

Usages of Contrastive Losses, Introduction and Applications

for sensor data

Halil Beglerovic & Jörg Simon, June 30th 2020

About me

- PhD on using DeepLearning to detect Human Factors from BioSignals
- Prof. Eduardo Veas and Herbert Danzinger
- Sometimes very Sparse Data!
- Bring fractioned Data Sets together with Contrastive Loss





Deep Learning Troubles

No Labels? Fragmented Datasets?
Nasty Noise Effects? Time Shifts have huge effect? Clustering?

Contrastive Loss*

*** is partly a solution for some of these problems**

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we already have seen clustering & time shifts

Contrastive Loss*

*** is partly a solution for some of these problems**

- clustering & time shifts
- little labels
- fragmented datasets
- noise

Agenda

- History and other terms for the same
- Fractioned datasets of drowsiness
- Unifying sensor-recordings for later supervised training
 - Demo & Code
- Summary

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- few labels
 - fragmented datasets
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History and other terms for the same

2005 CVPR: Face Verification

Chopra, S., Hadsell, R., LeCun, Y. (2005). Learning a Similarity Metric Discriminatively, with Application to Face Verification 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'05) 1, 539-546. <https://dx.doi.org/10.1109/cvpr.2005.202>

History and other terms for the same



Sumit Chopra



Raia Hadsell



Yann LeCun

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imposter pair

genuine pair

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2005 CVPR: Face Verification

$$\begin{aligned}\mathcal{L}(W) &= \sum_{i=1}^P L\left(W, (Y, X_1, X_2)^i\right) \\ L\left(W, (Y, X_1, X_2)^i\right) &= (1 - Y)L_G\left(E_W(X_1, X_2)^i\right) \\ &\quad + YL_I\left(E_W(X_1, X_2)^i\right)\end{aligned}$$



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$$L\left(W, (Y, X_1, X_2)^i\right) = (1 - Y)L_G\left(E_W(X_1, X_2)^i\right)$$

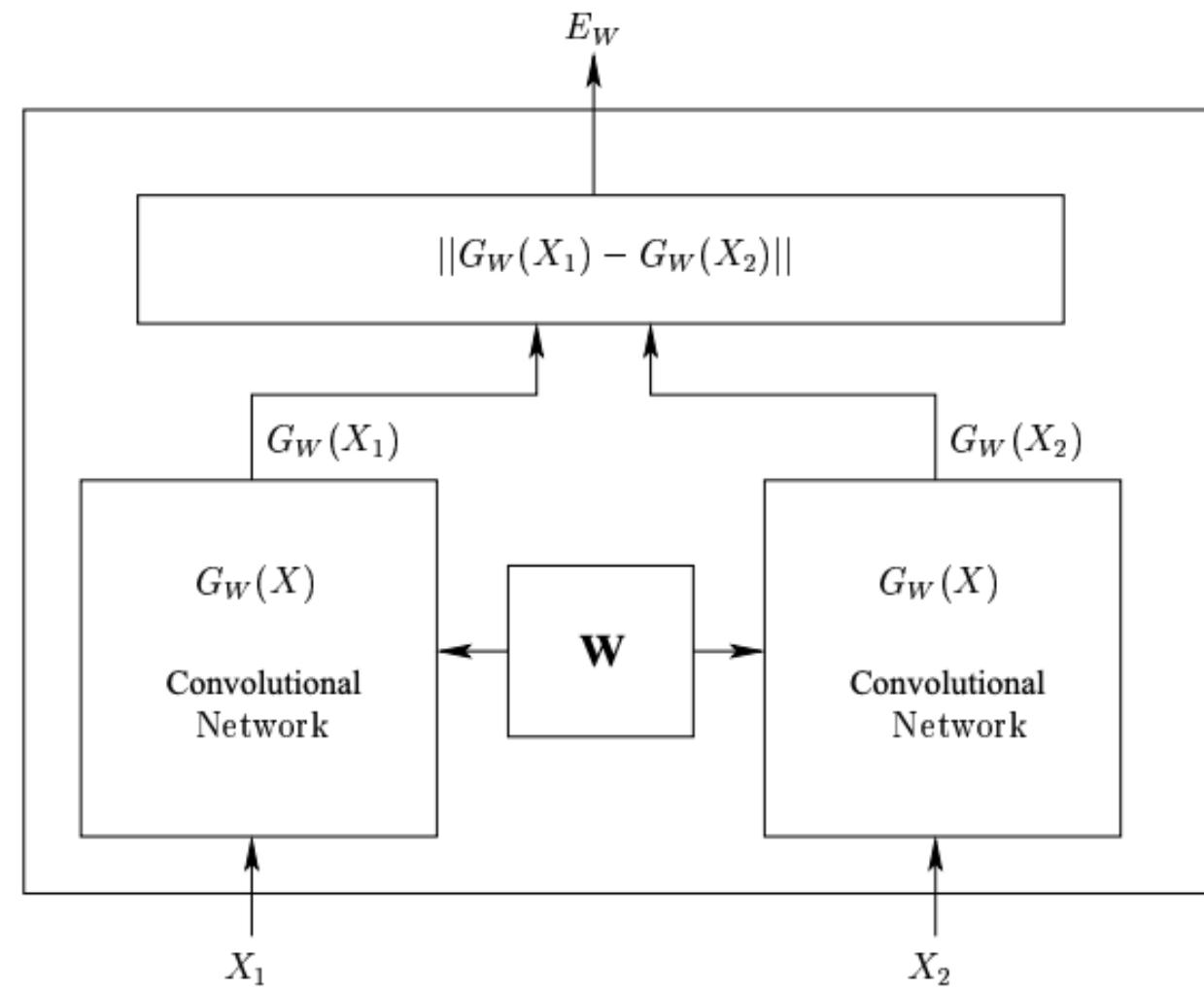
$$+ YL_I\left(E_W(X_1, X_2)^i\right)$$



imposter pair genuine pair

History and other terms for the same

Siamese Networks



$$\mathcal{L}(W) = \sum_{i=1}^P L\left(W, (Y, X_1, X_2)^i\right)$$

$$L\left(W, (Y, X_1, X_2)^i\right) = (1 - Y)L_G\left(E_W(X_1, X_2)^i\right) + YL_I\left(E_W(X_1, X_2)^i\right)$$

