30 Years of Signal Processing

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Hierarchical Approach for Decision Making

D2D Application Layer

Monitoring | Scheduling | Management | Recommendation | Understanding/ Reasoning

D2D Analysis Layer

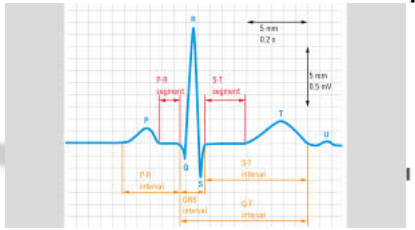
Representation Learning | Optimization | Machine/ Deep Learning | Detection/ Recognition/ Prediction | Visual Analytics

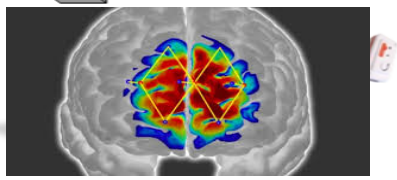
D2D Abstraction, Description, and Augmentation Layer

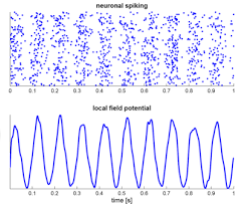
Sampling | Denoising | Encoding | Multimodal Feature Engineering | Object Segmentation | Metadata

HETEROGENEOUS

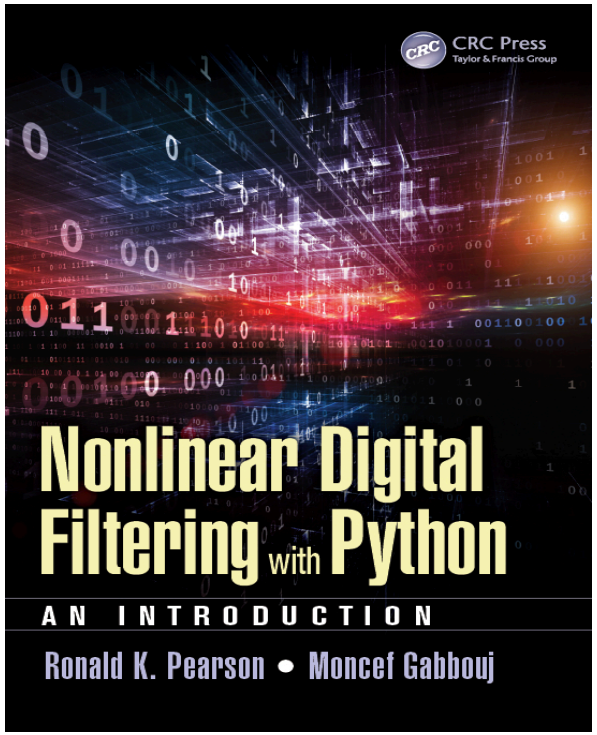
LARGE-SCALE DATA







NEUVO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AN INTRODUCTION
Ronald K. Pearson • Moncef Gabbouj


Serkan Kiranyaz
Turker Ince
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ADAPTATION, LEARNING, AND OPTIMIZATION Volume 15
Multidimensional Particle Swarm Optimization for Machine Learning and Pattern Recognition
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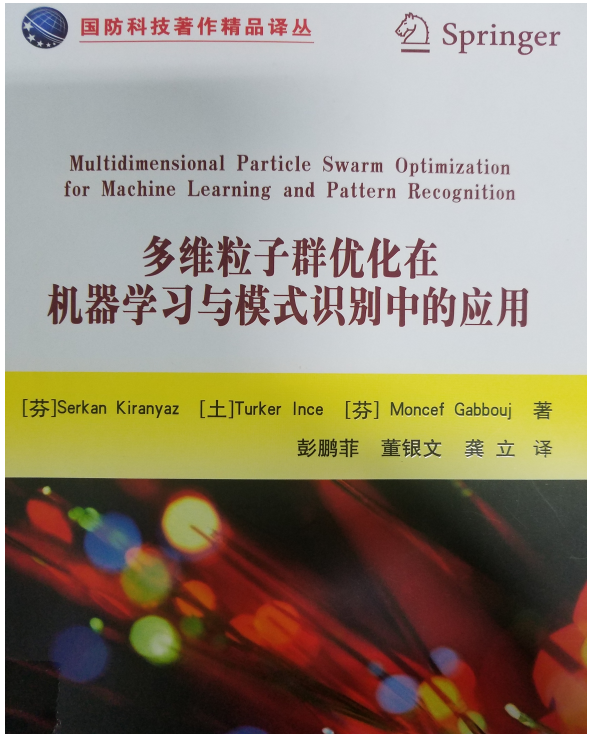
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Multidimensional Particle Swarm Optimization for Machine Learning and Pattern Recognition
多维粒子群优化在机器学习与模式识别中的应用
[芬]Serkan Kiranyaz [土]Turker Ince [芬] Moncef Gabbouj 著
彭鹏菲 董银文 龚 立 译

