Industrial Approach: Automated Fault Detection with 1-Dimensional Sensory Signals for Quality Inspection

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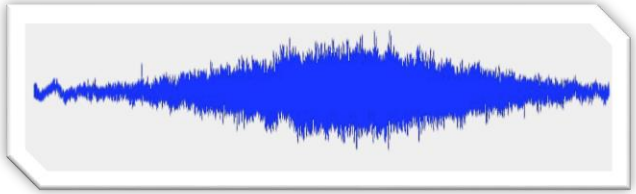
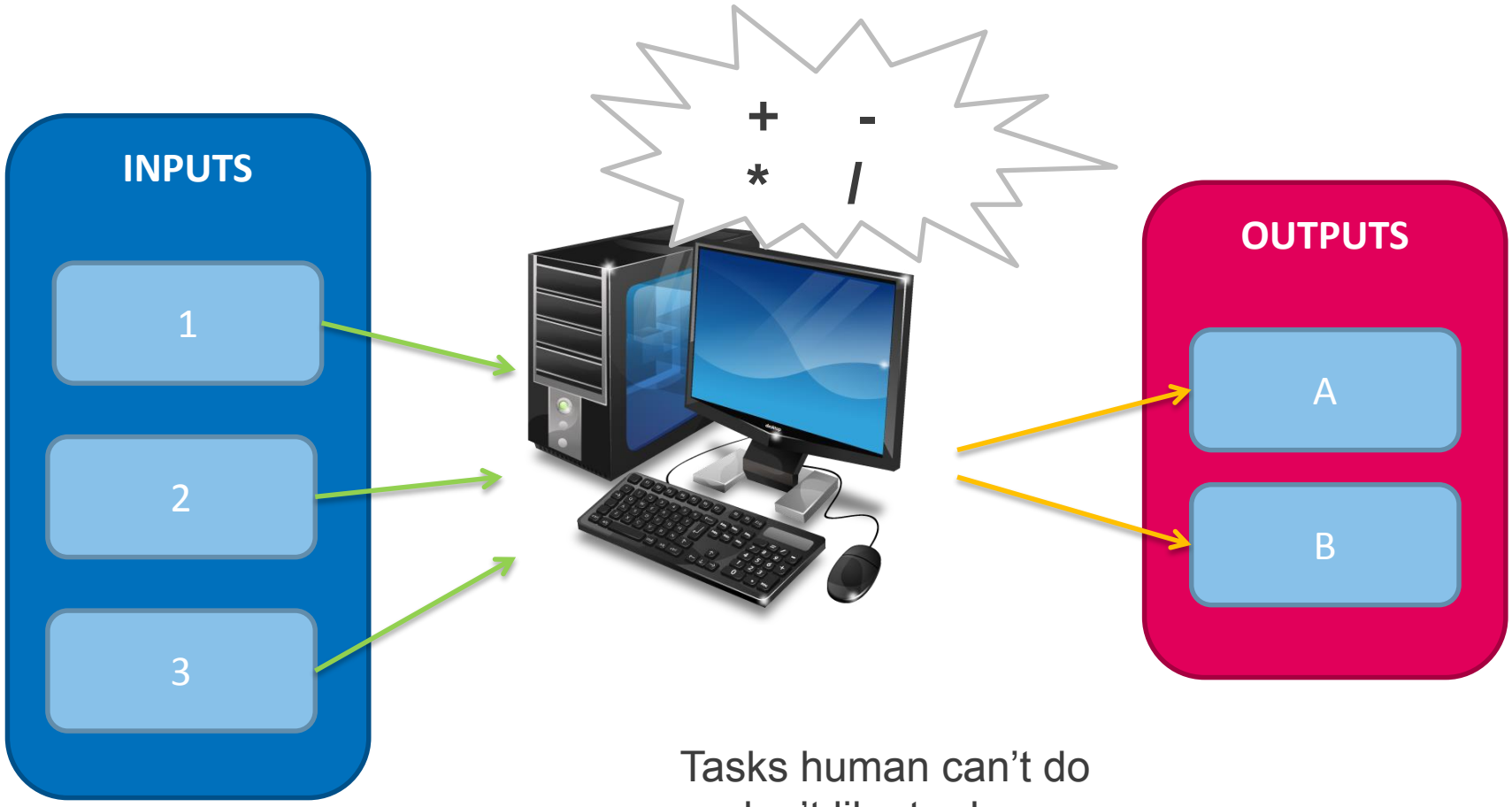
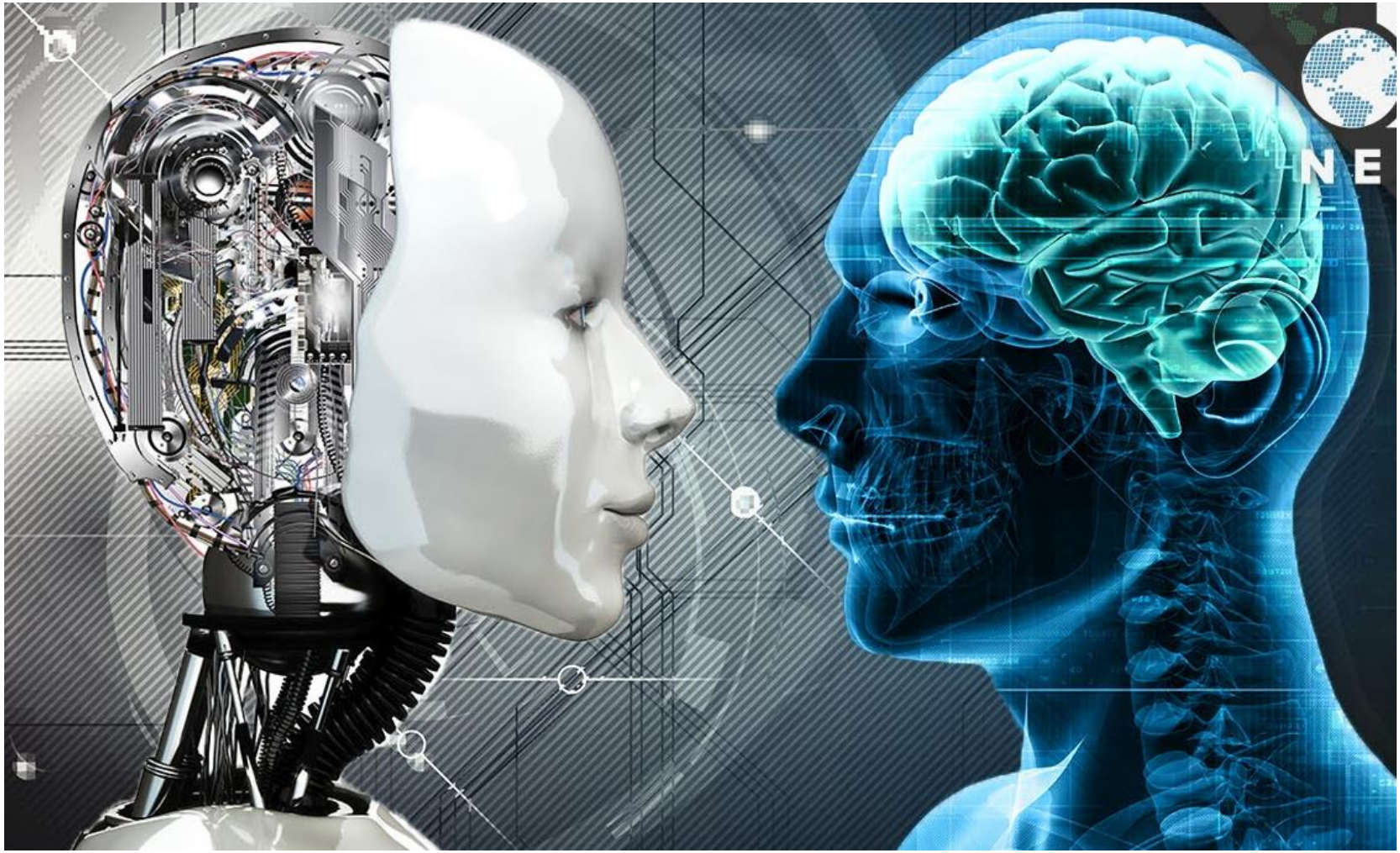


Smart Computers?



