-score	support
Abnormal	1.00	0.92	0.96	13
Normal	0.99	1.00	1.00	107
Avg / Total	0.99	0.99	0.99	120

Cross Validation: 99.42% (+/- 0.65%)

Hybrid



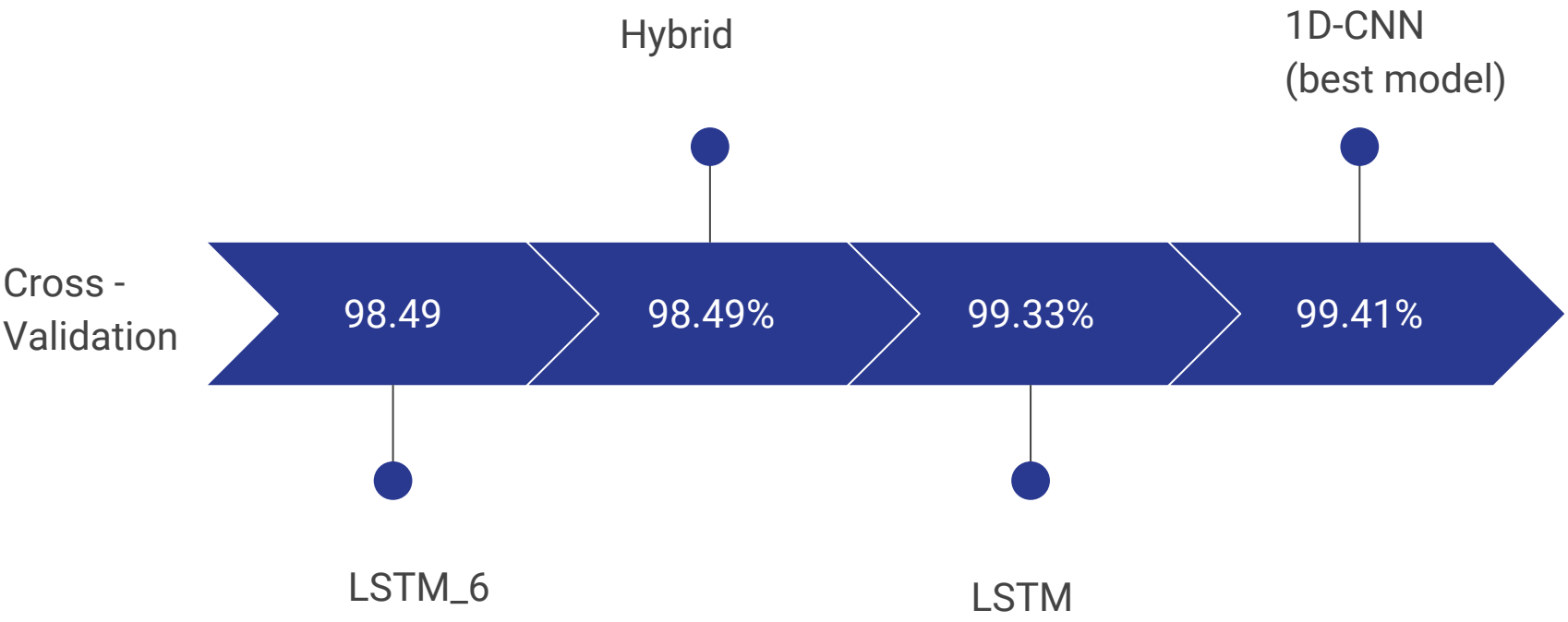
Confusion Matrix:

Actual/Predicted	Abnormal	Normal
Abnormal	11	2
Normal	1	106

Classification Report:

	Precision	recall	f1-score	support
Abnormal	0.92	0.85	0.88	13
Normal	0.98	0.99	0.99	107
Avg / Total	0.97	0.97	0.97	120

Cross Validation: 98.49% (+/- 1.04%)


Hybrid
1D-CNN
(best model)
Cross -
Validation
98.49
98.49%
99.33%
99.41%
LSTM_6
LSTM

