Intelligent
Embedded Systems

opsolution
spectroscopic systems

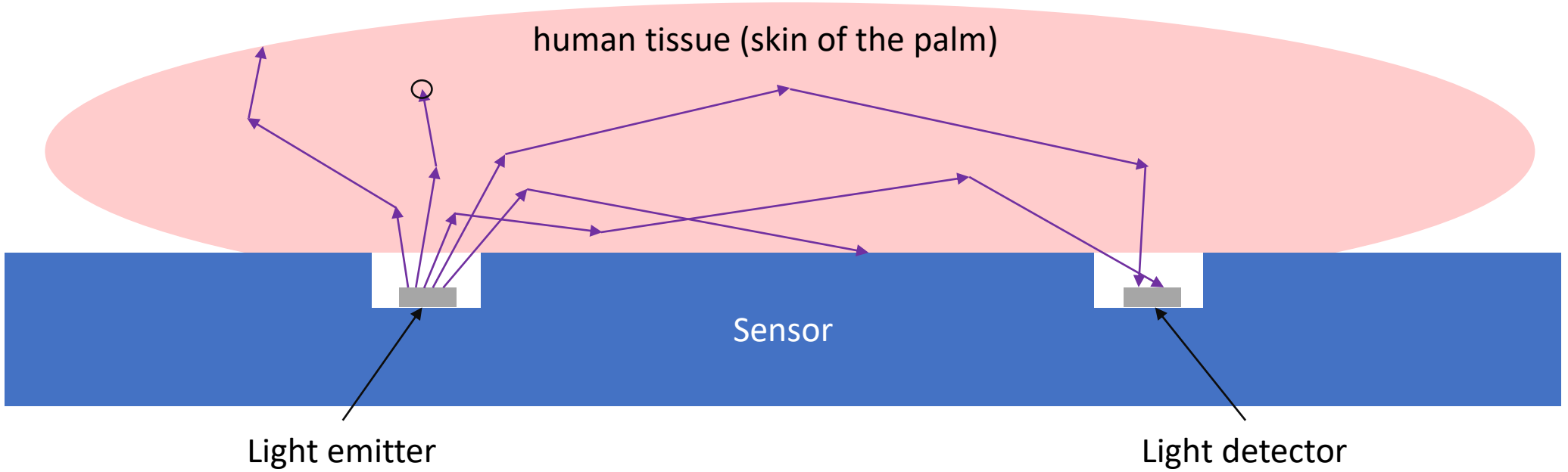
Utilizing Continuous Kernels for Processing Irregularly and Inconsistently Sampled Data With Position-Dependent Features

What we do

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

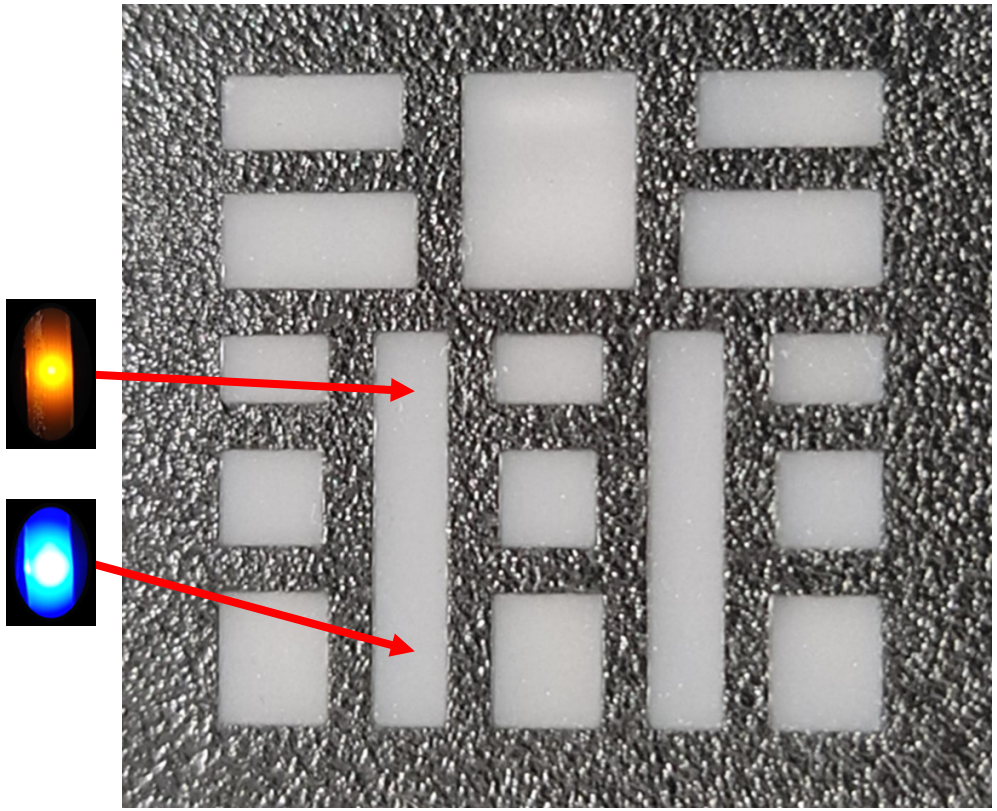
→ Concentration of carotenoids in human skin