Tasks human can't do
or don't like to do

Machine Learning!



Learning Categories

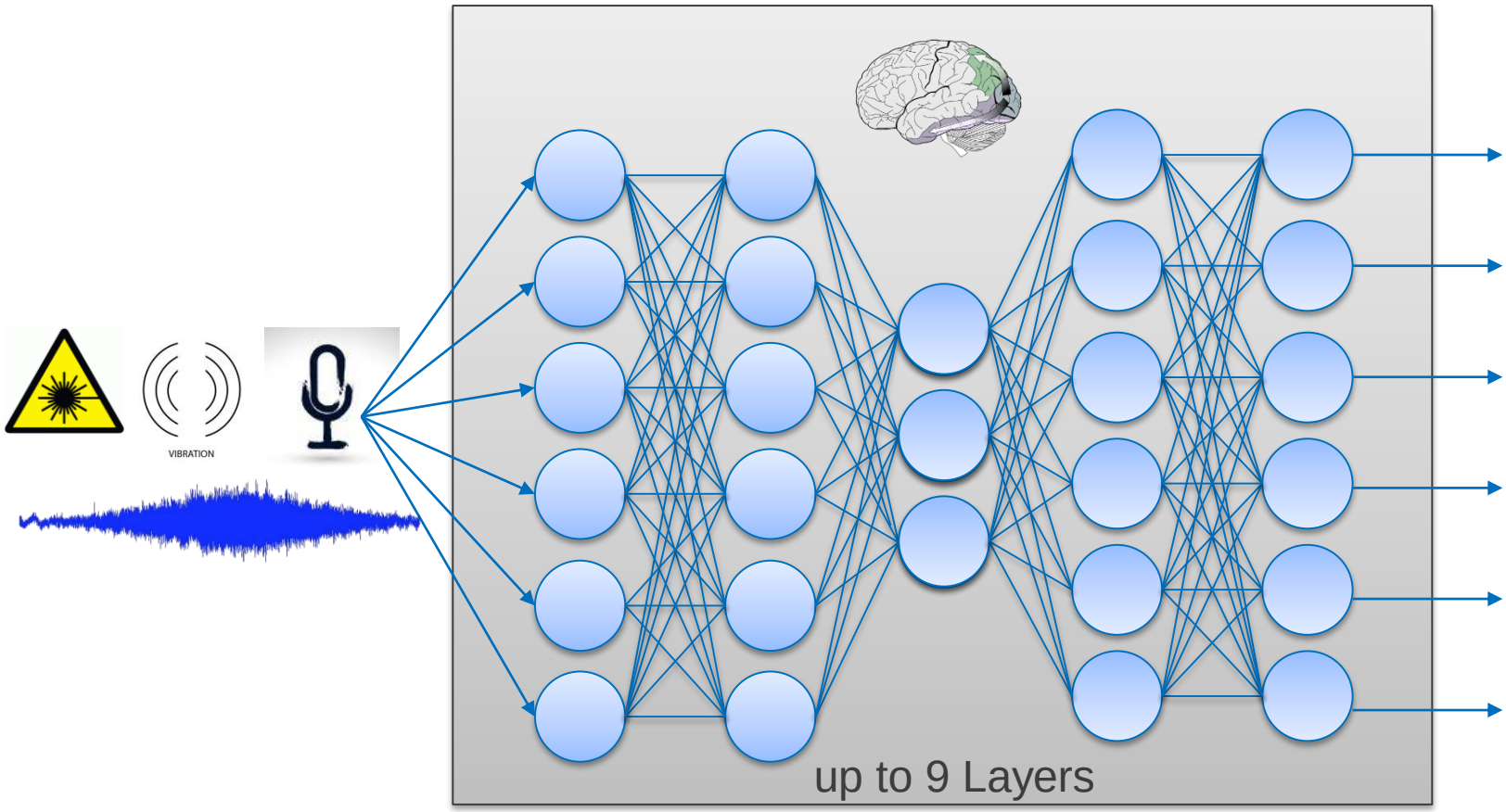
Supervised Learning

Reinforcement Learning

Unsupervised Learning

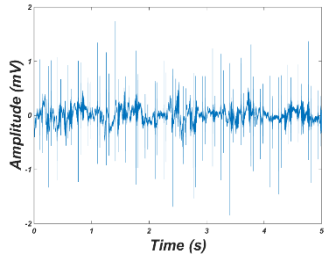
How works our Brain?

How to model the human Brain?