2005 CVPR: Face Verification



History and other terms for the same

2012 NeurIPS:
Distances on
Images

Norouzi, M., Fleet, D., Salakhutdinov, R. (2012). **Hamming Distance Metric Learning** 2012 Neural Information Processing Conference (NIPS), 1061–1069, <http://papers.nips.cc/paper/4808-hamming-distance-metric-learning.pdf>

History and other terms for the same



Mohammad
Norouzi



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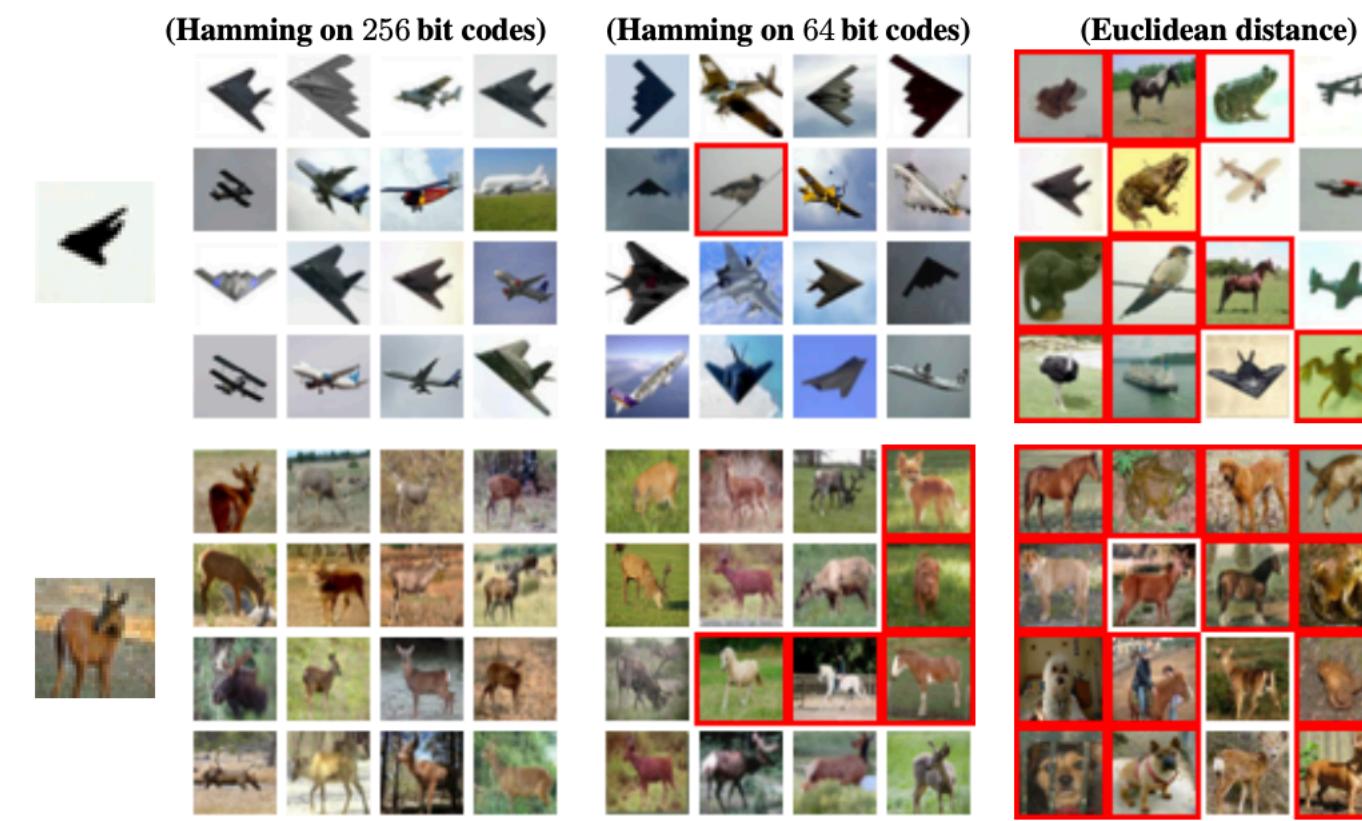
2012 NeurIPS:
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Images

Triplet Loss

$$\ell_{\text{triplet}}(h, h^+, h^-) = \left[\|h - h^+\|_H - \|h - h^-\|_H + 1 \right]_+$$

Norouzi, M., Fleet, D., Salakhutdinov, R. (2012). **Hamming Distance Metric Learning** 2012 Neural Information Processing Conference (NIPS), 1061–1069, <http://papers.nips.cc/paper/4808-hamming-distance-metric-learning.pdf>