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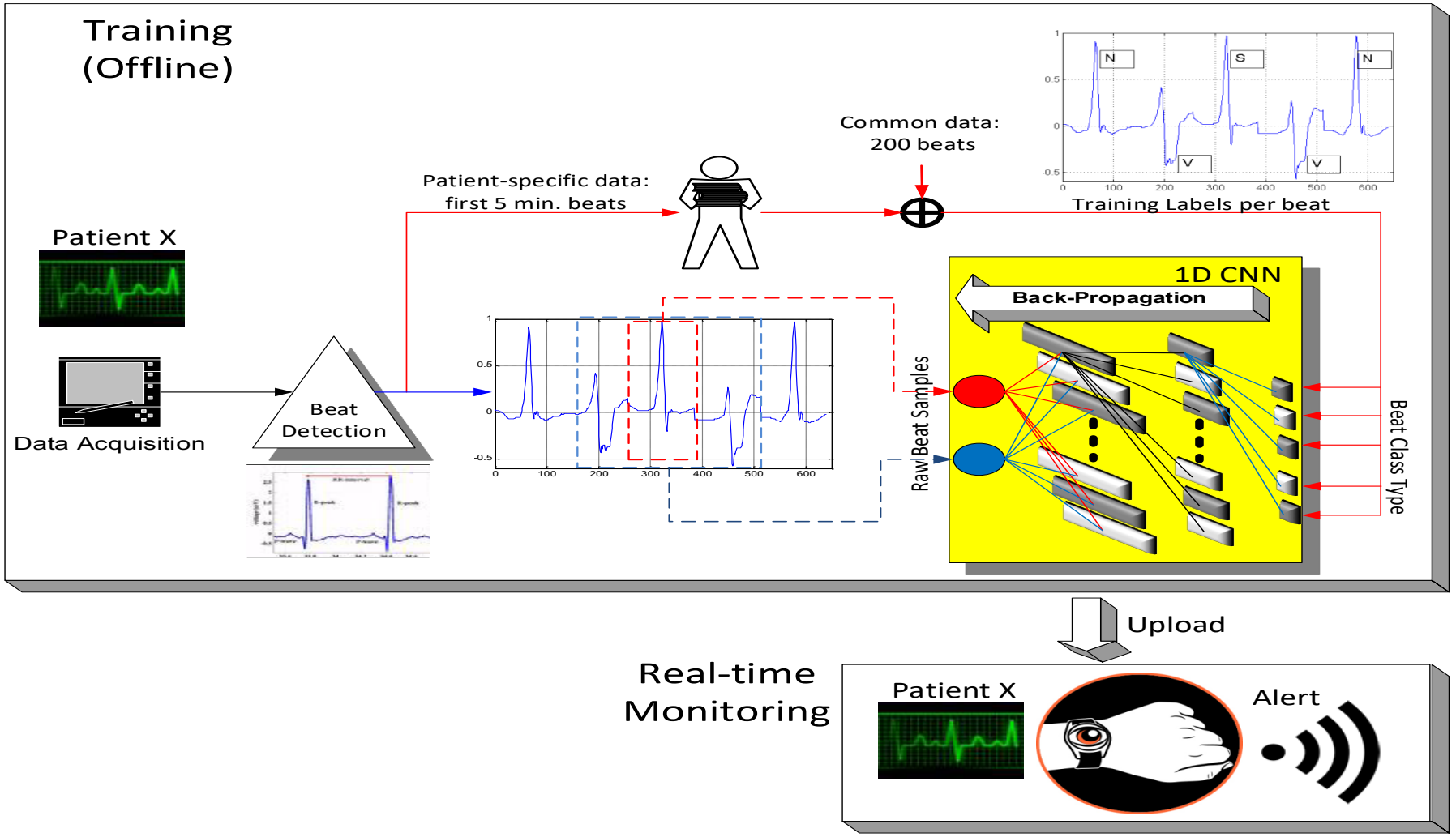
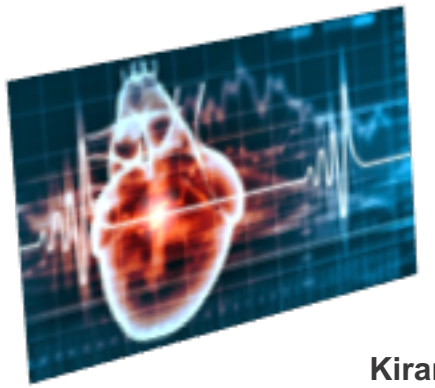
Real-Time Patient-Specific ECG Classification by 1-D CNN





Kiranyaz, IEEE Transactions on Biomedical Engineering, 2016

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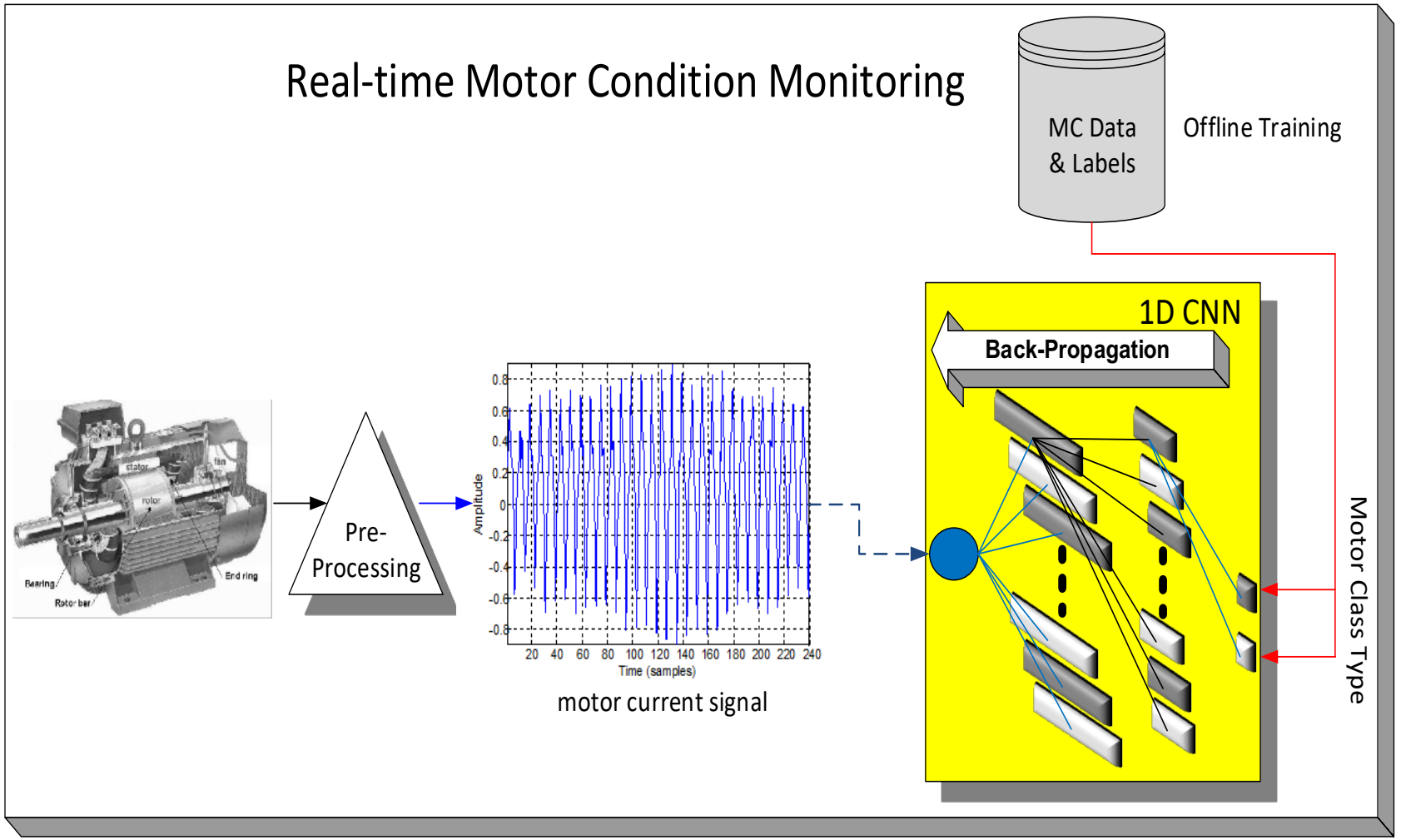
Applications of 1D CNNs
Real-time motor fault detection