How does MSRRS work



○ = absorbed photon

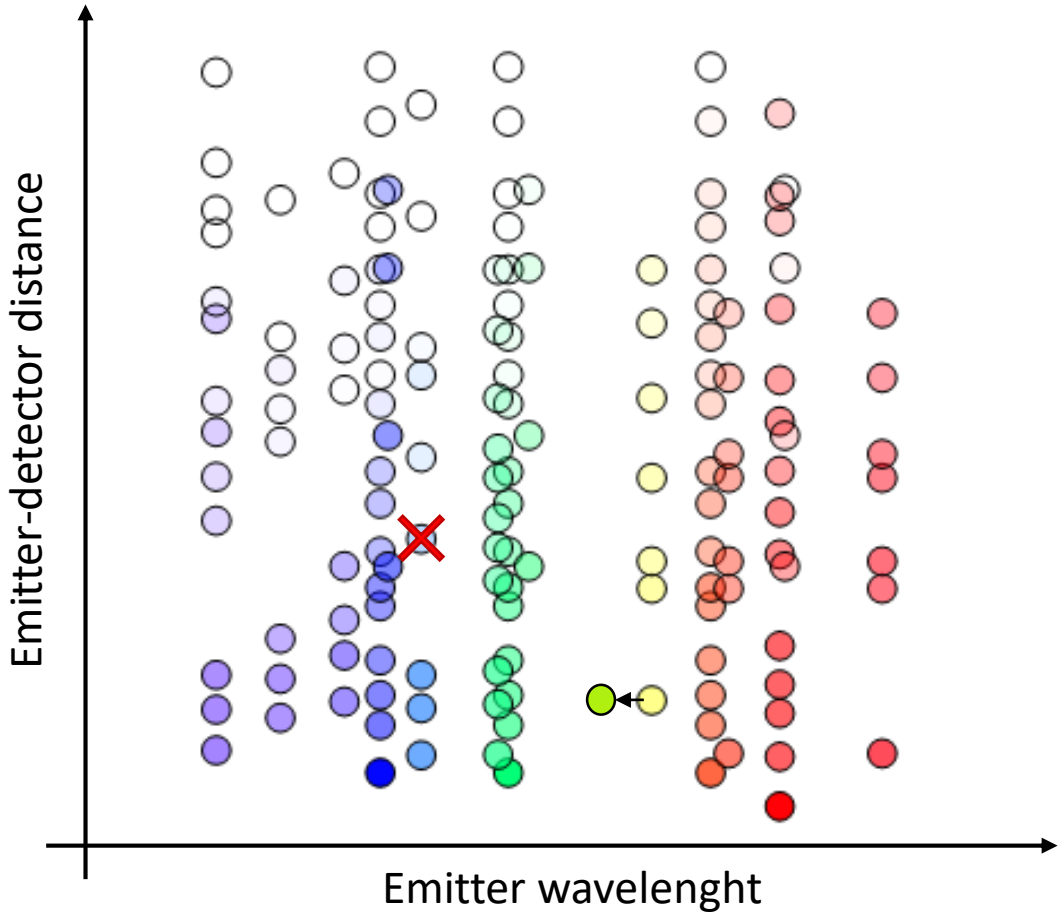
How does MSRRS work



- Multiple emitters
  - Including different wavelenghts
- Multiple detectors
- Each detector-emitter pair provides a data point

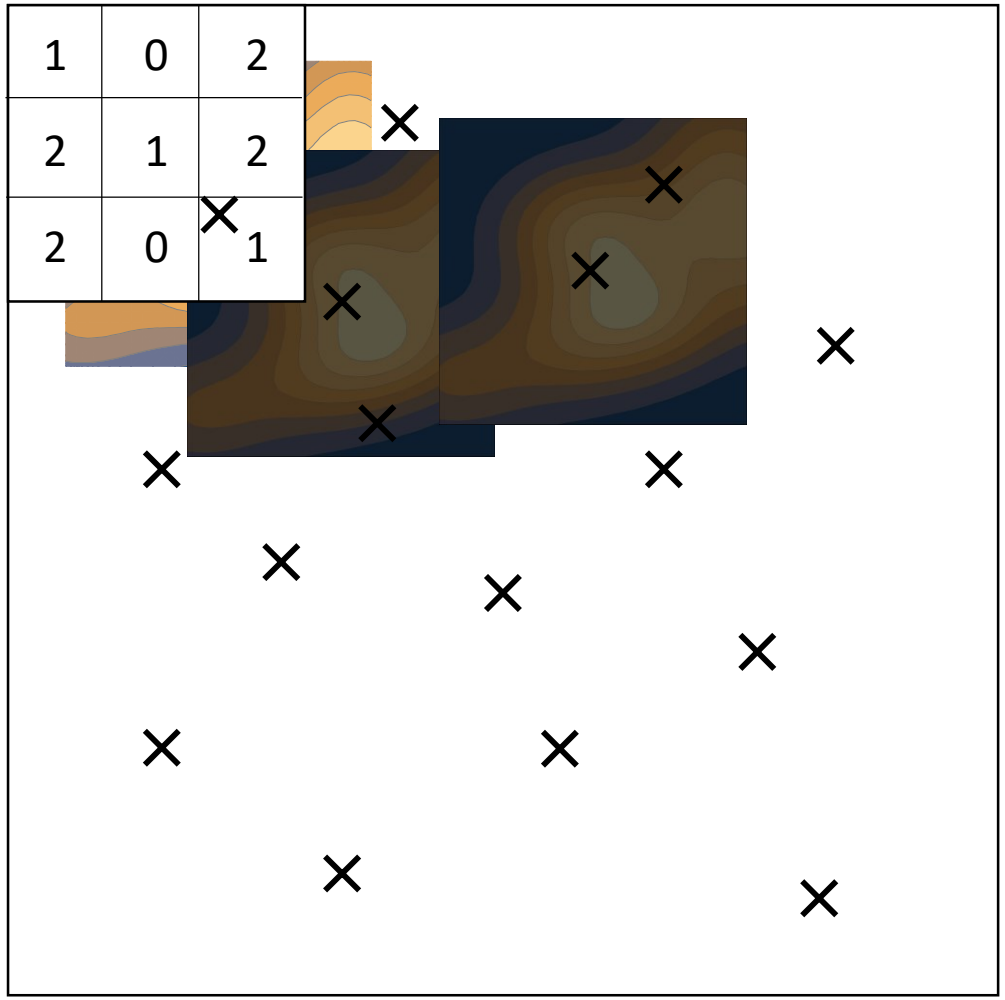
→ Many different data points for different detector-emitter distances and wavelengths