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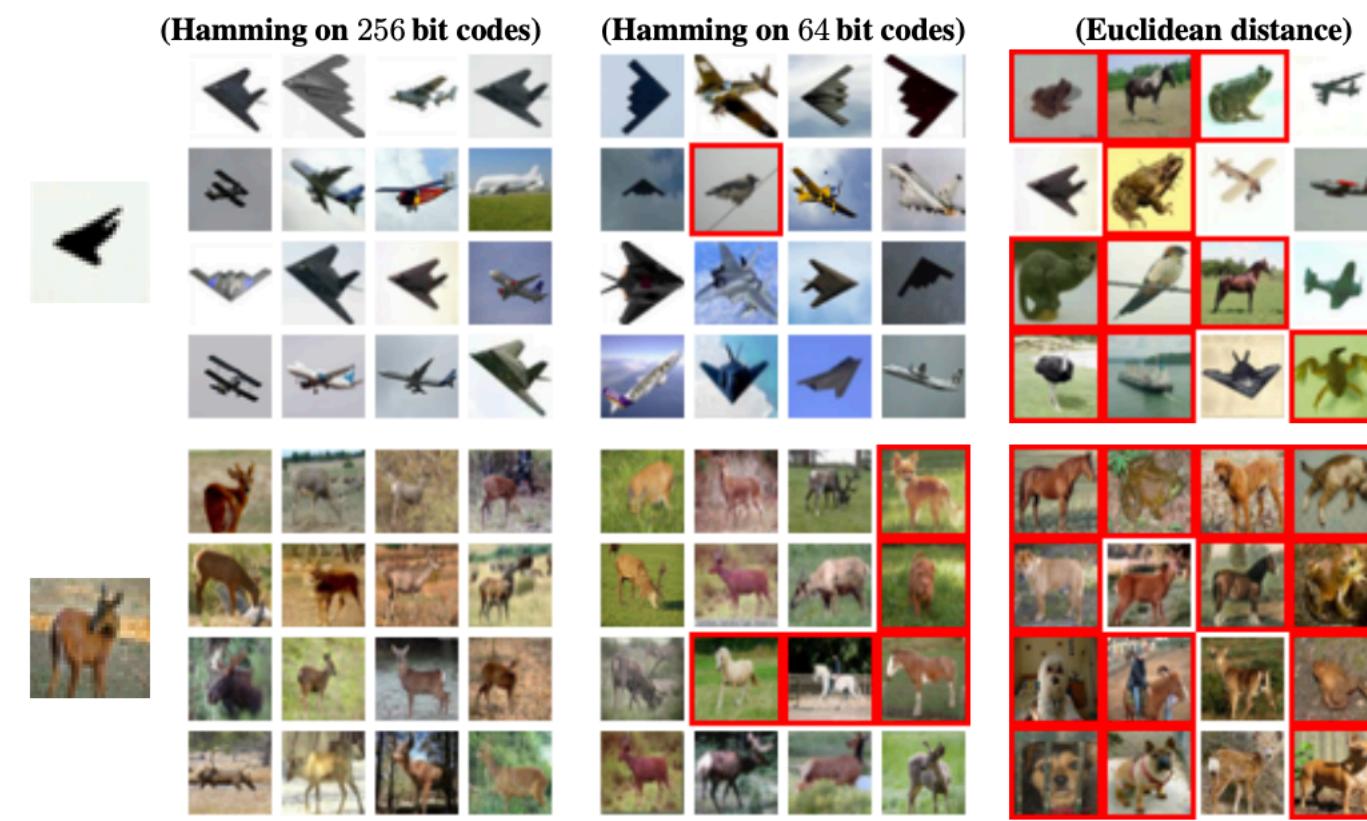
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History and other terms for the same

Metric Learning



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Images



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Triplet Loss

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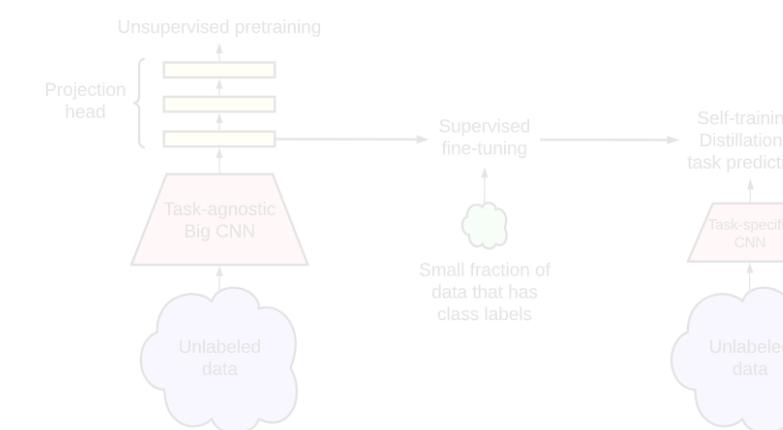
History and other terms for the same



Lian, Z., Li, Y., Tao, J., Huang, J. (2018). Speech Emotion Recognition via Contrastive Loss under Siamese Networks <https://dx.doi.org/10.1145/3267935.3267946>