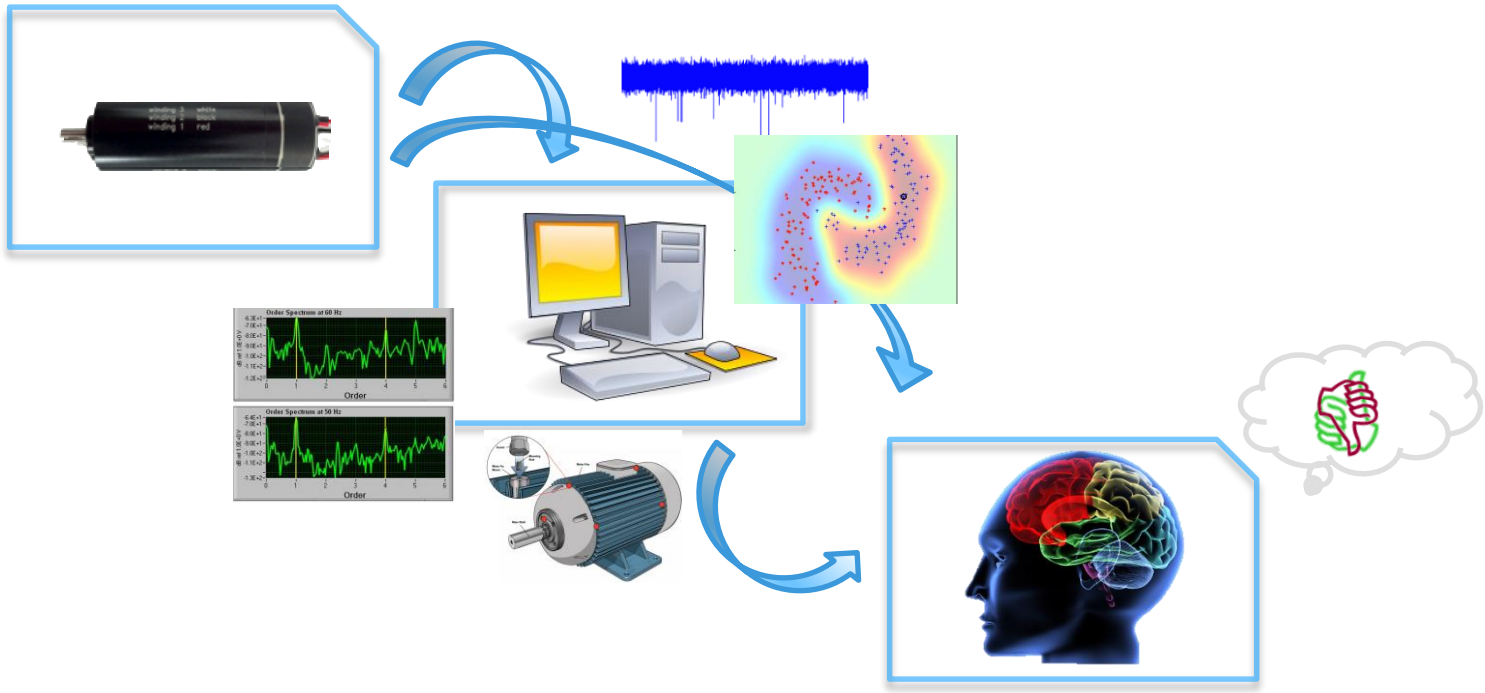
Deep Belief Network

Applications

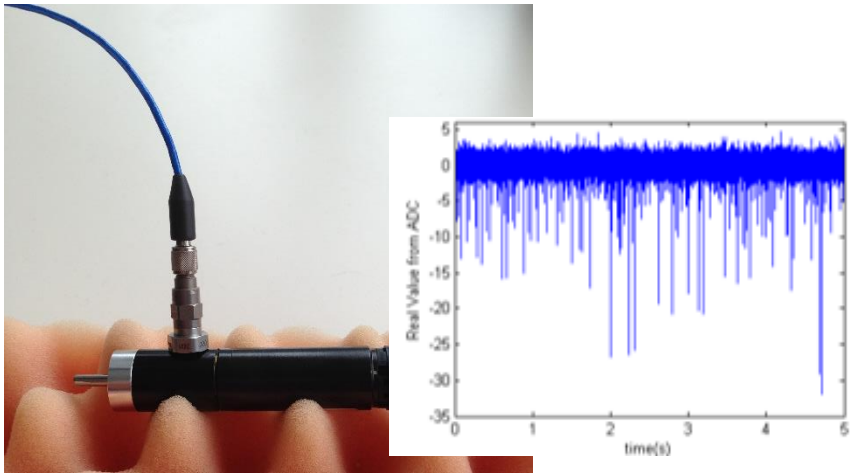


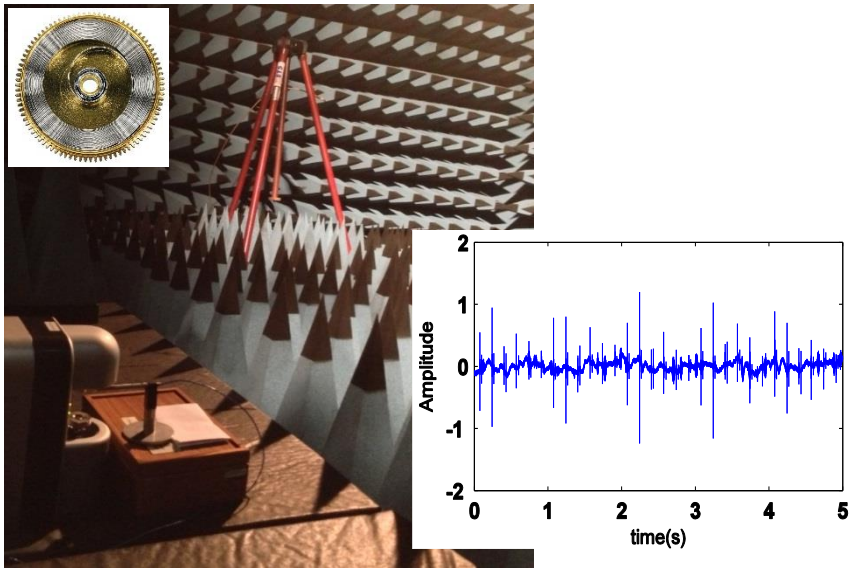
- 1-Dimensional sensory signal analysis and automated quality decision (Good/Bad)

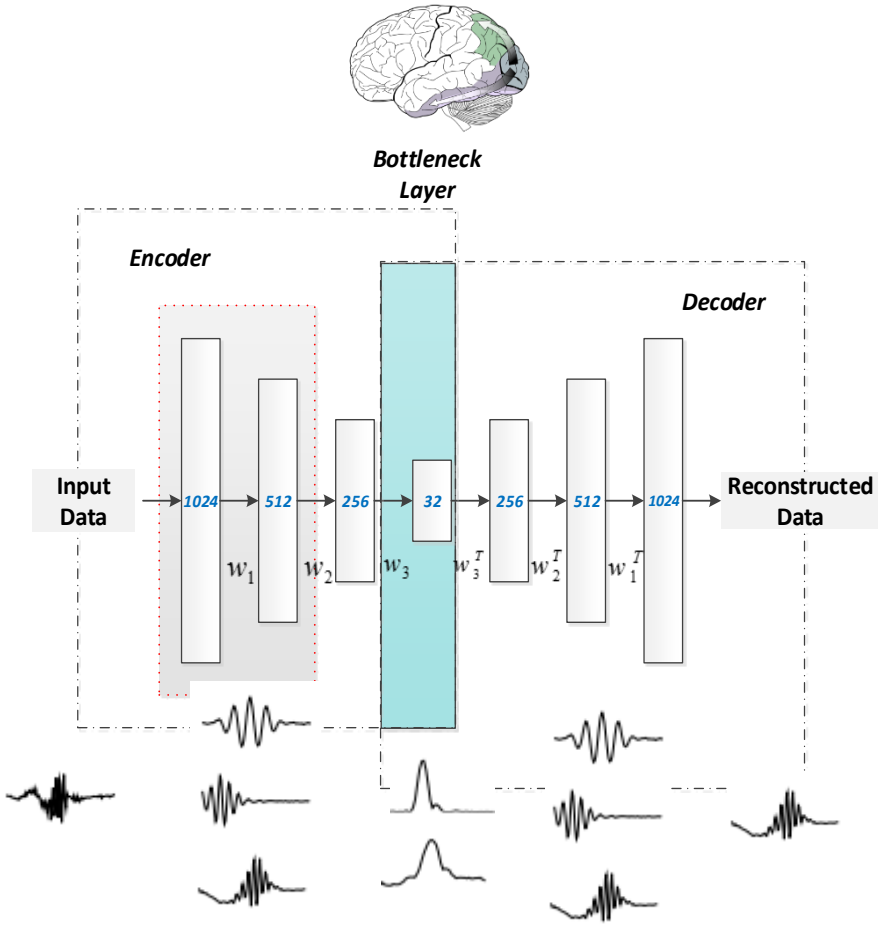
Industrial Acoustic Quality Check Today



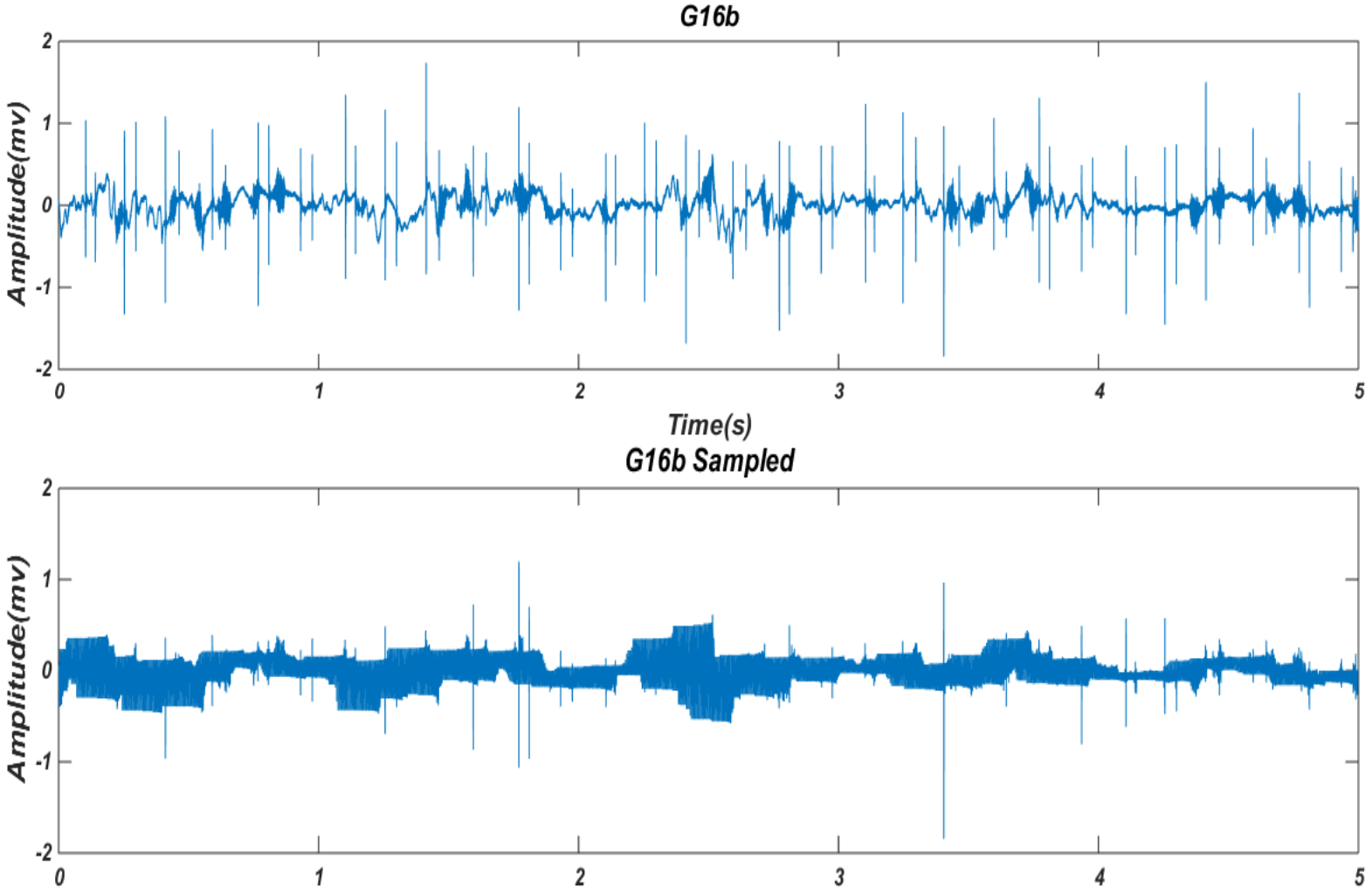
How to Use Deep Belief Networks?