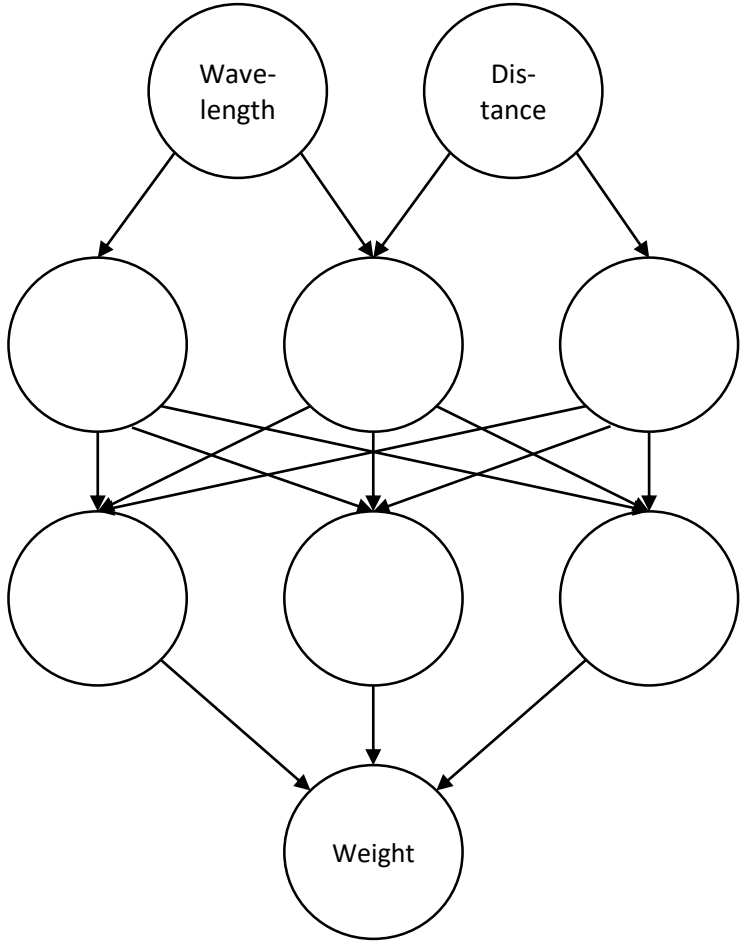
MSRRS data



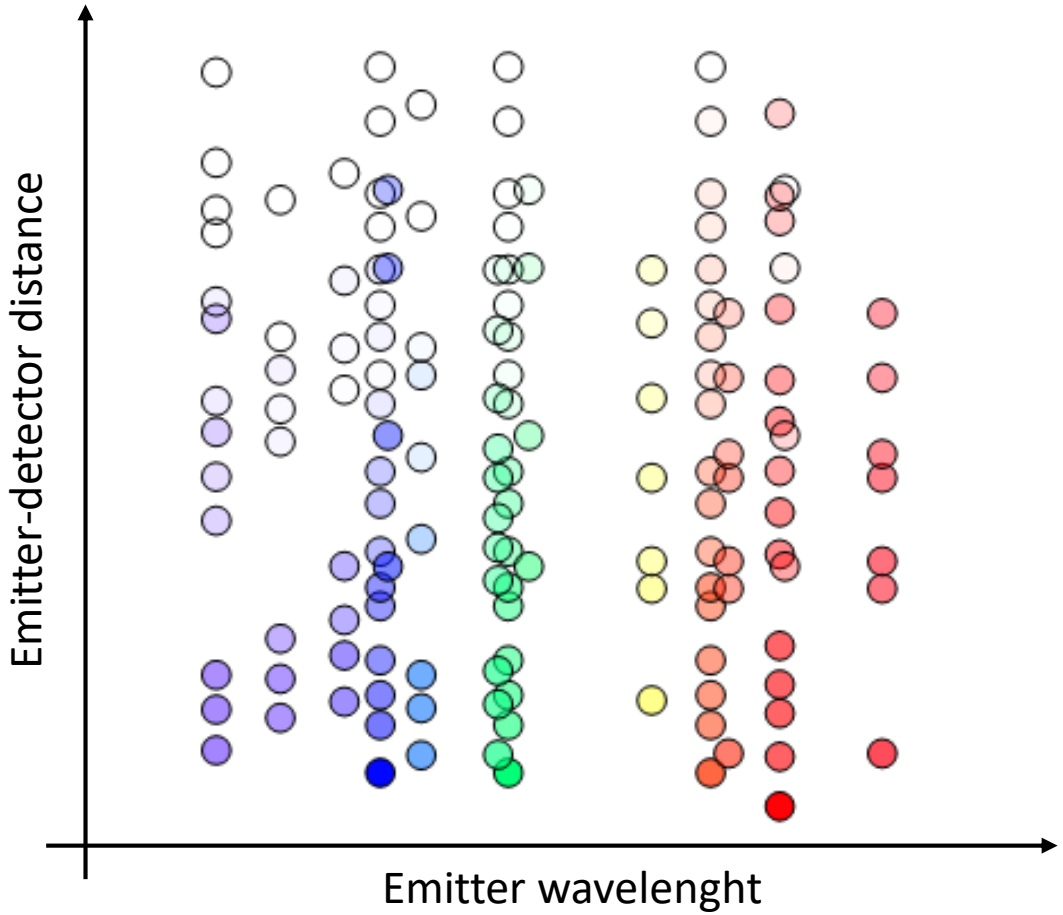
- Irregular data
  - Wavelength not sampled regularly
  - Distance not sampled regularly
- Inconsistent data
  - Production inaccuracy of emitters
  - Failing detectors or emitters
  - Changes between sensor revisions