Kiranyaz, IEEE Transaction on Industrial Electronics 2016

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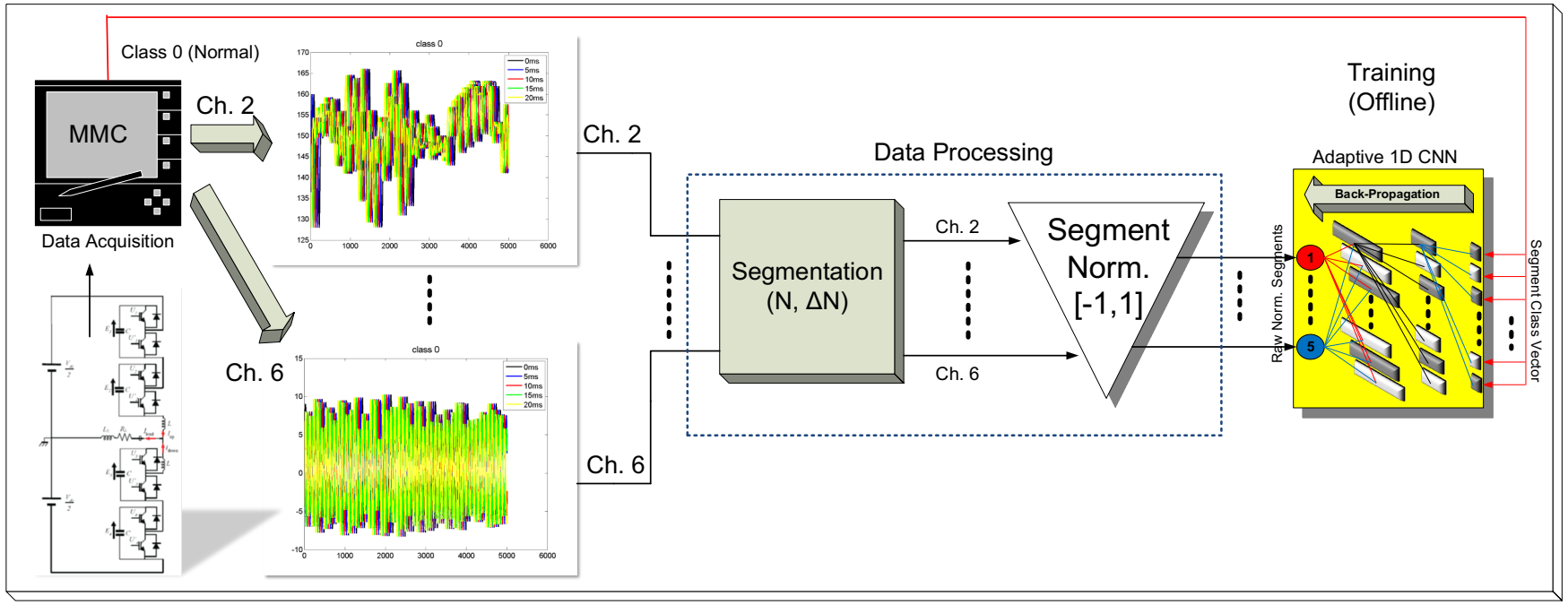
Applications of 1D CNNs

Fault detection in Modular Multilevel Converters (MMC) (High voltage to direct current conversion)



Kiranyaz, IEEE Transaction on Industrial Electronics 2019

Tampereen yliopisto
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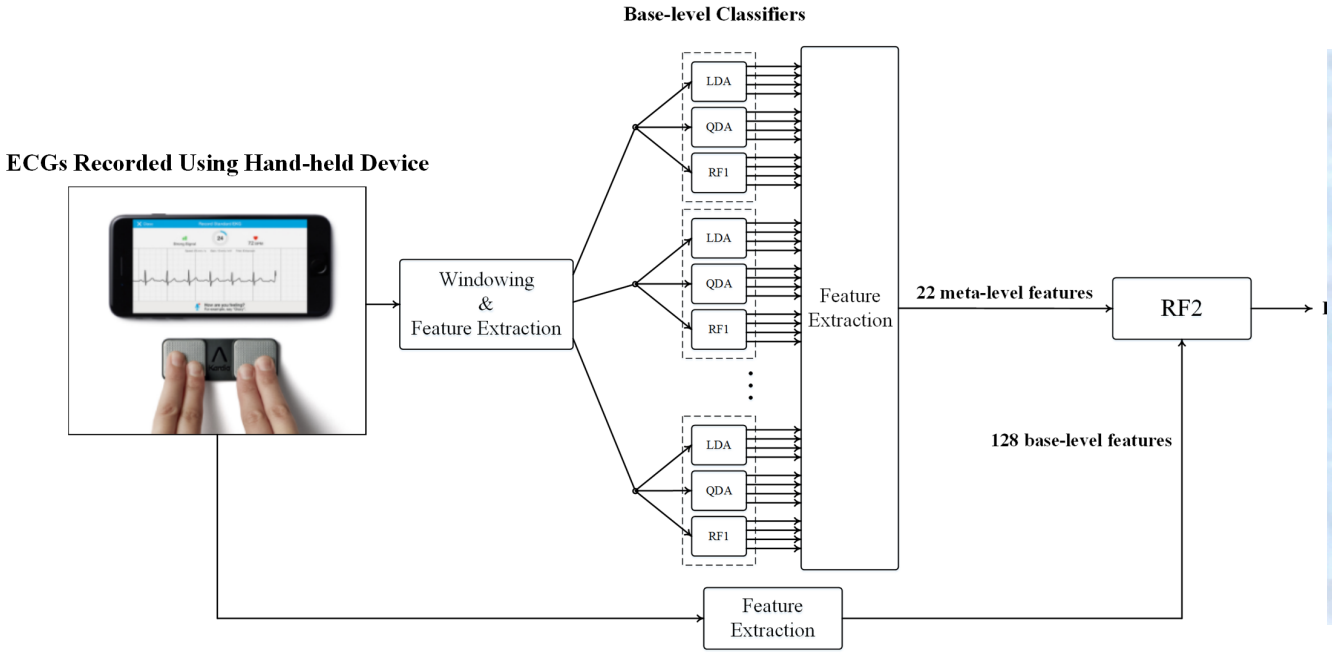
2017 Challenge: AF Detection Using Hand-held ECG Devices

Objective: To automatically detect AF rhythm using a hand-held ECG device (normal or sinus rhythm, other rhythms and too noisy rhythms to classify)

Approach: A subset of 150 features (time, frequency, time-frequency domains, and phase space reconstruction)