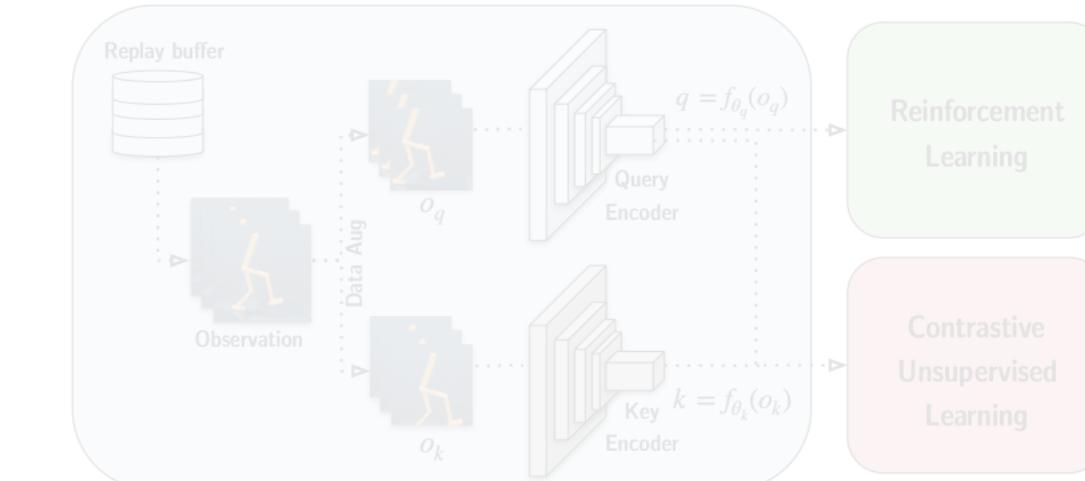
2018 Application to Sensor Data

Chen, T., Kornblith, S., Norouzi, M., Hinton, G. (2020). A Simple Framework for Contrastive Learning of Visual Representations <https://arxiv.org/abs/2002.05709>



Chen, T., Kornblith, S., Swersky, K., Norouzi, M., Hinton, G. (2020). Big Self-Supervised Models are Strong Semi-Supervised Learners

Srinivas, A., Laskin, M., Abbeel, P. (2020). CURL: Contrastive Unsupervised Representations for Reinforcement Learning arXiv <https://arxiv.org/abs/2004.04136>

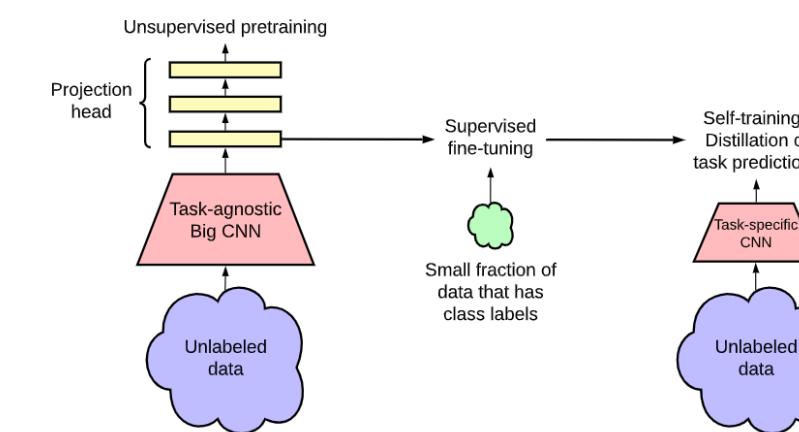


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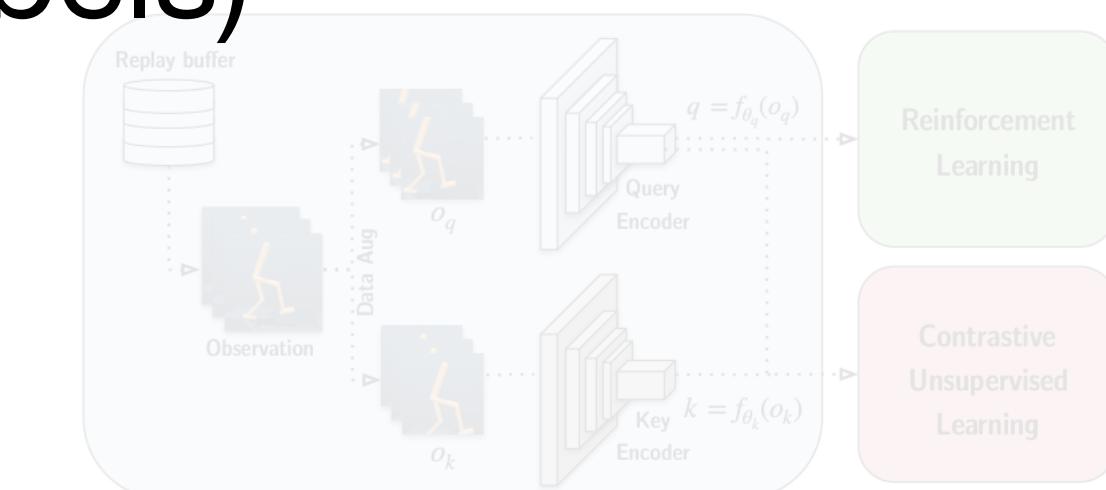
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Early 2020 Sample Efficiency (few labels)

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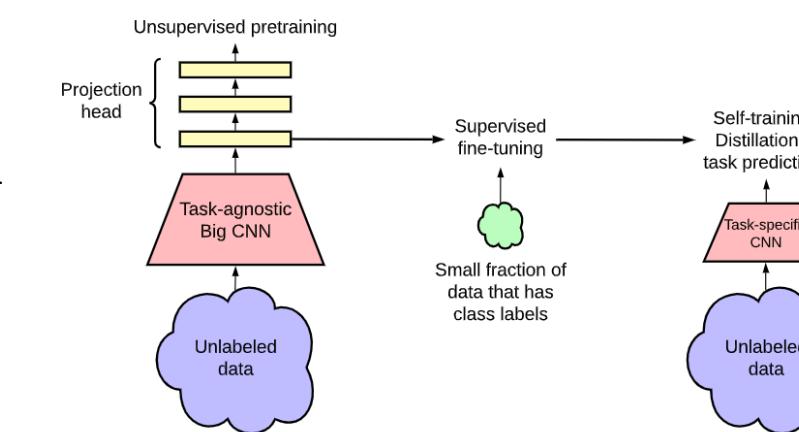