Continuous Kernels





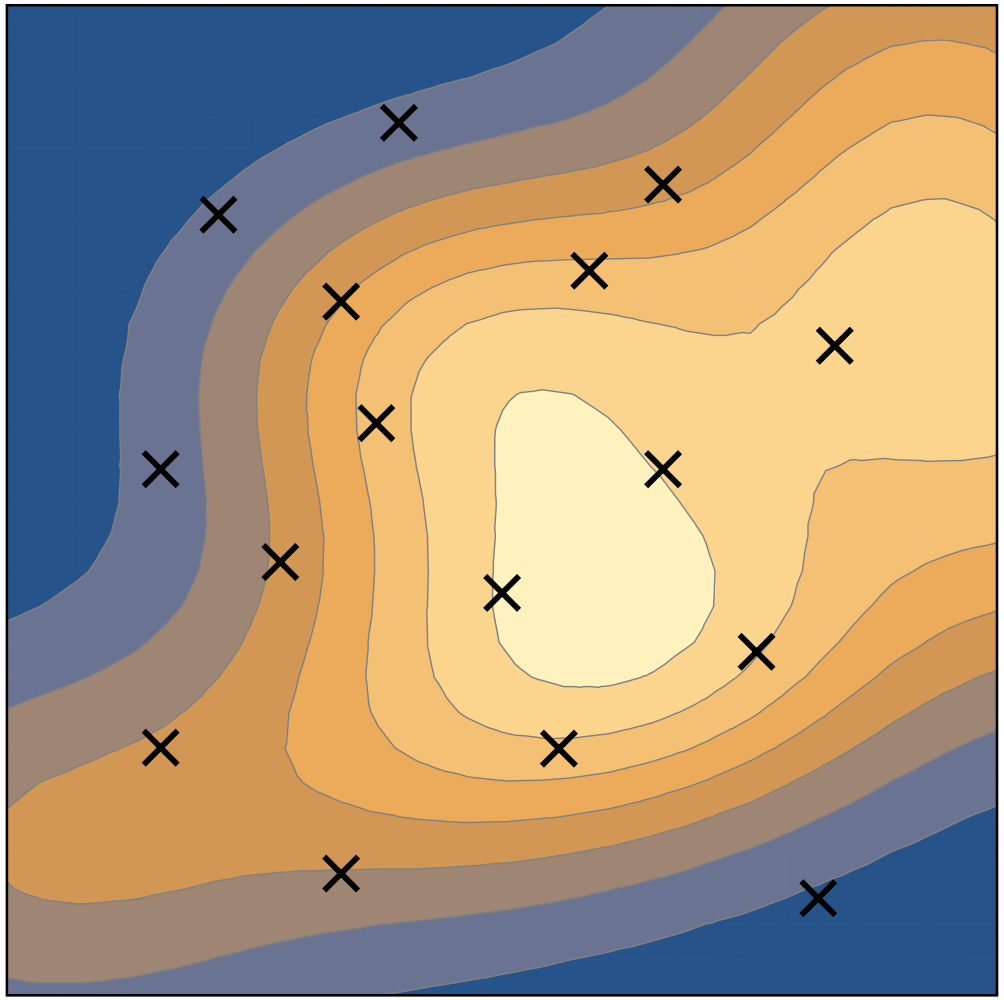
Use of CNNs for MSRRS



- Data is NOT in shape of absorption curve
- Distance and wavelength is as important as the value of the absorption