Evaluation Metrics	Ave. on Train Dataset (%) 10-fold cross-validation	Ave. on Test Dataset (%)
F1n (Normal)	90.49	
F1a (AF)	79.43	
F1o (Other)	75.64	
F1p (Noisy)	61.11	
F1(Total)	81.85	83

M. Zabihi, et. al., CinC, Rennes, 2017

Winner of the ***PhysioNet/CinC Challenge 2017***

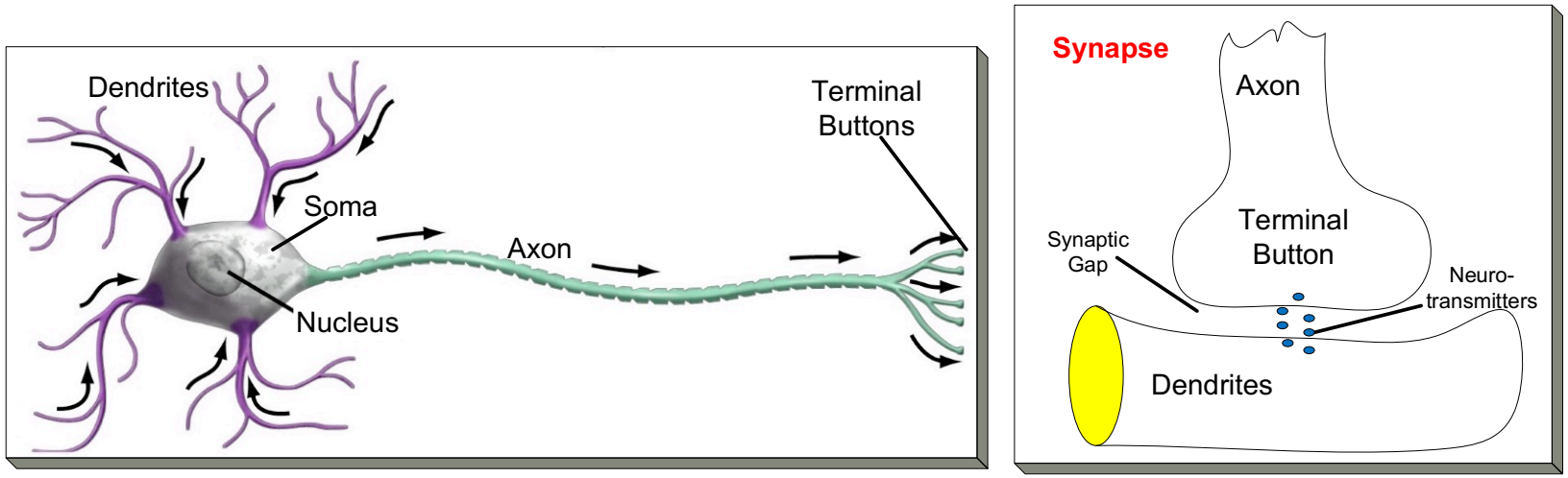
A Simple question:

- Does anybody from the audience use anything from 40s or 50s?
  …. No?

❑ Yes! You all use the classical neuron model from 40s..

W. McCulloch and W. Pitts, “A logical calculus of the ideas immanent in nervous activity,” Bulletin of Mathematical Biophysics, 5:115–133, 1943

Modelling the Biological Neuron



In the brain and nervous system, each neuron conducts electrical signals over three distinct operations:

- Modification of input signals in Dendrites
- Pooling of the modified input signals in Soma
- Sending pulses when pooled signal exceeds a limit in Axon hillock