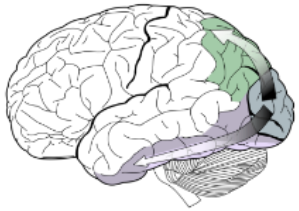


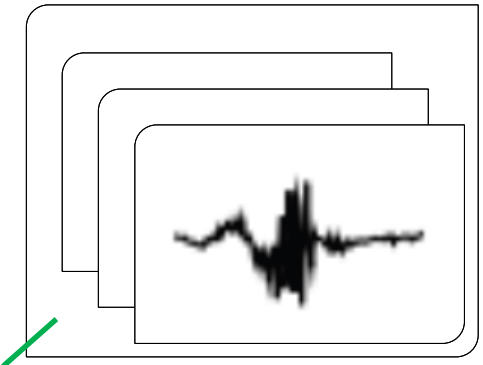


Acoustic Signal Sampling

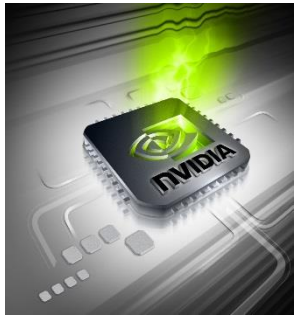


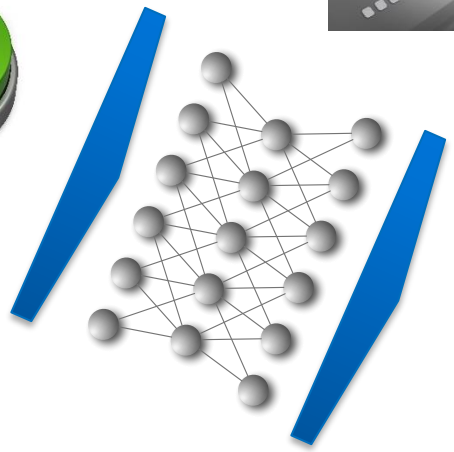
Train the Brain



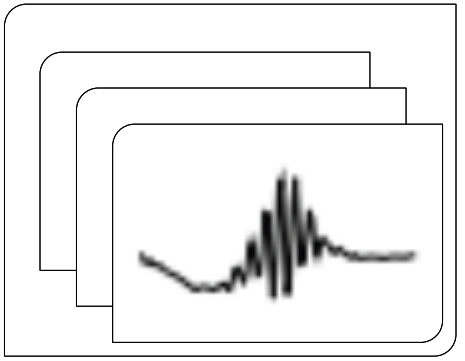


Sensor signals **ONLY** from **GOOD** samples

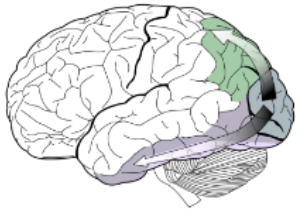


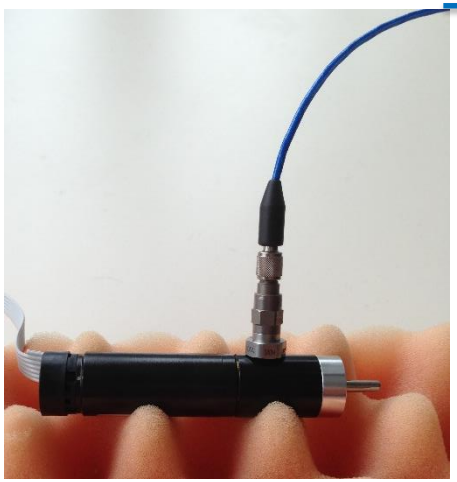


20-30min

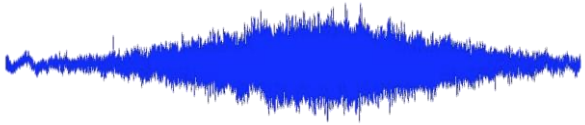


Use the Brain

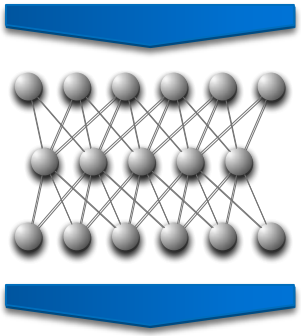




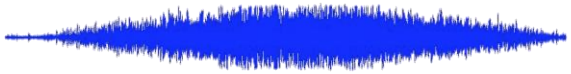
Input signal



Trained Tilear



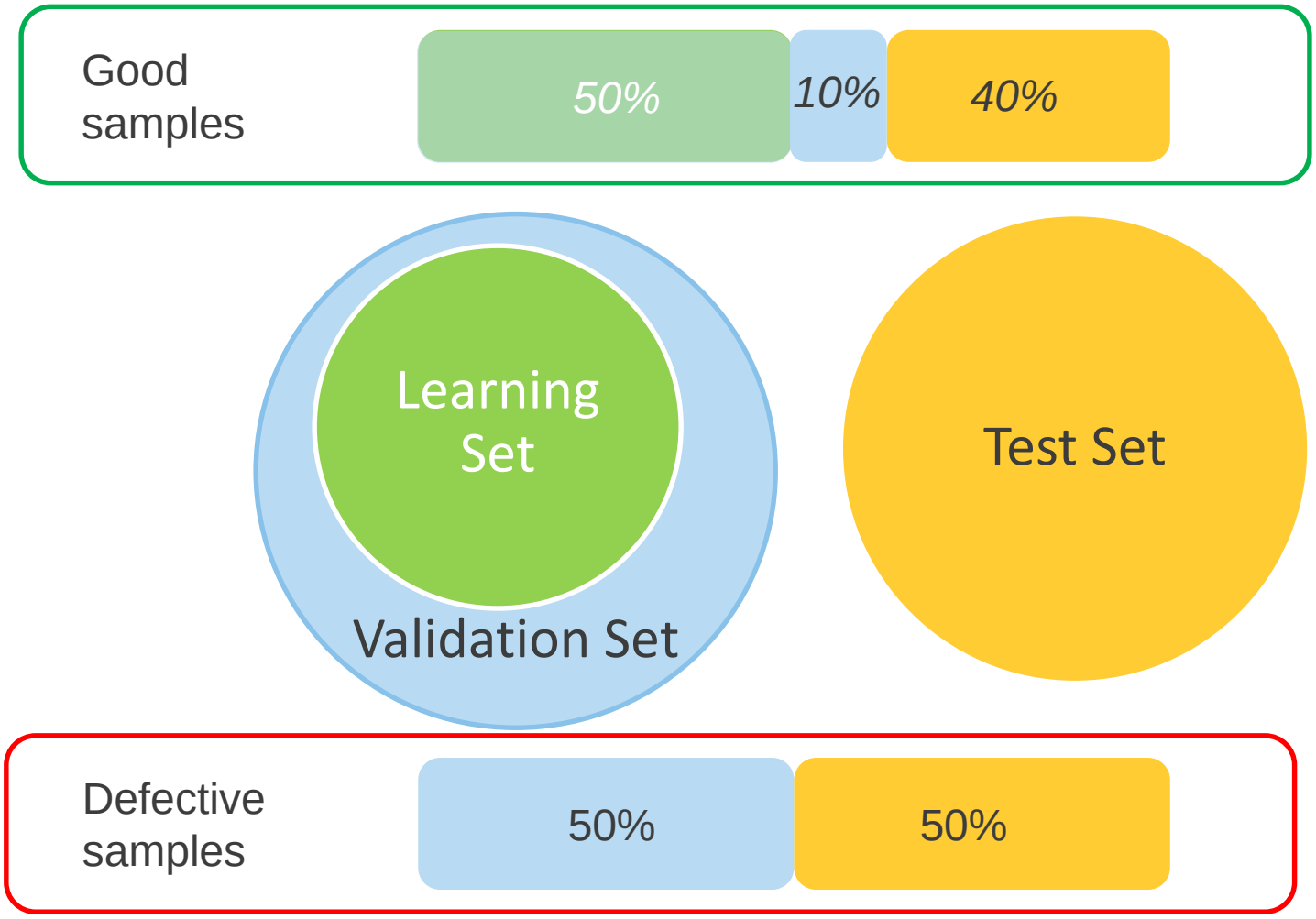
Reconstruction error > Decision threshold ?