→ Translational invariance of CNN with pooling is undesired

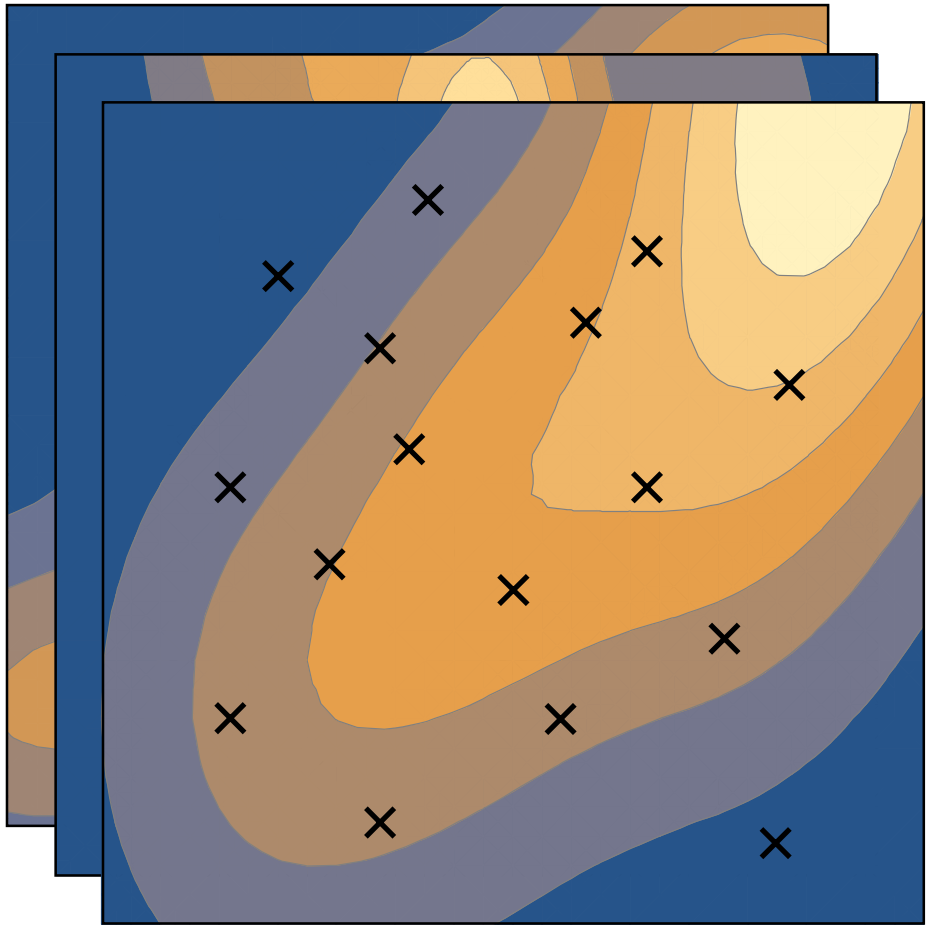
Globally applied Continuous Kernel



Weighted sum*

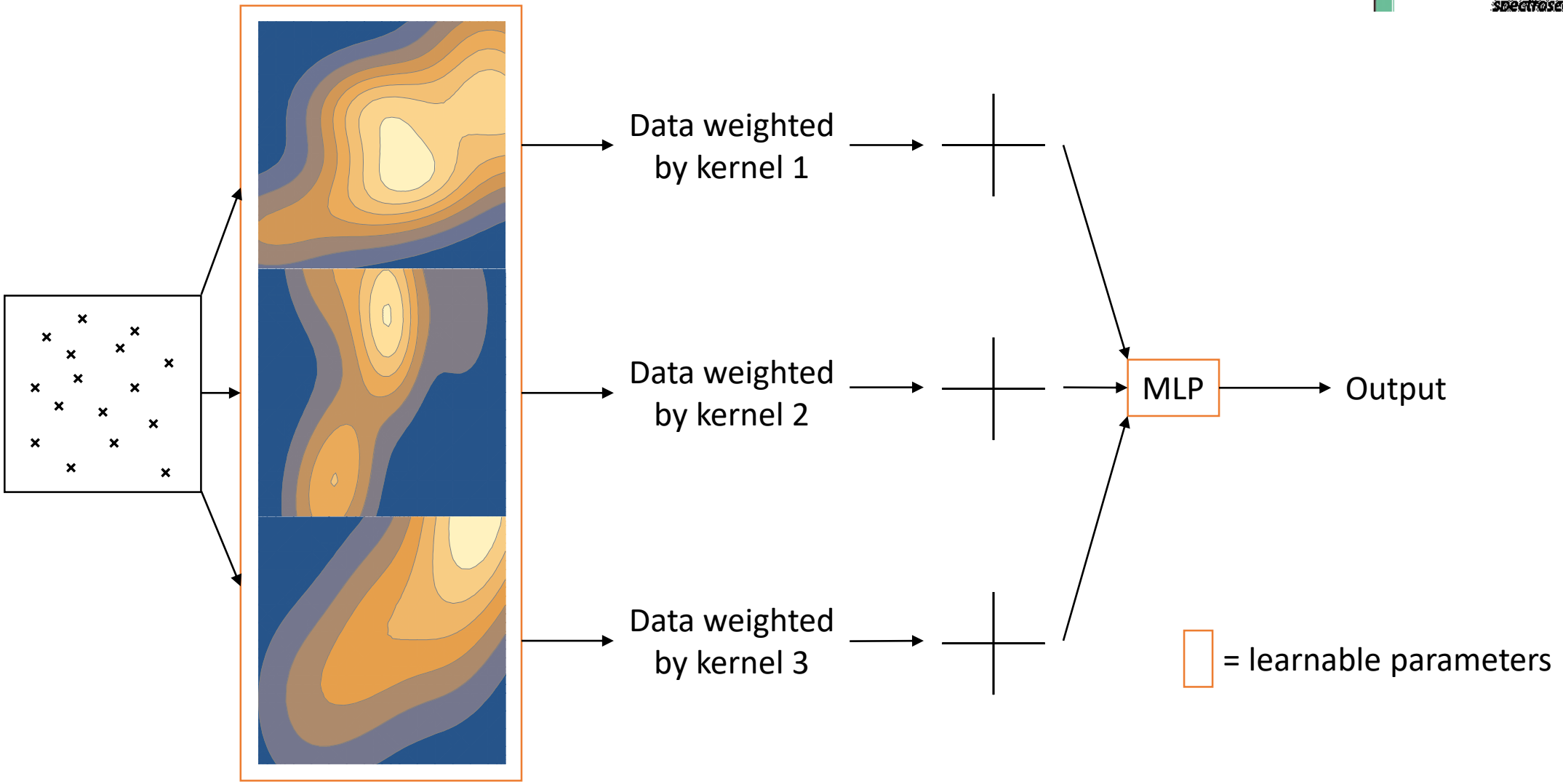
* Point density must be considered