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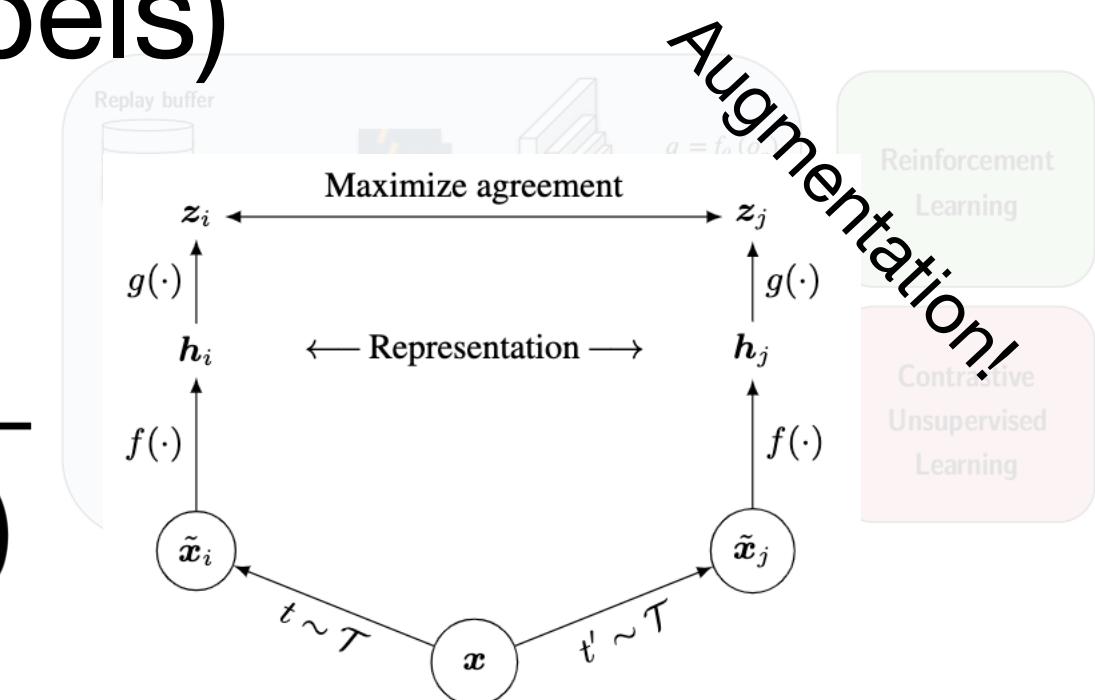


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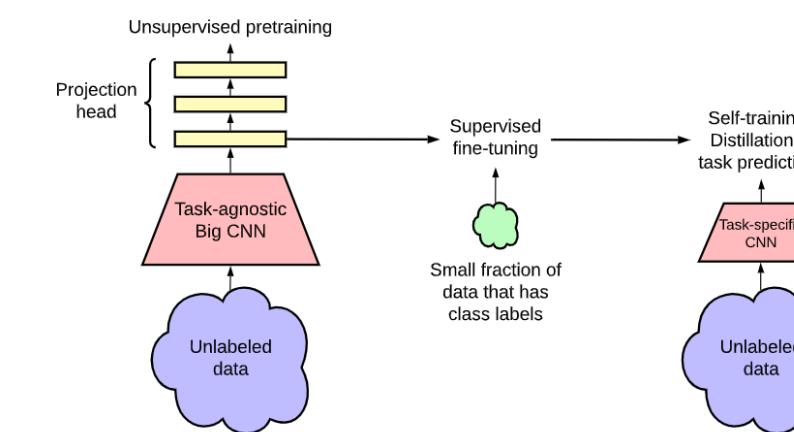
$$\ell_{i,j} = - \log \frac{\exp(\text{sim}(\mathbf{z}_i, \mathbf{z}_j)/\tau)}{\sum_{k=1}^{2N} \mathbf{1}_{[k \neq i]} \exp(\text{sim}(\mathbf{z}_i, \mathbf{z}_k)/\tau)}$$