Reconstructed test signal

0.1 – 1s

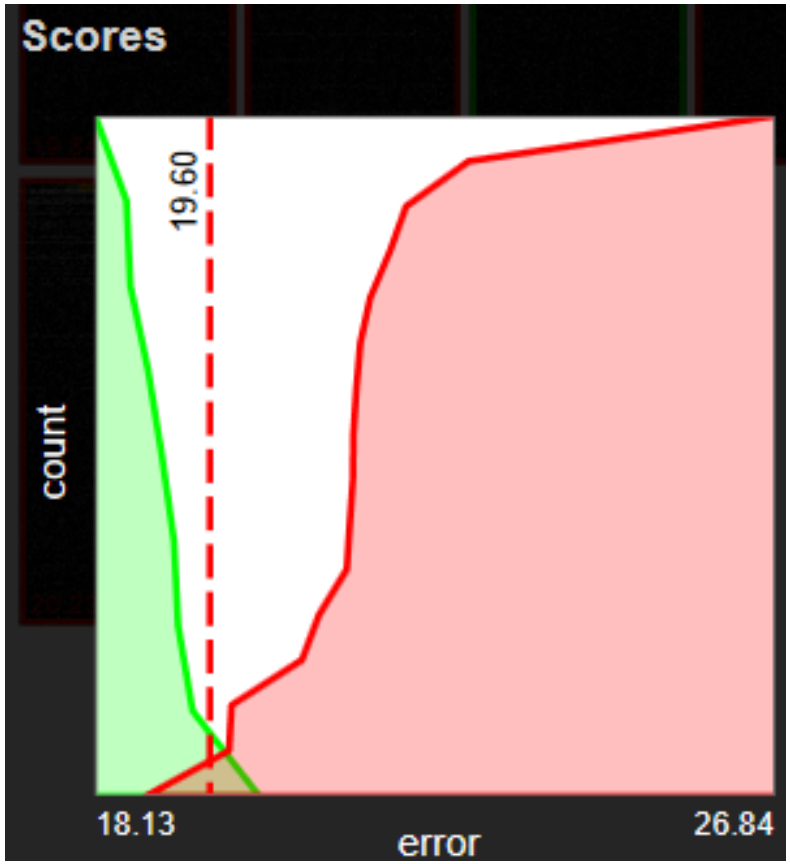
Dataset Split



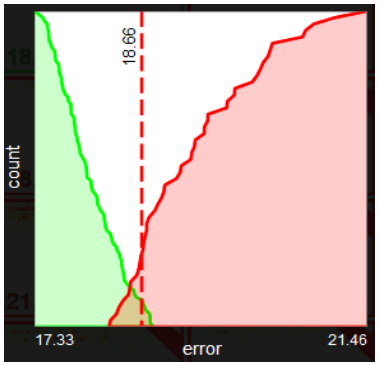
Experiment Results: Electromotors

- Cumulative Distribution of Reconstruction Errors
  - Red part: defective samples
  - Green part: good samples
  - Red dash line: threshold value for