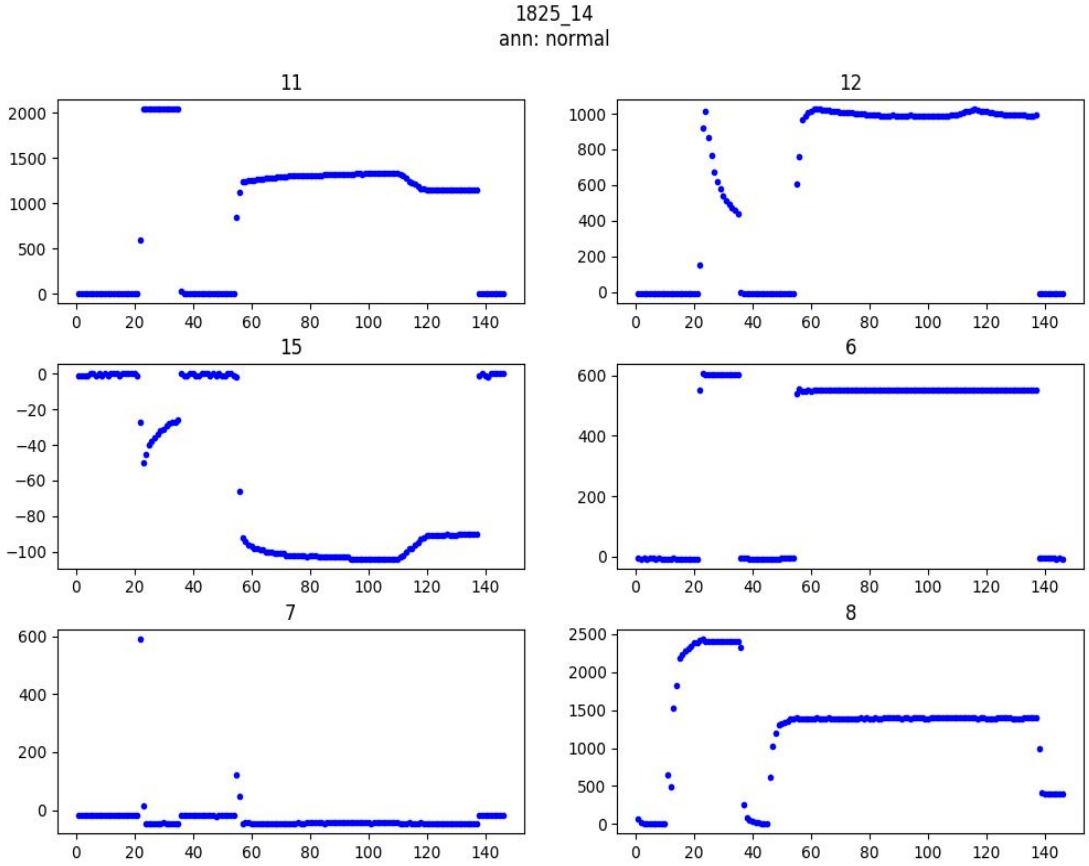
Occlusion Experiment

For each sensor:

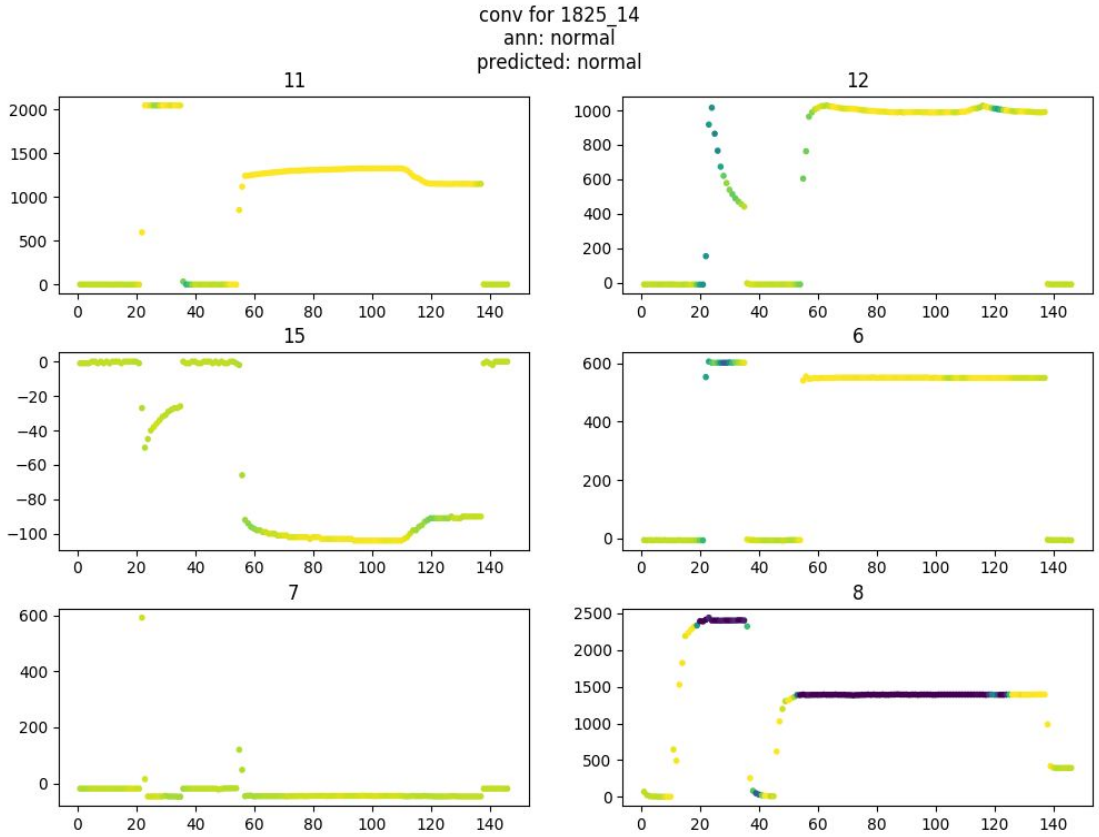
- occ_length=5
- pixel_value=0
- occ_stride=2

It finds the part of an input image that an output neuron responds to. It iterates a blank window that occludes various parts of the image and monitors the output of the classifier model. This representation helps us to localize the slots within the input data due to the fact that when a significant portion is occluded, the probability of the correct class drops.