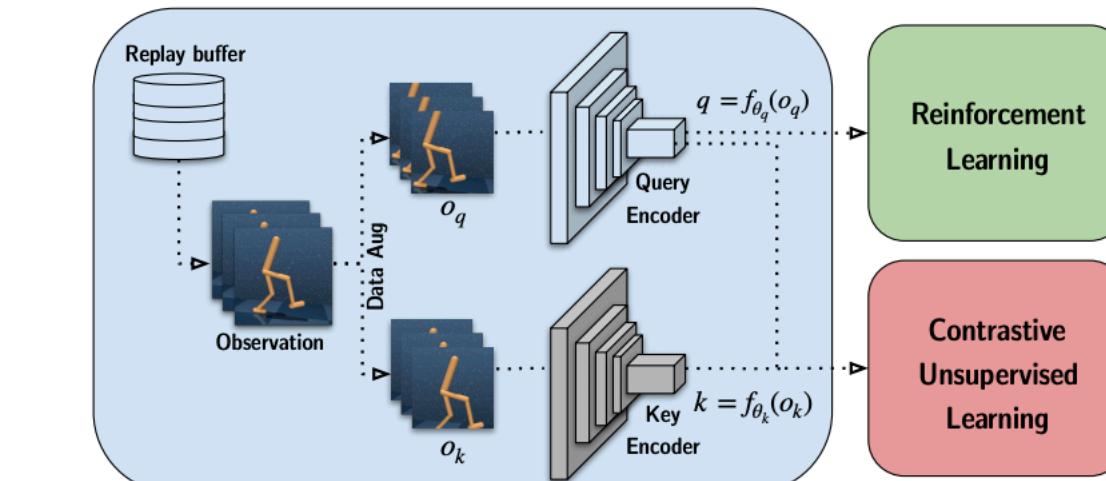
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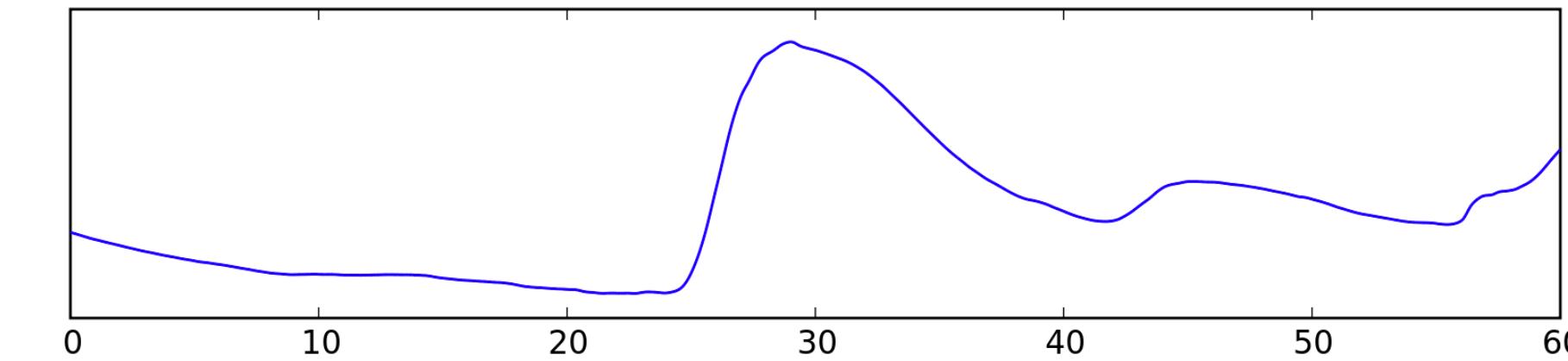
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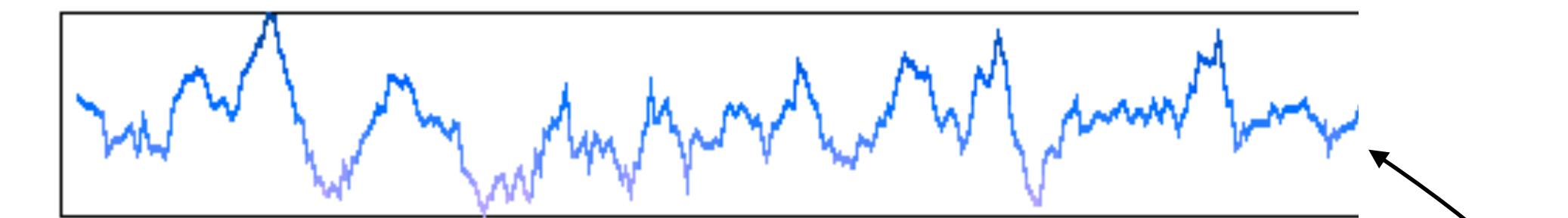
2020 Sample Efficiency in Reinforcement Learning

Fractioned Datasets of Drowsiness

- We have a unit generating a signal
 - Unit: f.e. a **driver** of a car
 - Signal: **Physiological signals** for modes (alert, normal, drowsy, asleep)
 - We have data from 4 experiments, but they all used **slightly different sensors** of the same type (EEG, ECG, GSR)