Continuous Feature Layer

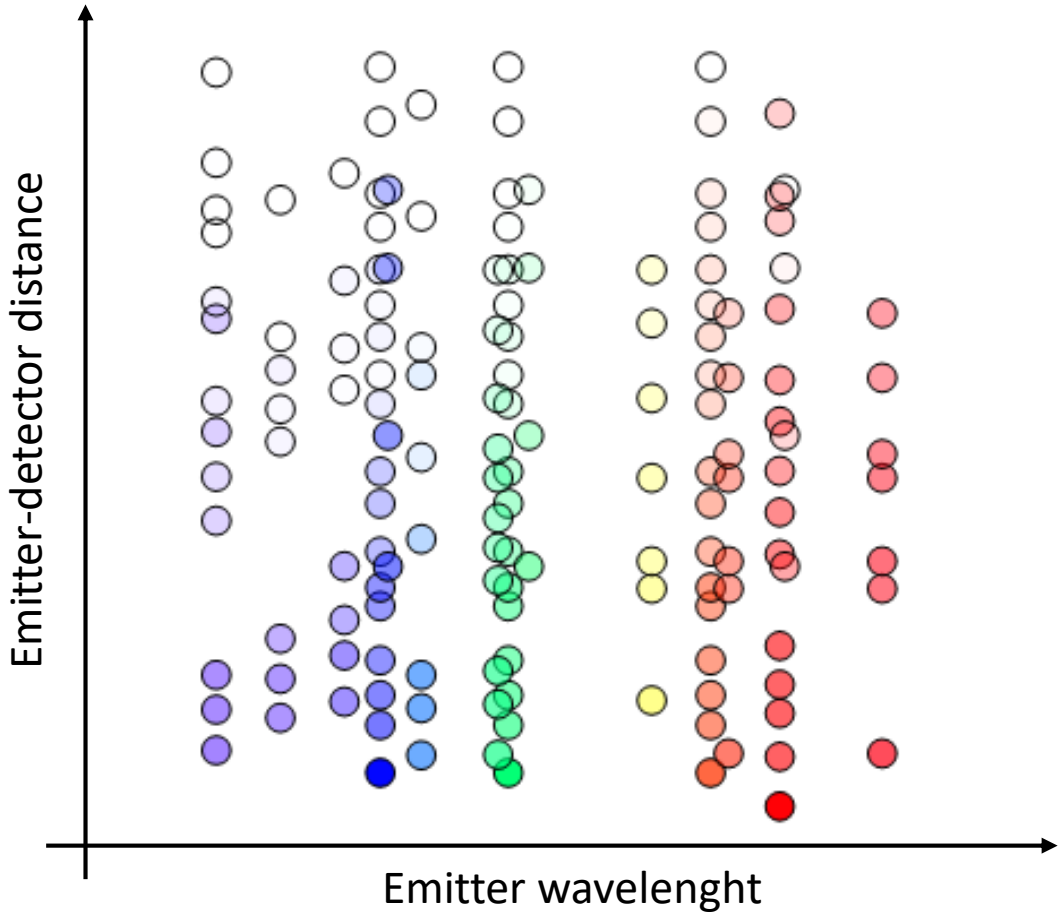


Fixed-size vector
of weighted sums

Continuous Feature Network

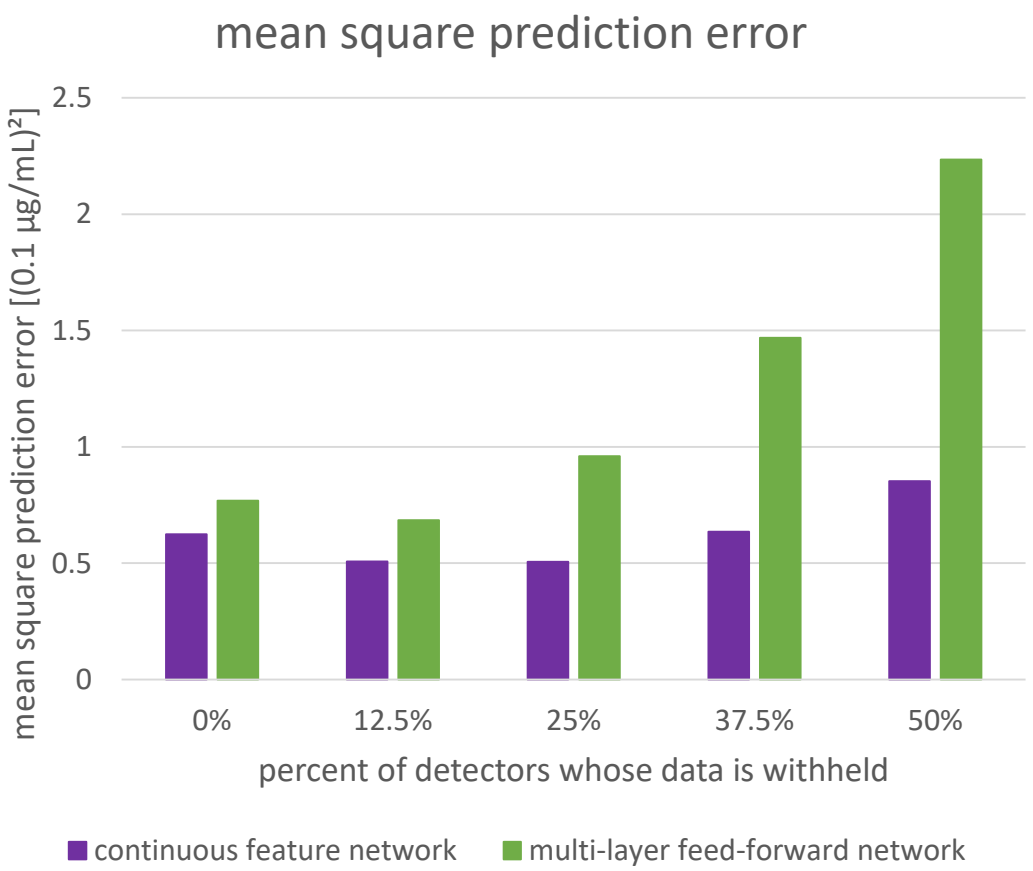


Use-case scenario



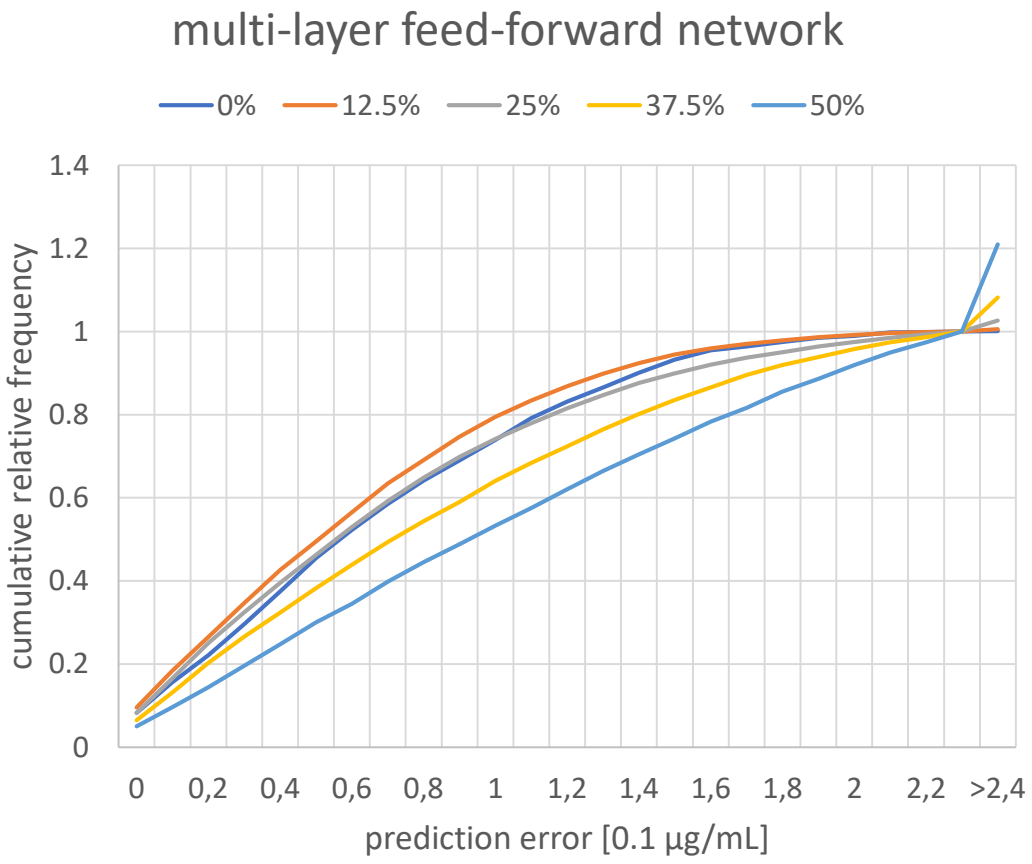
- Prediction of carotenoid concentration in human skin
- Test for inconsistent data during inference by withholding data of random detectors
- Continuous feature network with 64 kernels
- Multi-layer feed-forward network of similar size as comparison