S. Kiranyaz, T. Ince, A. Iosifidis, M. Gabbouj. Progressive Operational Perceptrons, Neurocomputing 2017.

Multilayer Perception vs. Generalized Operational Perceptron

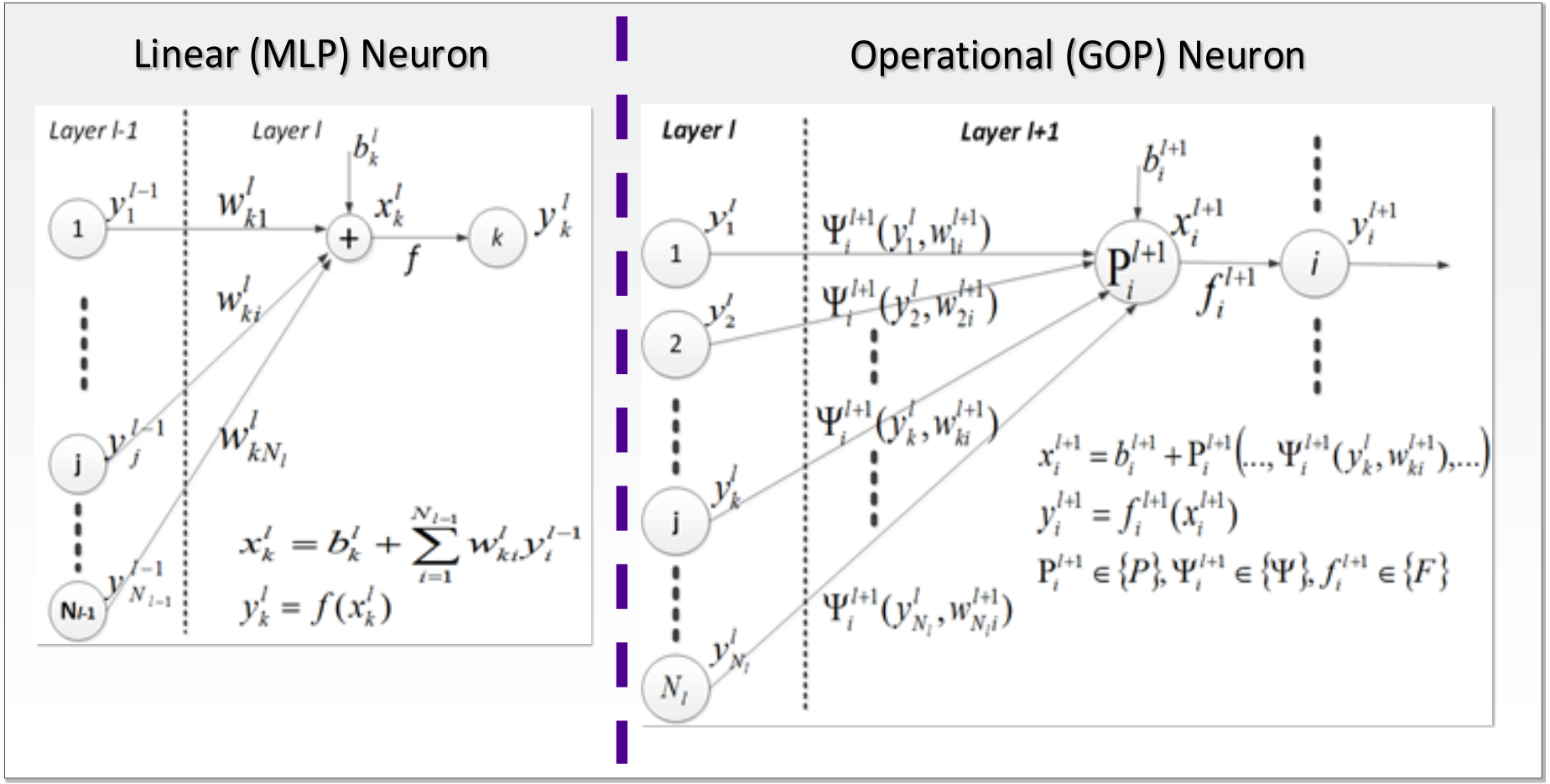


Figure 1: Conventional MLP neuron (left) vs. GOP neuron with Nodal, Ψ_i^{l+1},, Pool, P_i^{l+1} , and Activation, f_i^{l+1}, operators.

Extend CNN to Operational Neural Networks

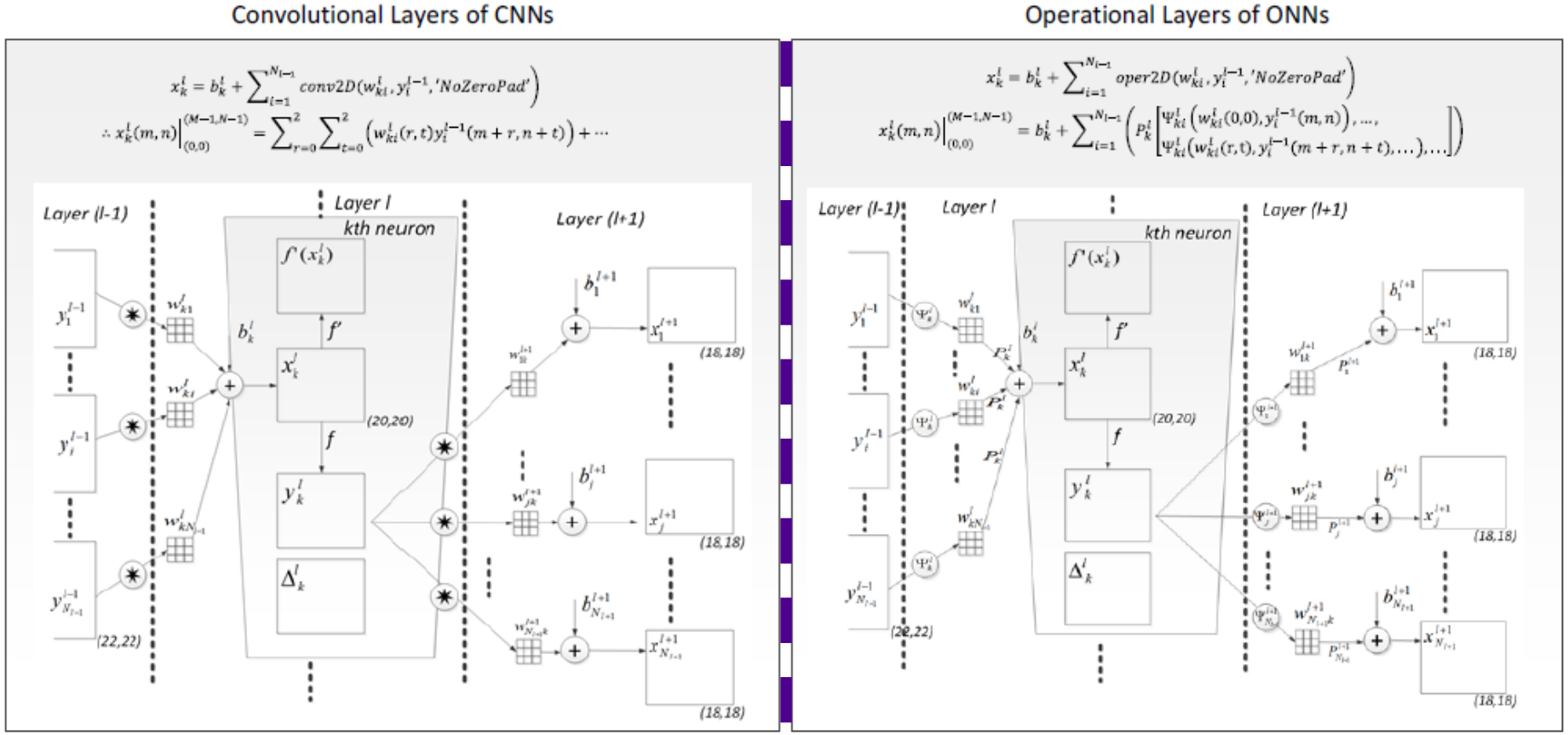


Figure 3: Three consecutive convolutional (left) and operational (right) layers with the k^{th} neuron of a CNN (left) and an ONN (right).

Kiranyaz, Iosifidis, Ince and Gabbouj, Neural Computing and Applications (2020)