Example: Normal

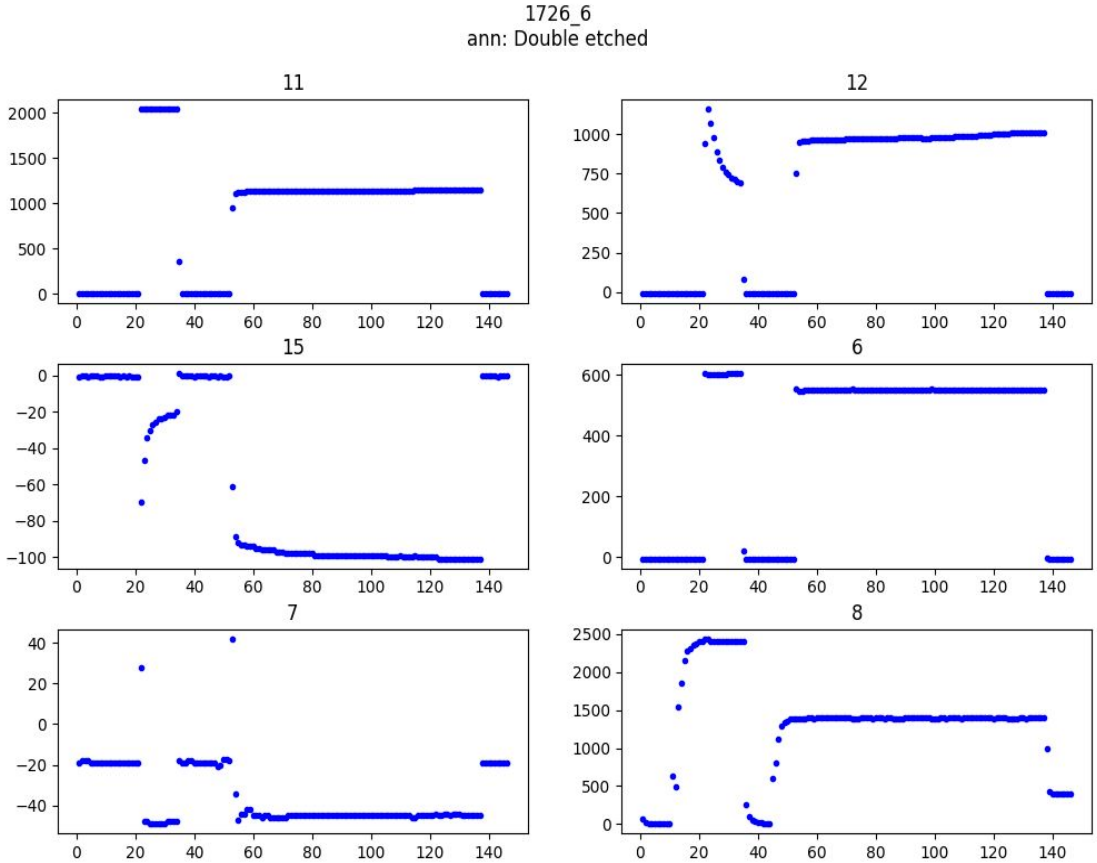


Example: Normal: 1D-CNN

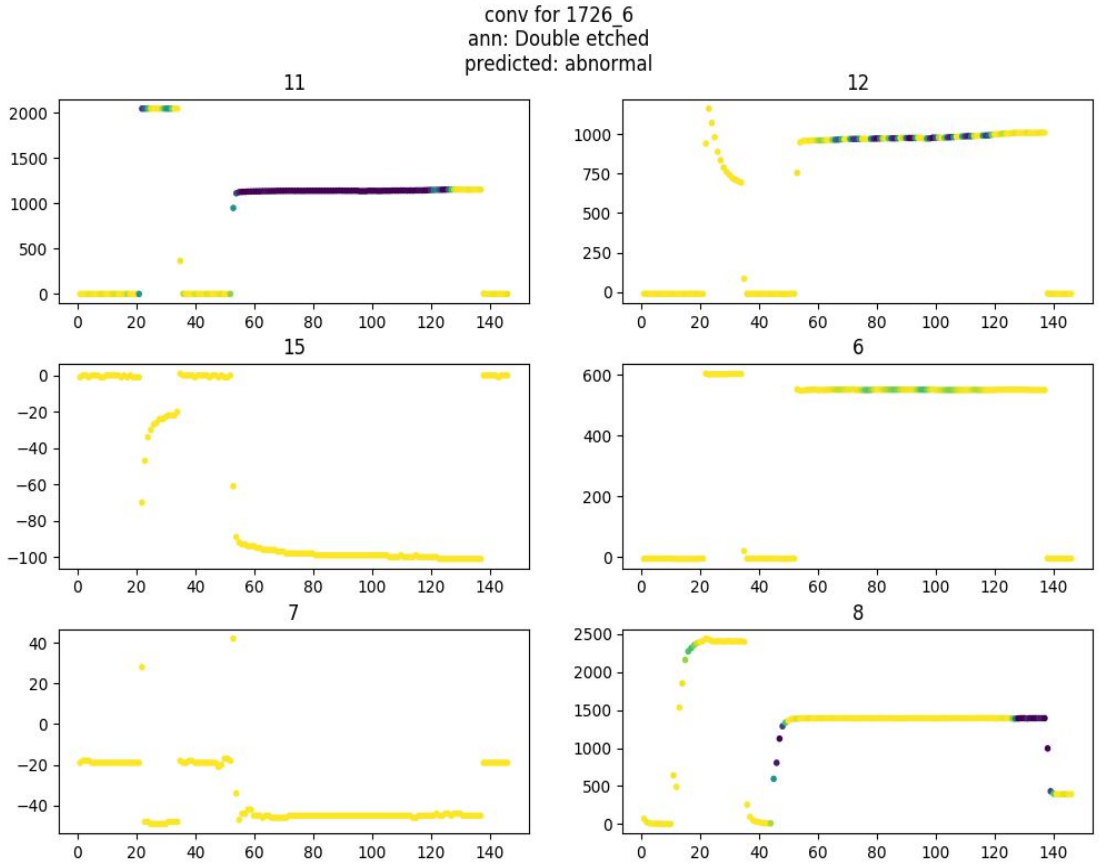


Darker-Violet part represents the time-slot in the input data that activates the “Normal” (predicted) neuron in the output layer.

Example: Abnormal



Example: Abnormal: 1D-CNN



Darker-Violet part represents the time-slot in the input data that activates the “Abnormal” (predicted) neuron in the output layer.