GSR Signal Sensor 1

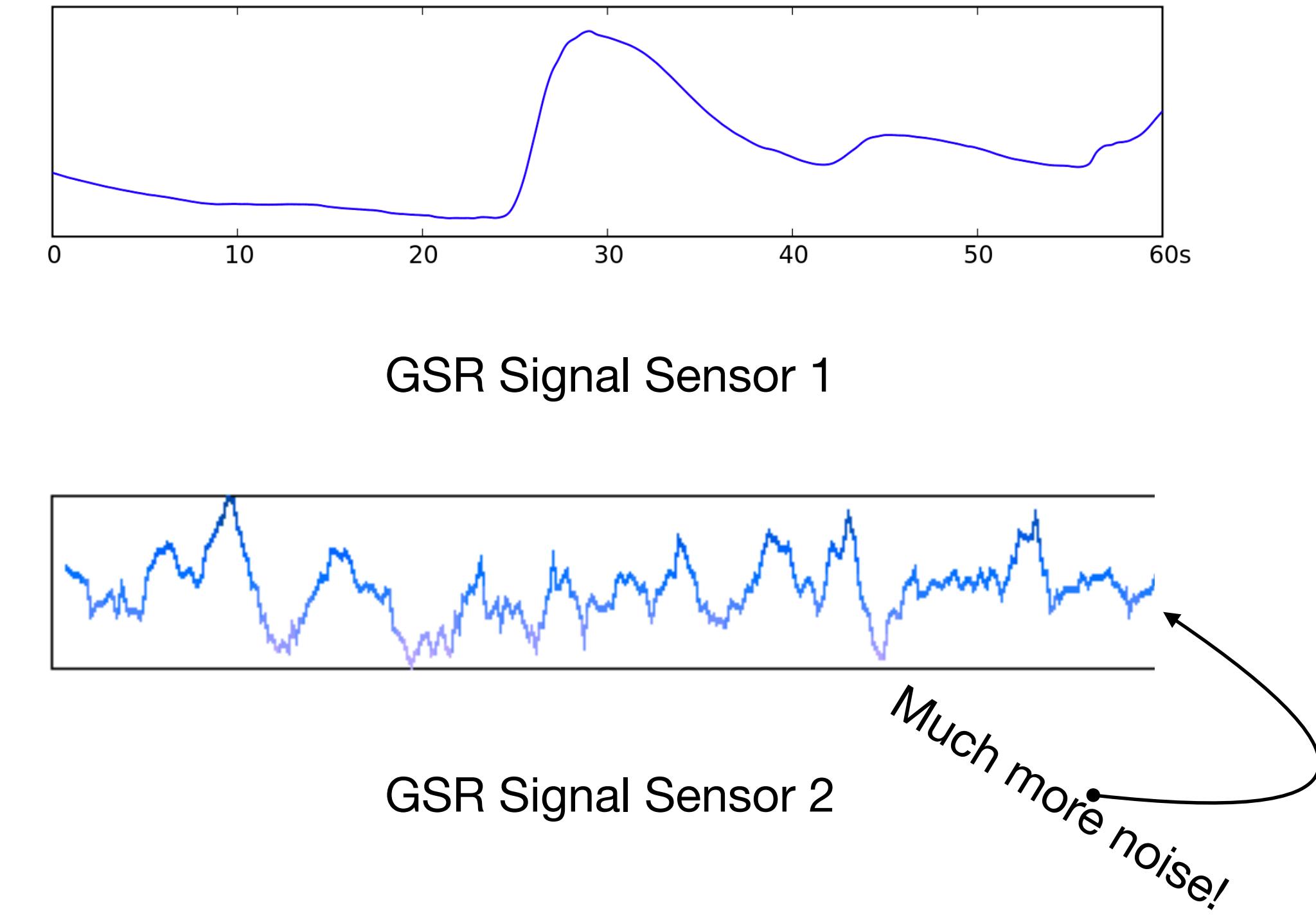


GSR Signal Sensor 2

Much more noise!

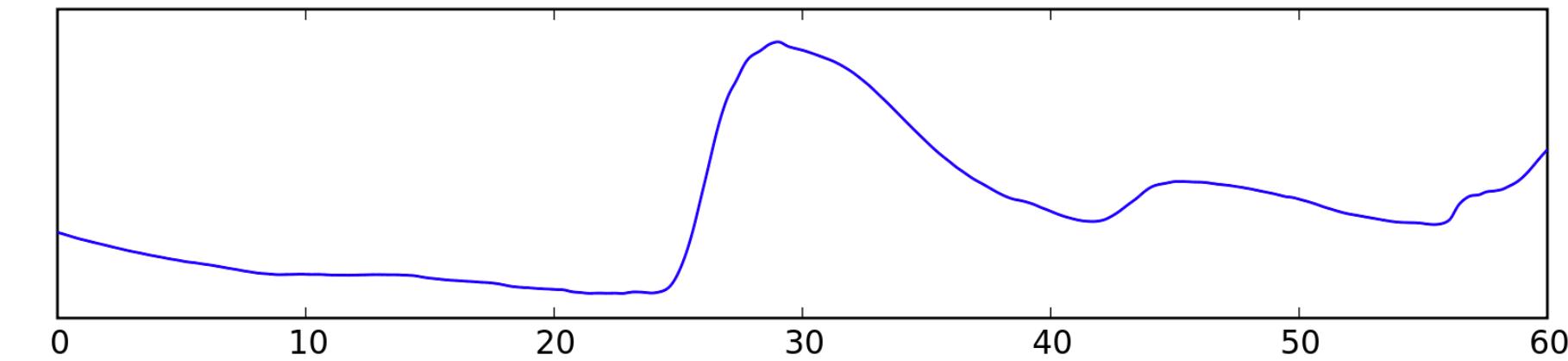
Fractioned Datasets of Drowsiness

- Contrastive Loss:
 - Use all data
 - Transform data into embedding where differences of sensors are mitigated
- Fine-tune classifier on that