  Decision making

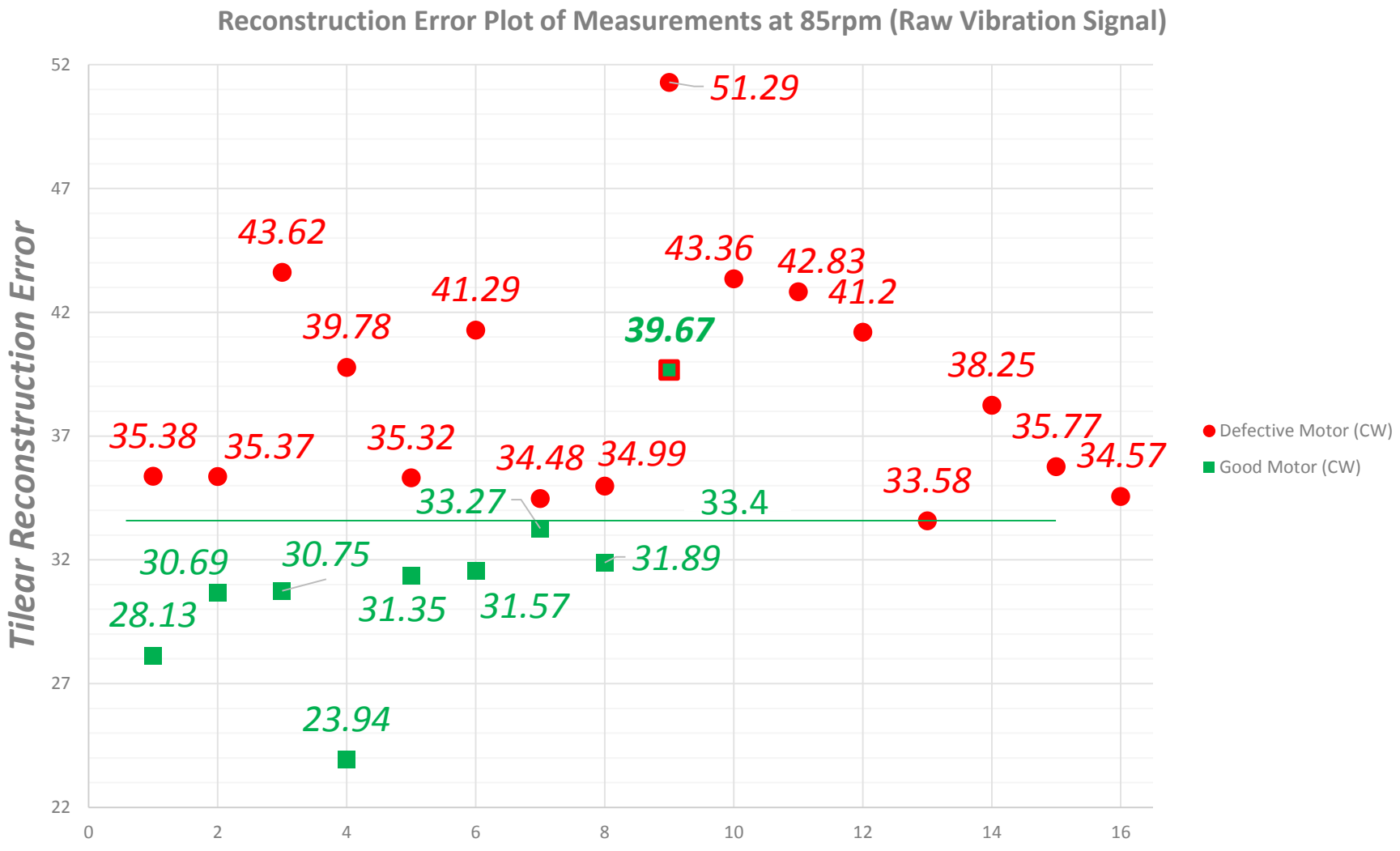


Validation set



Test set

Experiment Results: Electromotors

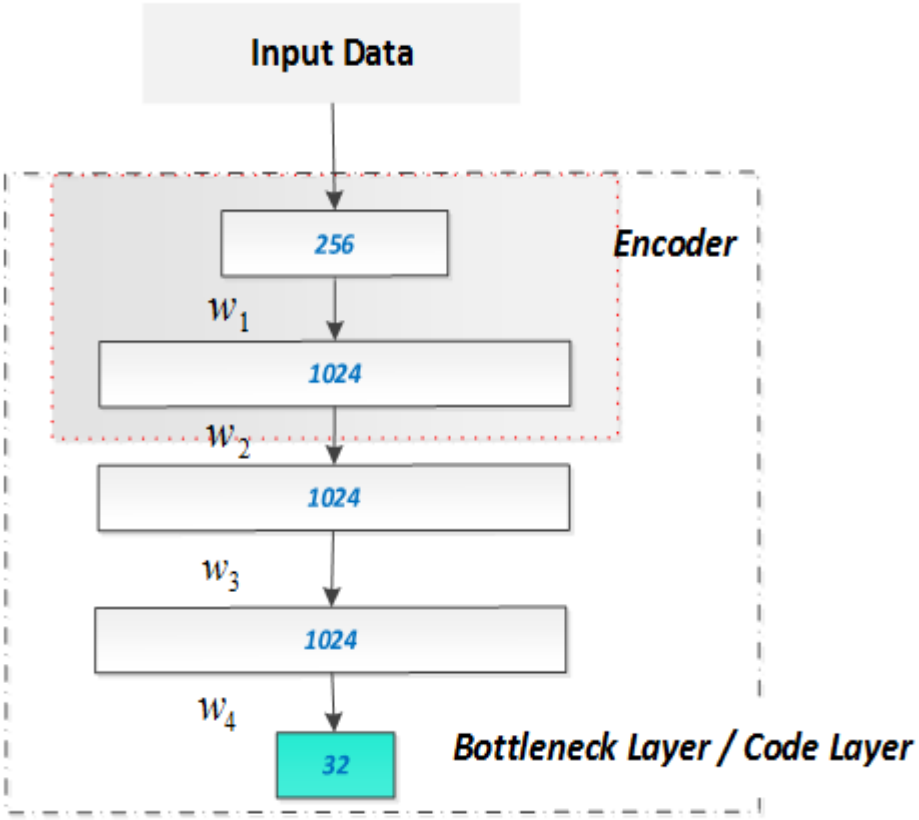


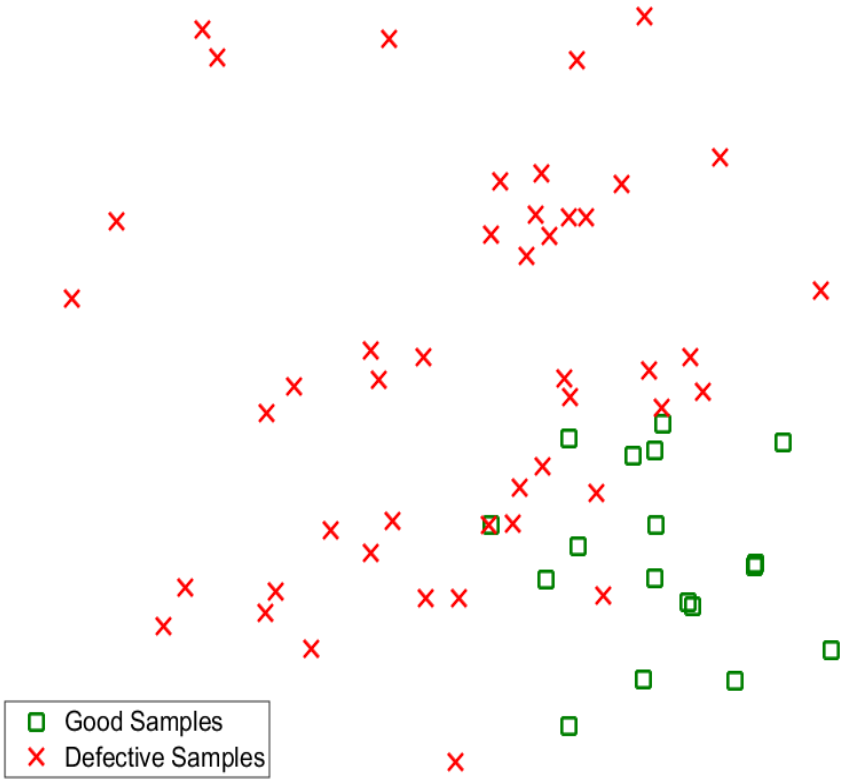
CSEM Tilear vs Industrial state of the Art*

	State of the Art		CSEM Tilear	
True Positive	87	92%	90	95%
False Positive	8	8%	5	5%
False Negative	5	6%	2	2%
True Negative	78	94%	81	98%

