Intelligent
Embedded Systems

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Leveraging Repeated Unlabelled Noisy Measurements to Augment Supervised Learning

26.11.2023

Birk Magnussen

What We Do

Intelligent Embedded Systems

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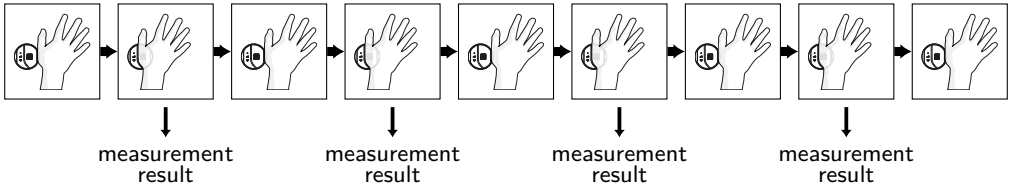
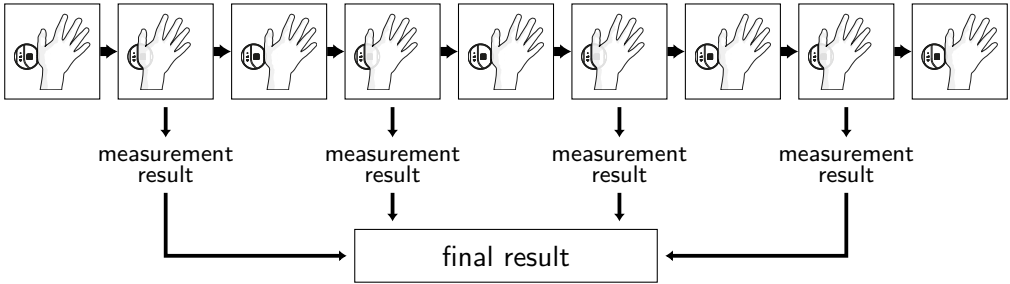
- Engineering and research for spectroscopy-based sensors
- Development of sensors using multiple spatially resolved reflection spectroscopy

→ Concentration of carotenoids in human skin

High-Precision Measurement



High-Precision Measurement



Available Dataset

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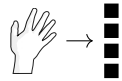

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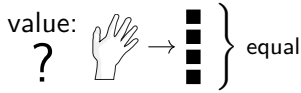

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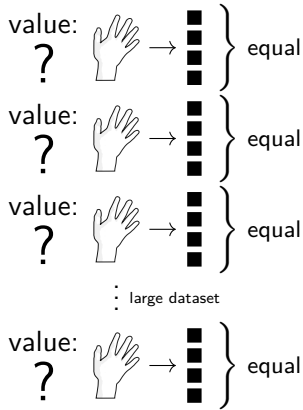

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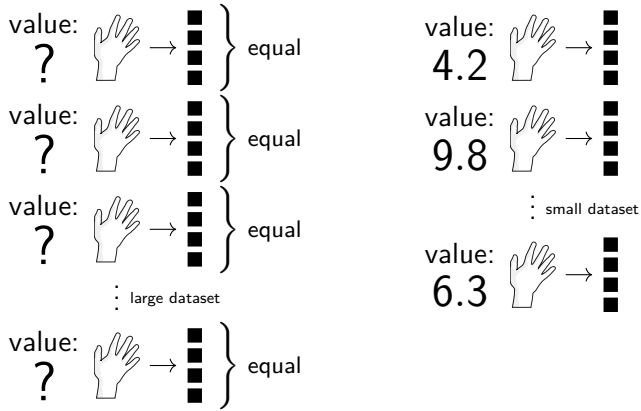

Goals For Precision Dataset

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Labelled Data

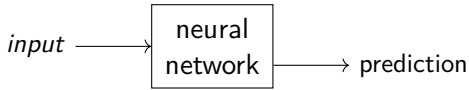
Less required data to achieve the same prediction accuracy

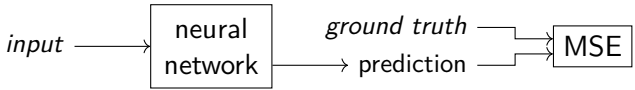
Noise

Less variation in measurements that should be equal

Training Loop

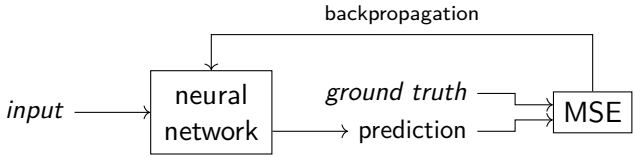
Supervised Learning




input
neural network
ground truth
prediction
MSE

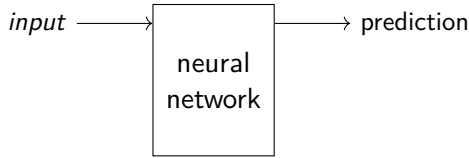
Training Loop

Supervised Learning



Training Loop

Known-Equal Learning



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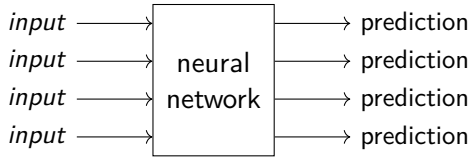