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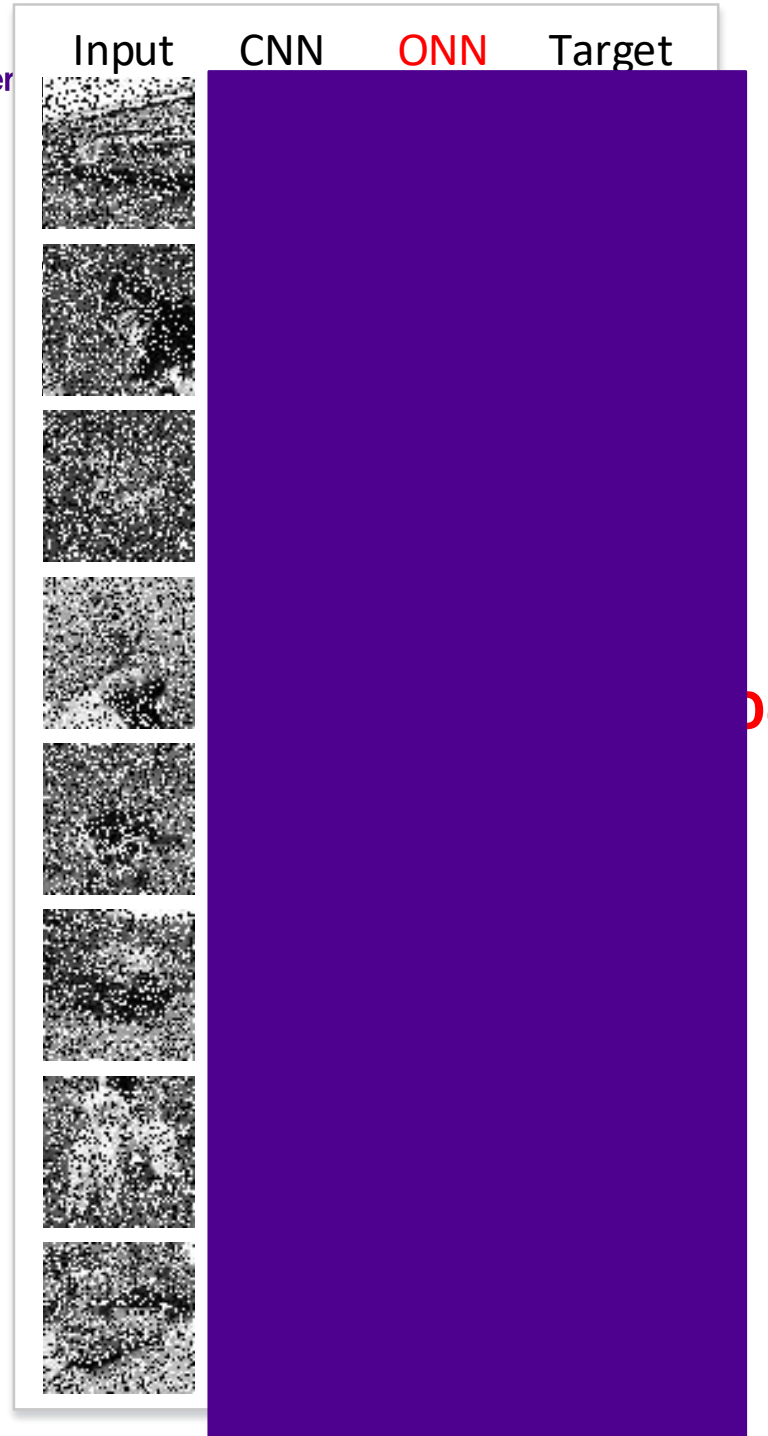
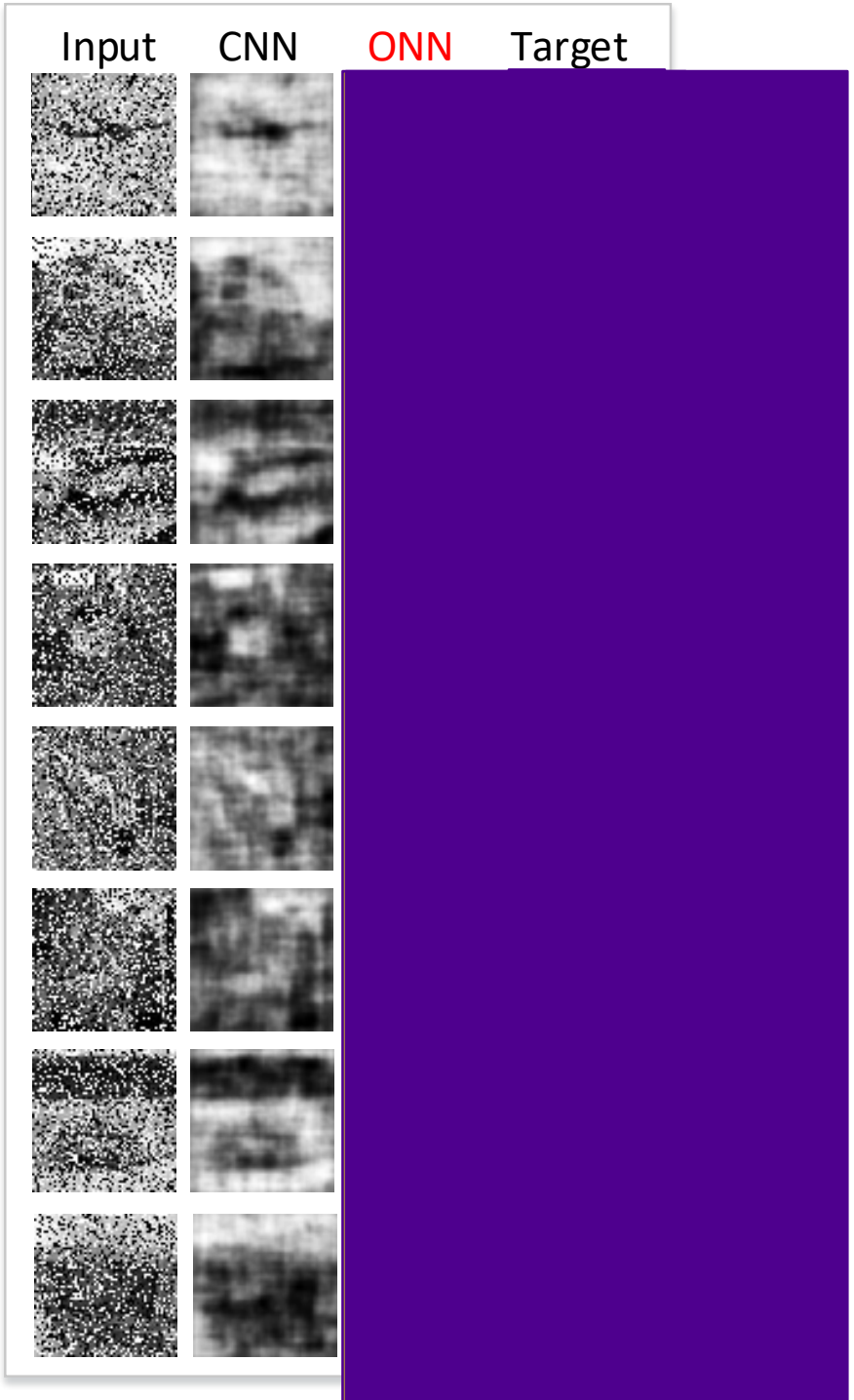
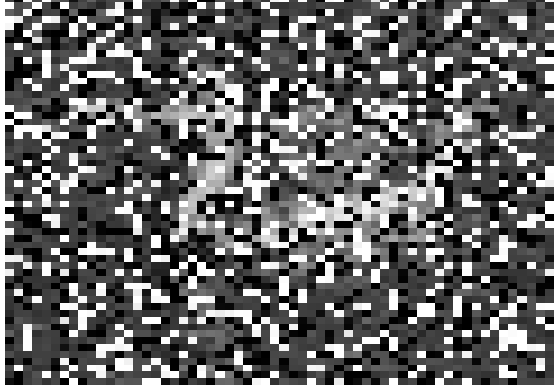
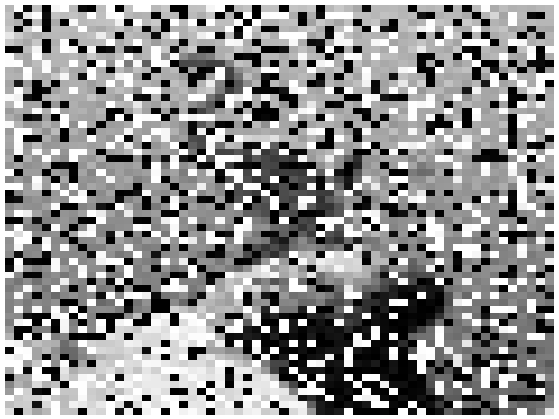
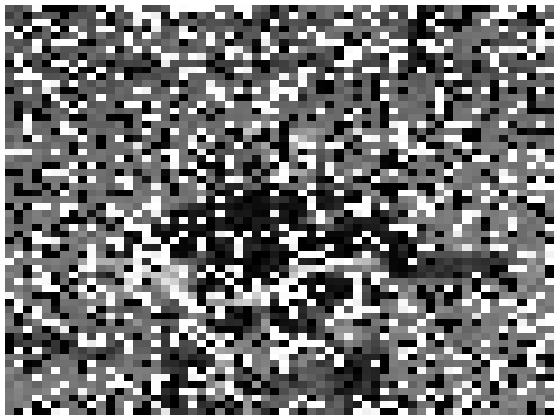