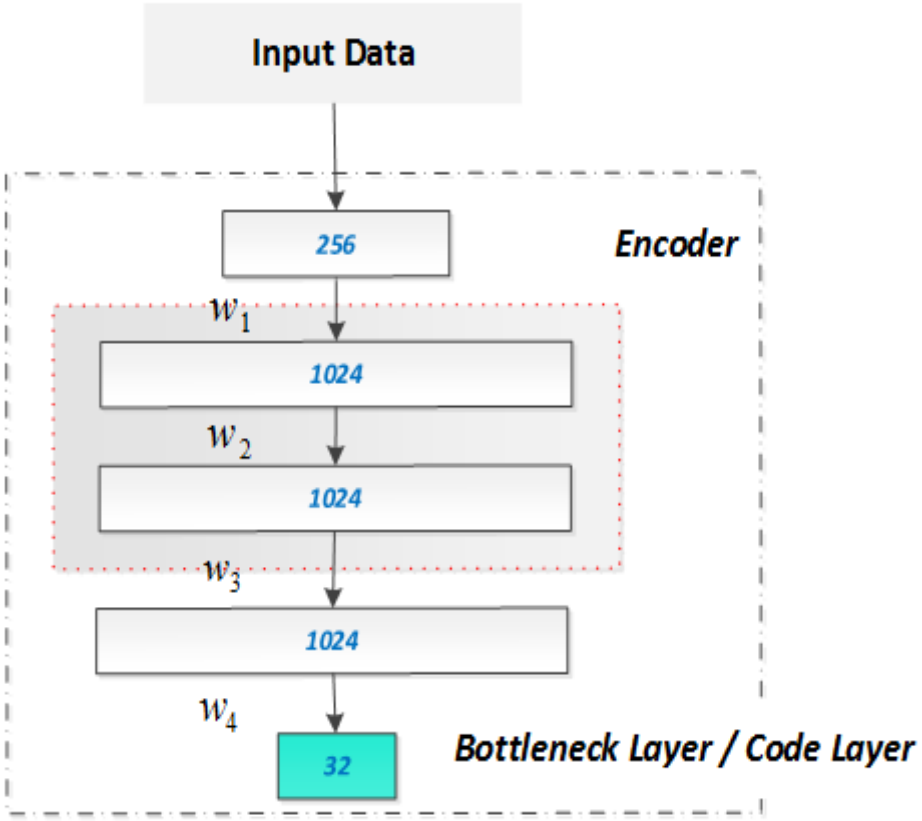
* RTE Akustik + Prüftechnik GmbH

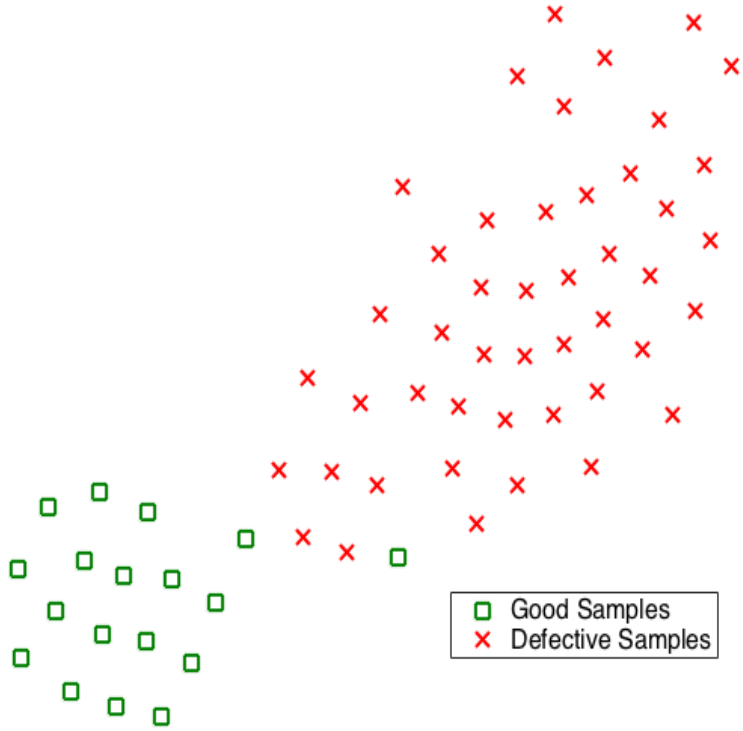
Visualization of Activity Patterns: 1st Hidden Layer



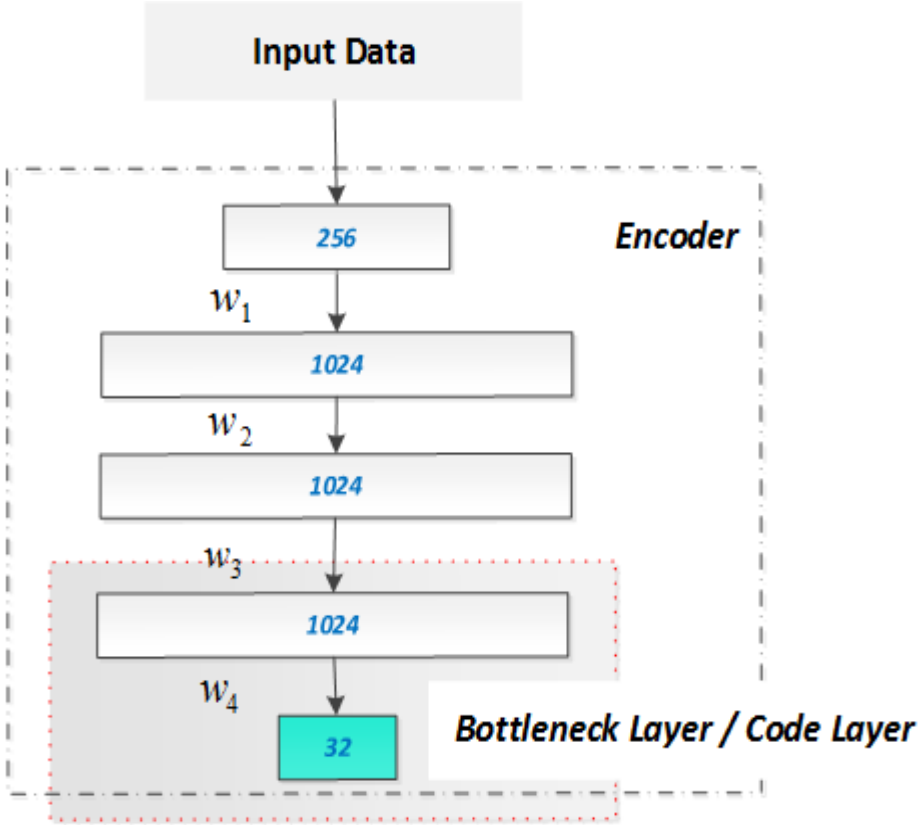


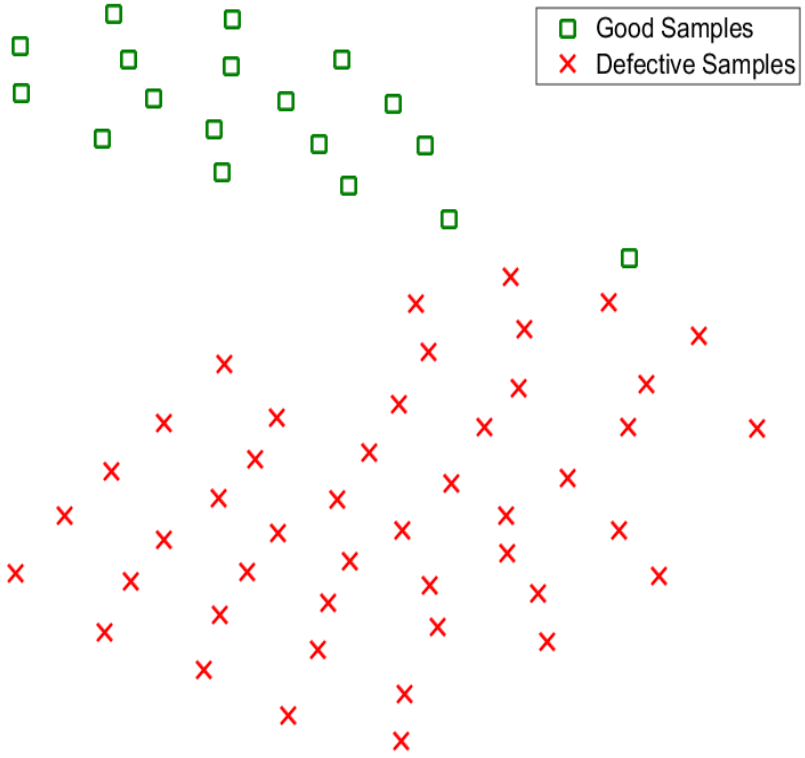
Visualization of Activity Patterns: 2nd Hidden Layer