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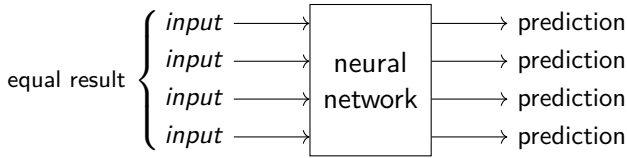

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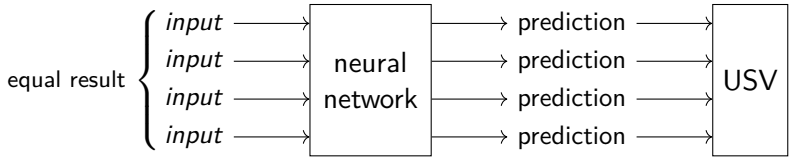

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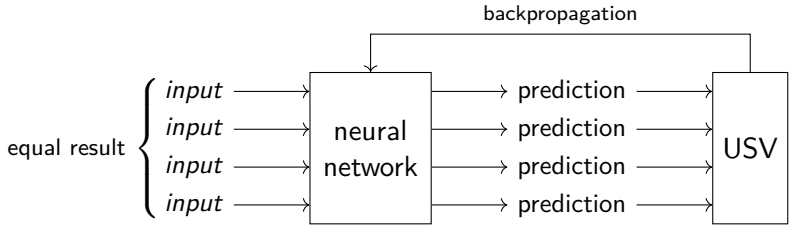

Training Loop

Combined Learning

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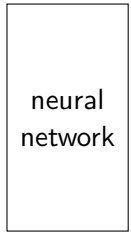
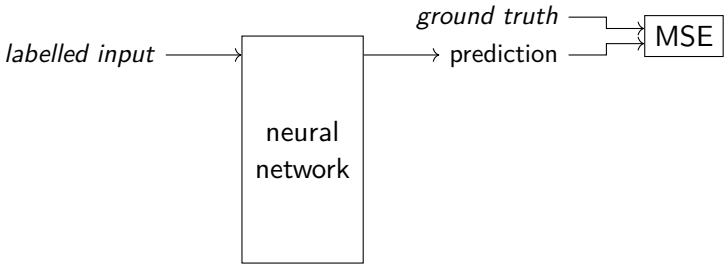
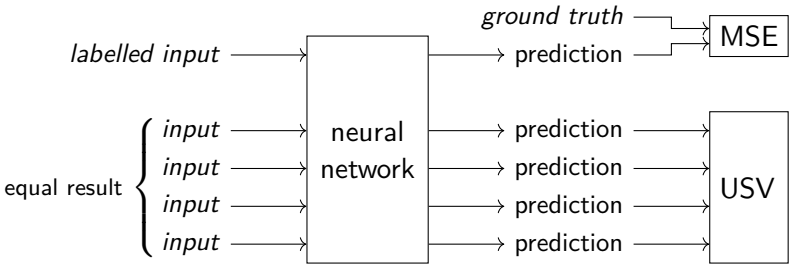
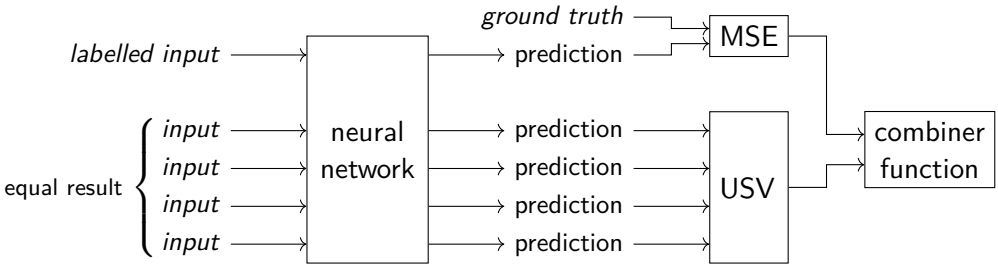



ground truth
MSE
labelled input
prediction
neural network


ground truth
MSE
labelled input
prediction
equal result
input
input
input
input
neural network
prediction
prediction
prediction
prediction
USV