Denoising Results
(train set)









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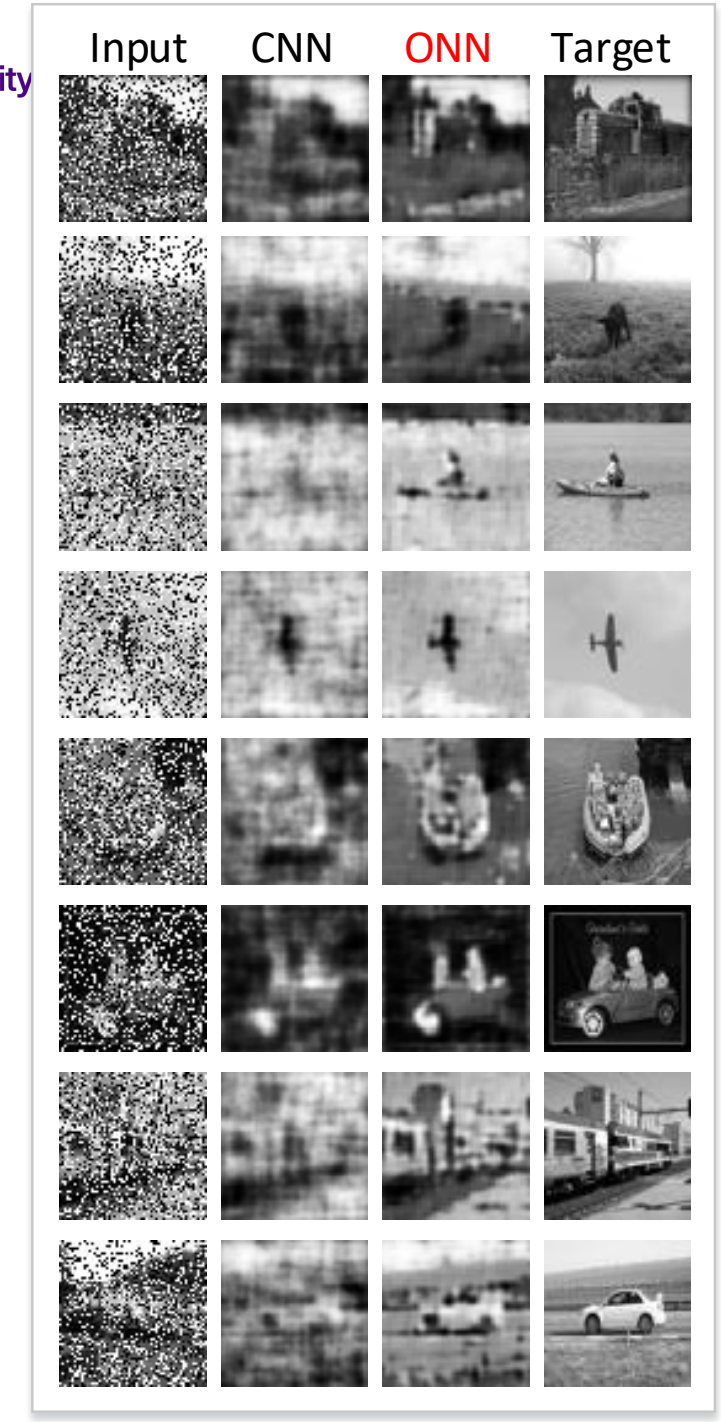
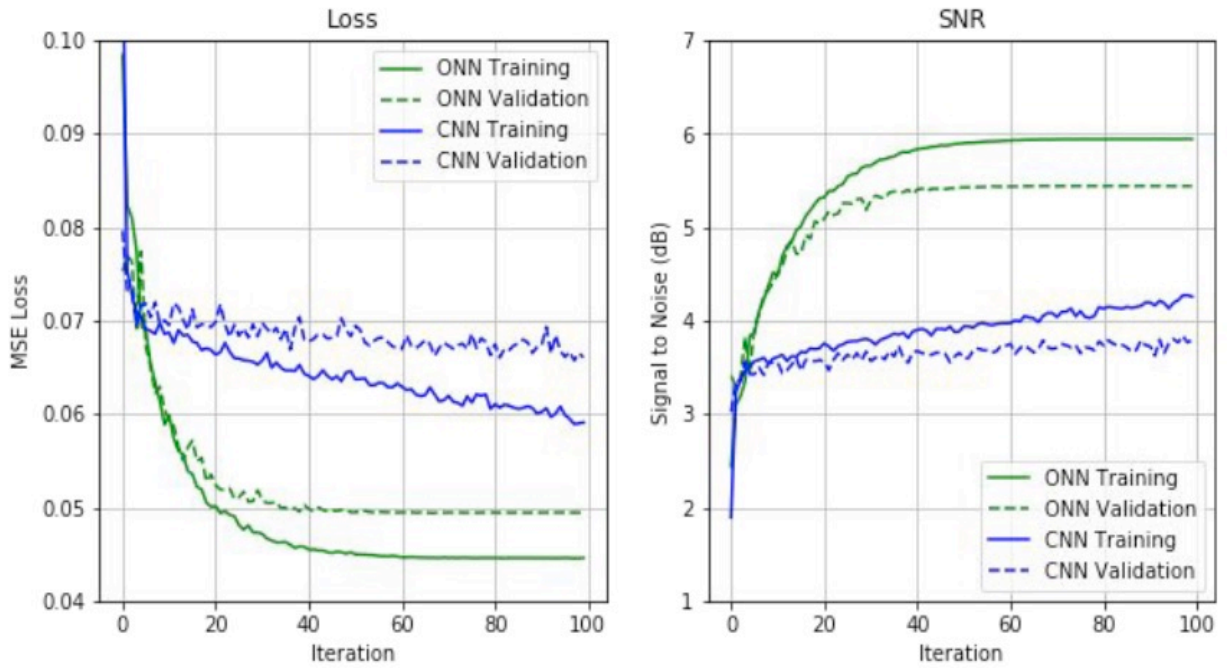