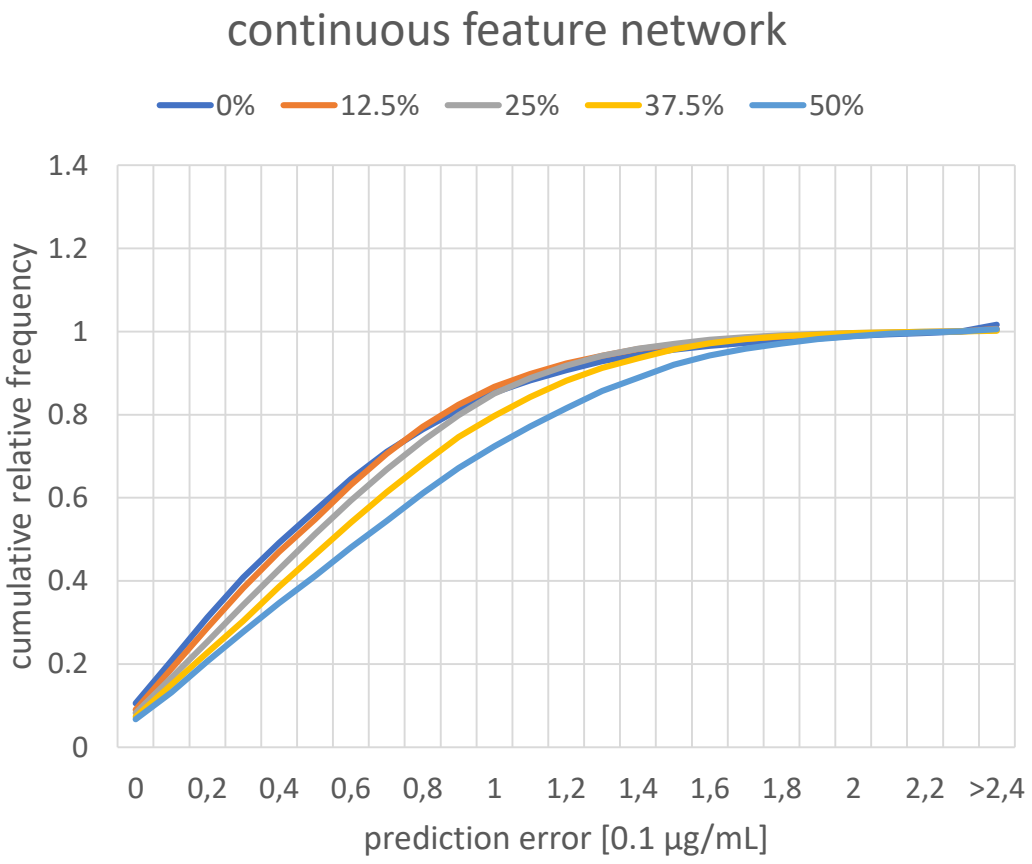
Results



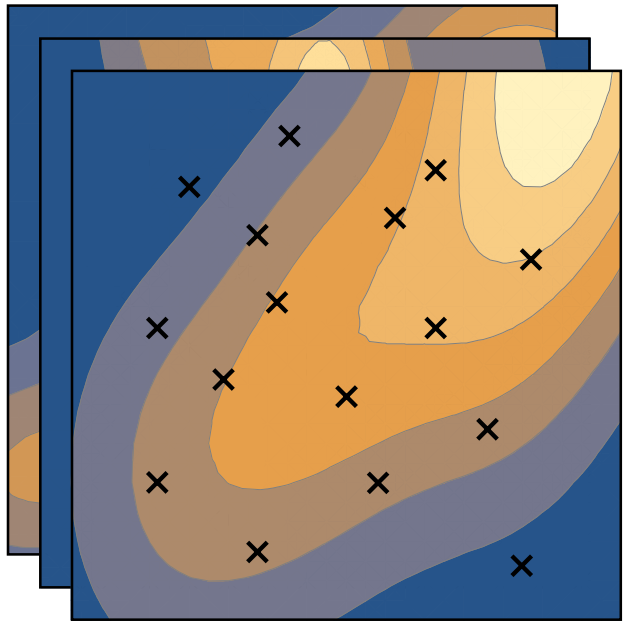
- Continuous feature network has consistently lower error
  - Capable of using measured emitter wavelength data
  - Optimized for type of data
- Continuous feature network is stable with less data
  - No error due to inaccurate data imputation
  - Capable of adapting to less available data during inference

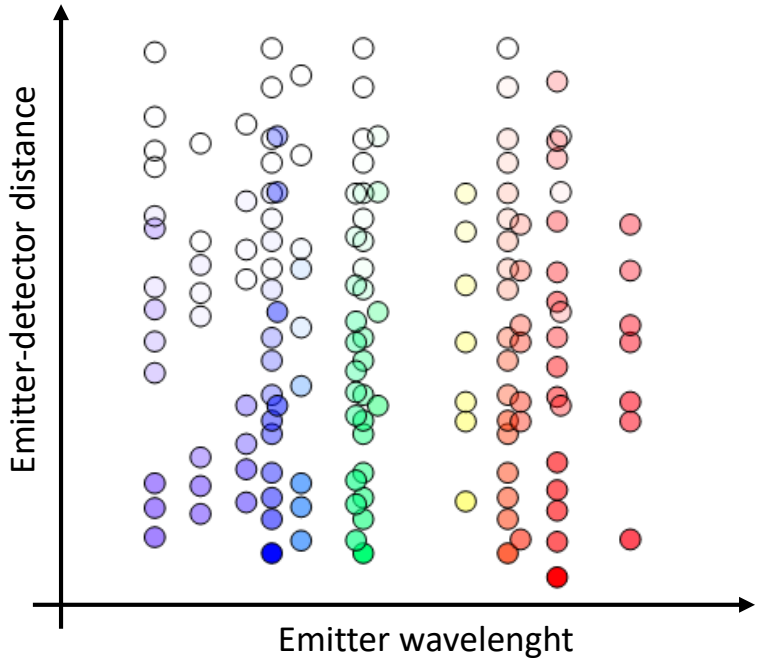
Stability against missing data

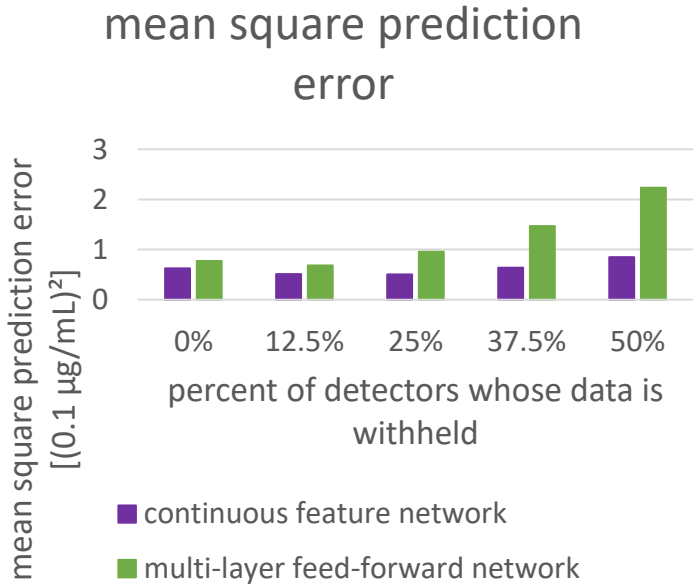




Conclusion




Emitter-detector distance
Emitter wavelenght


mean square prediction error
mean square prediction error [(0.1 µg/mL)²]
3
2
1
0
0%
12.5%
25%
37.5%
50%
percent of detectors whose data is withheld
continuous feature network
multi-layer feed-forward network