Training Loop

Combined Learning



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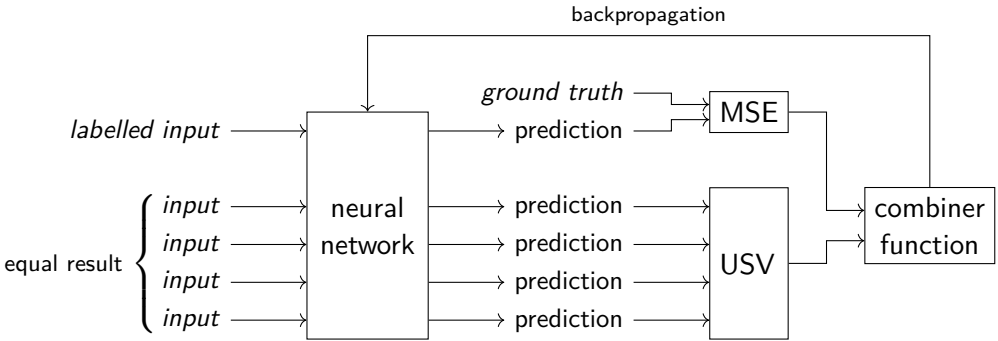

Combiner Functions

Requirements:

- Well defined for the range of the loss, usually $\mathbb{R}_{\geq 0}$
- Global minimum for minimal input losses
- Strictly monotonous wrt. to all input losses

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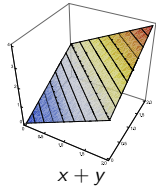

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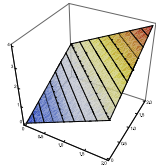
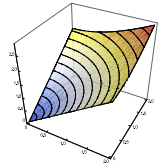


$x + y$



$\sqrt{x^2 + y^2}$

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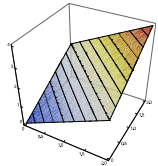

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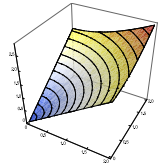

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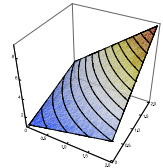

$(x + 1) \cdot (y + 1)$

Results

Required Labelled Data

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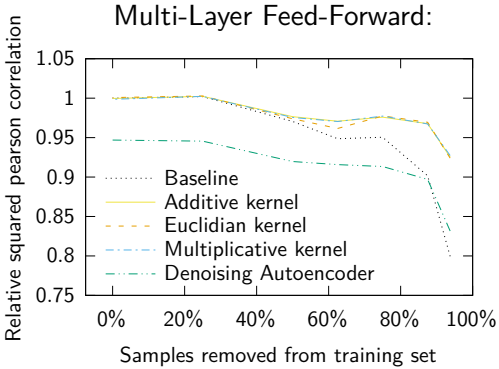

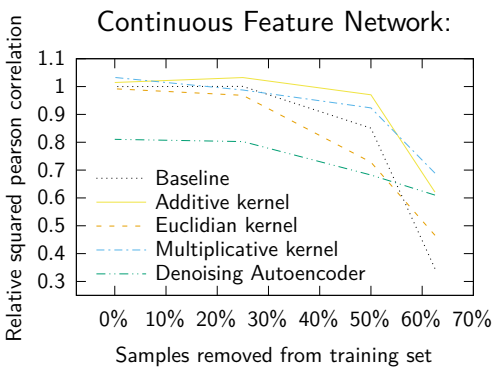

Results

Reduced Prediction Noise

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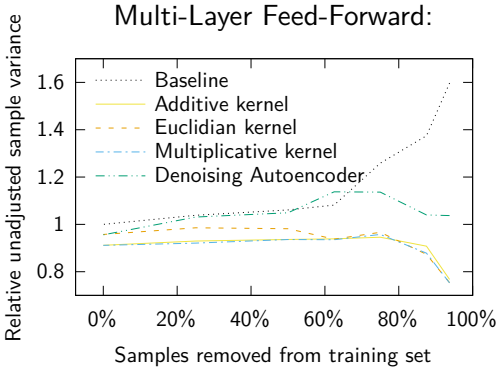

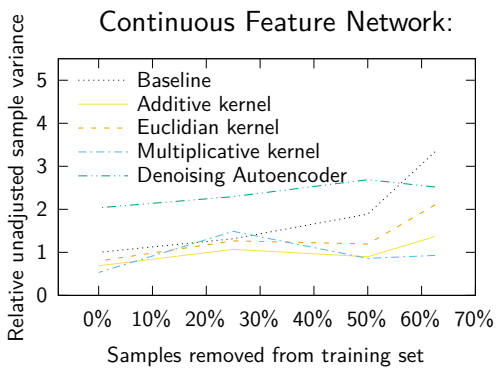

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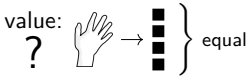
Known-Equal Data



Conclusion

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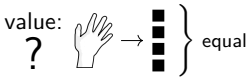
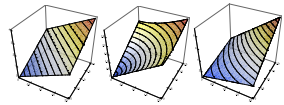
Known-Equal Data



Combiners



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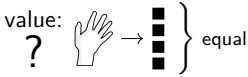

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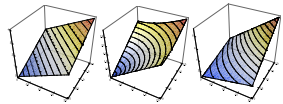
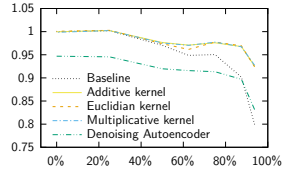
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