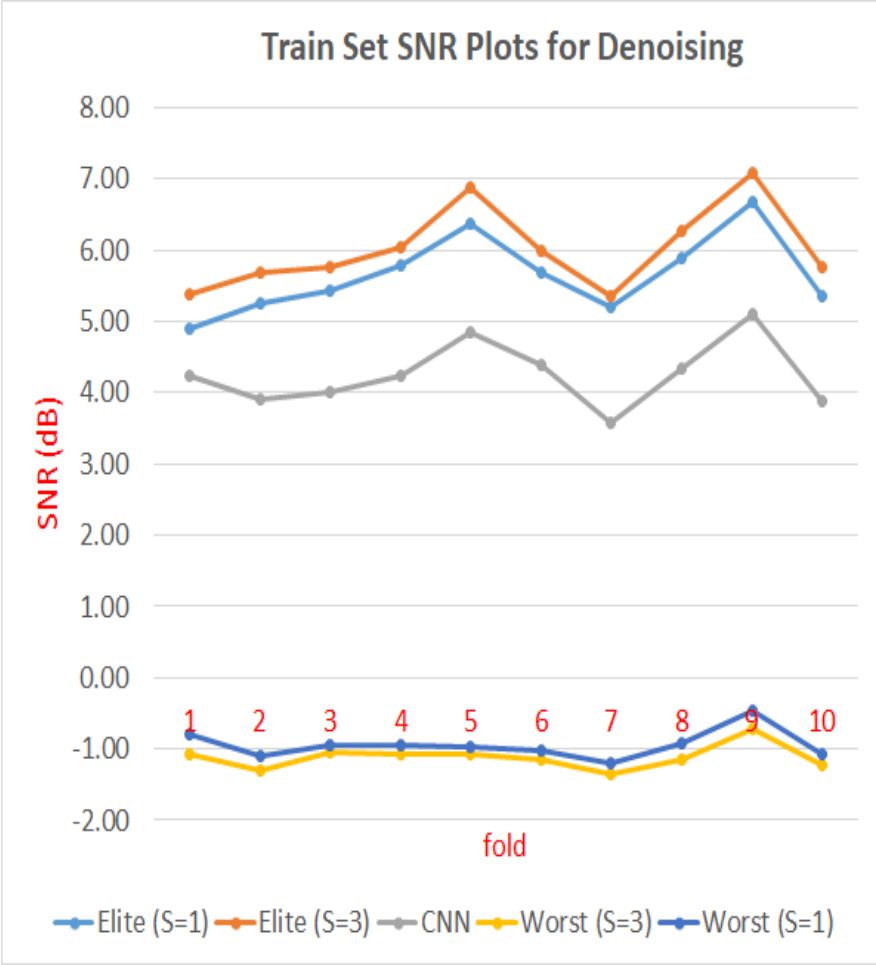
Denoising Results (test set)

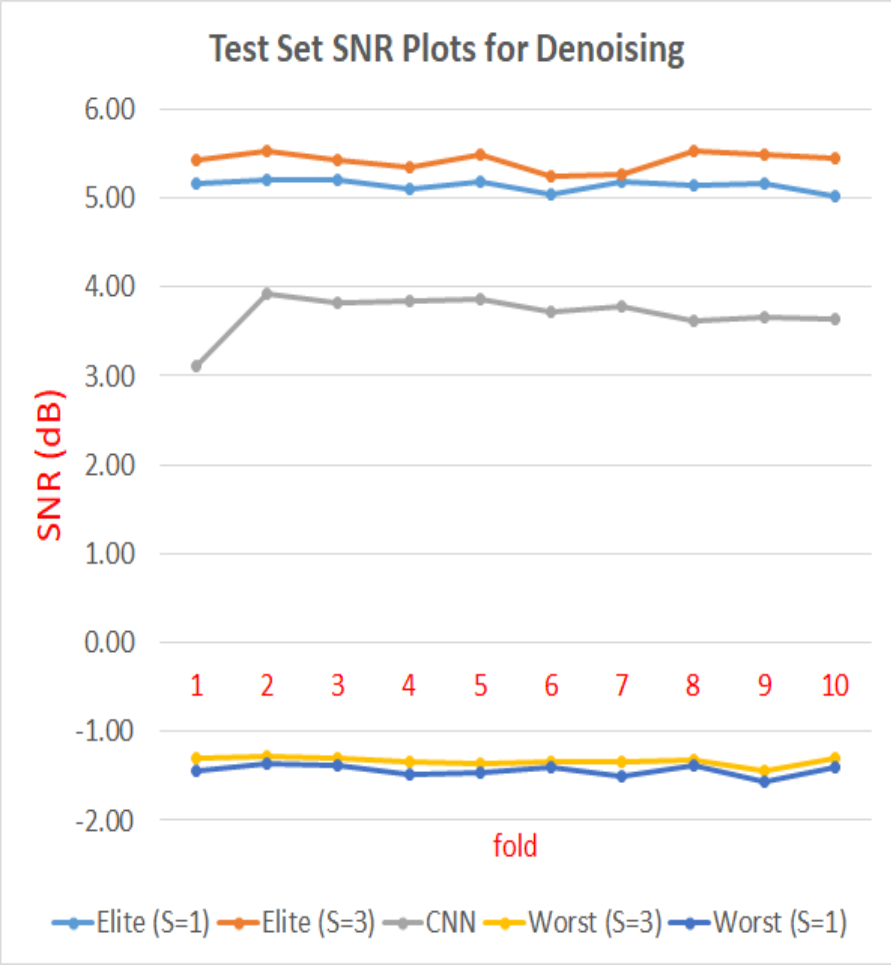
Denoising Results

Training Curves



Denoising SNR Plots





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