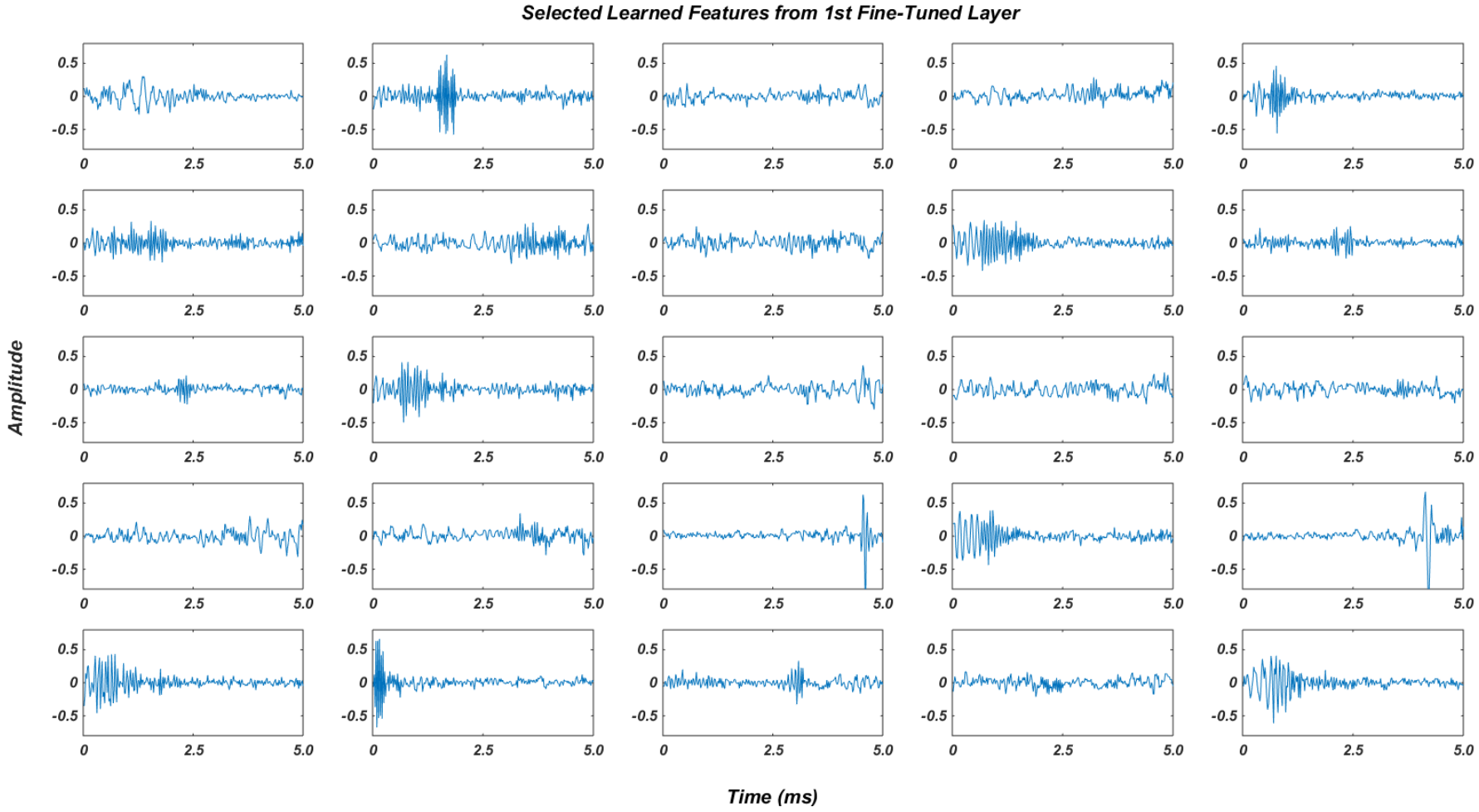
Visualization of Activity Patterns: 4th Hidden Layer





- ***Conclusion: the features learned by the DBN based auto-encoder can be used to discriminate these classes.***

Features Selected from 1st Fine-Tuned Layer

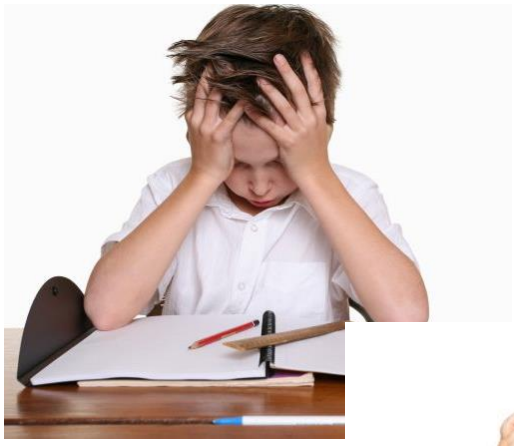


- *Selected features learned by the 1st Layer in Tilear Auto-encoder*

Low input samples vs. overfitting

Motivation

- Minimum number of training samples

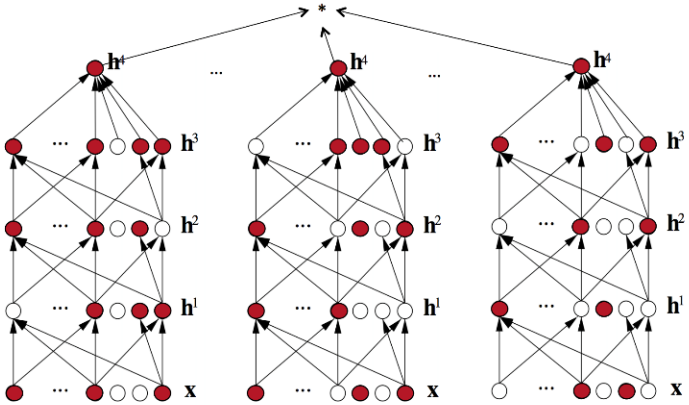


Problem

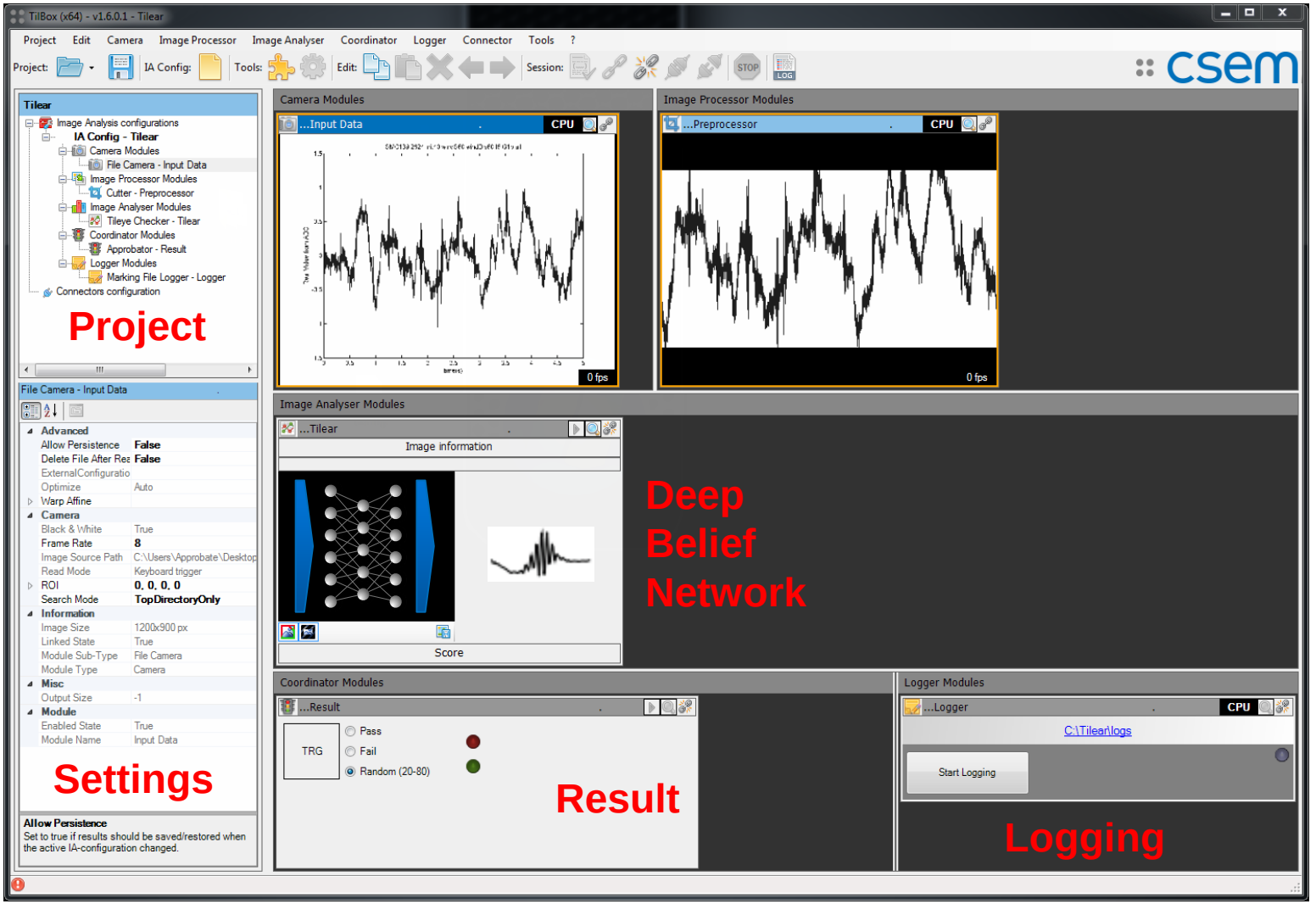
- Overfitting

Solution

- Dropout Technique



CSEM Industrial Integration



Outlook: Predictive Maintenance