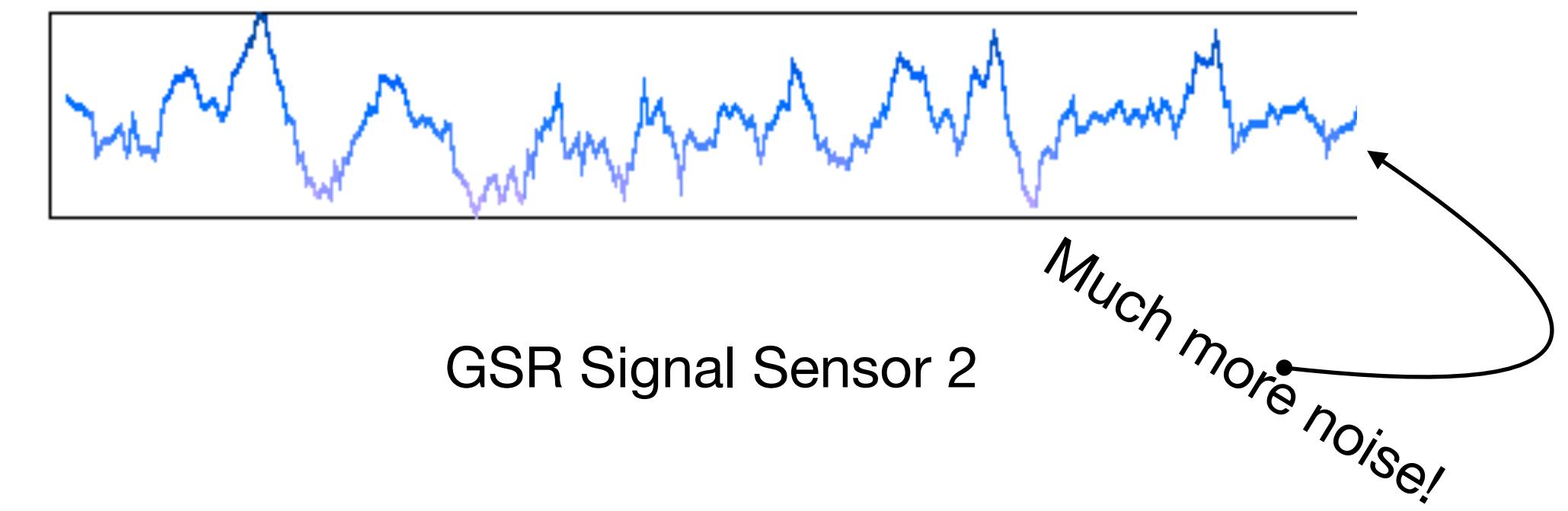


Fractioned Datasets of Drowsiness

- Bad news: I can not show you exactly this use case (confidential datasets)
- Good news: I have a “surrogate problem”



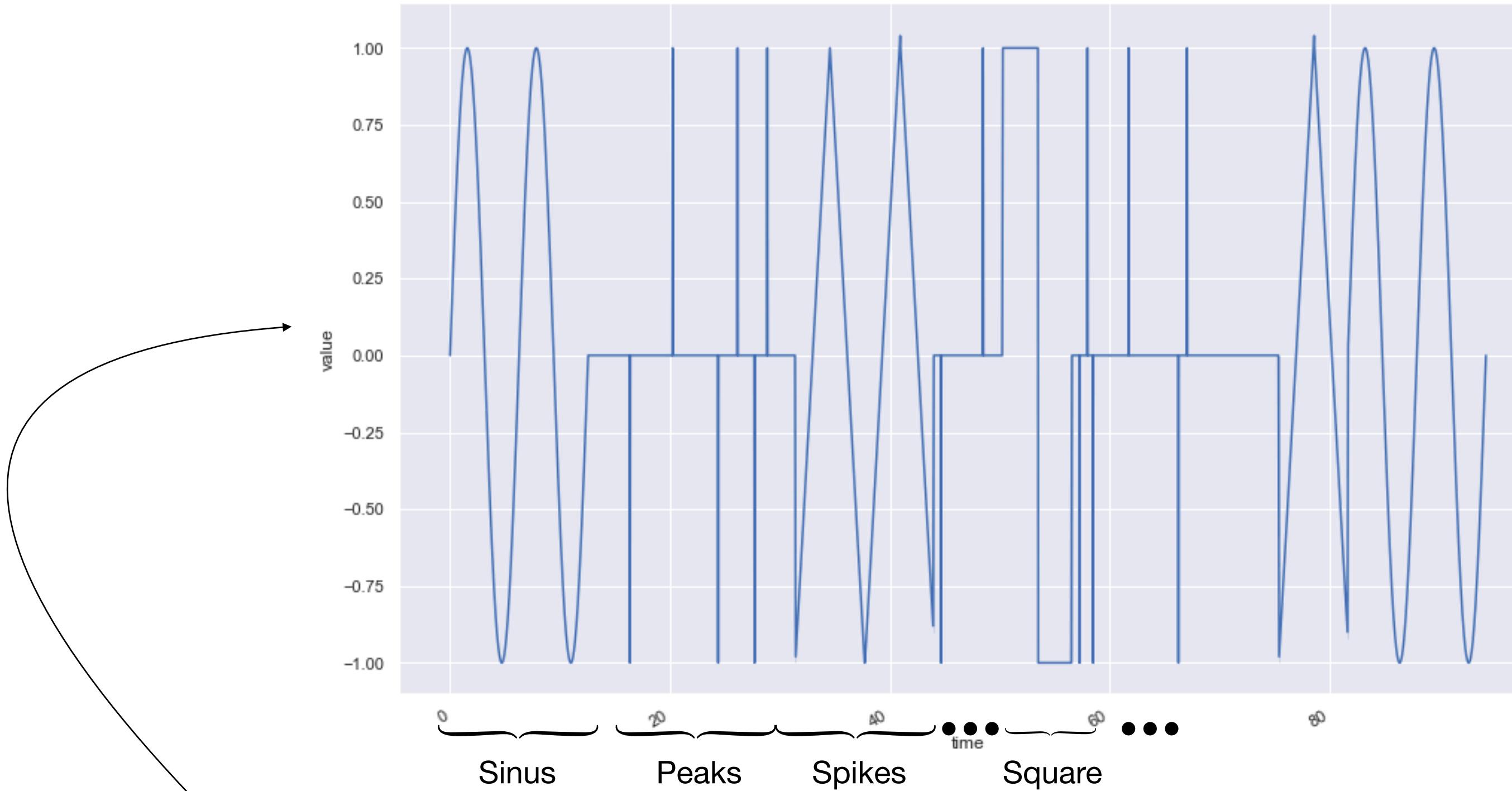
GSR Signal Sensor 1



GSR Signal Sensor 2

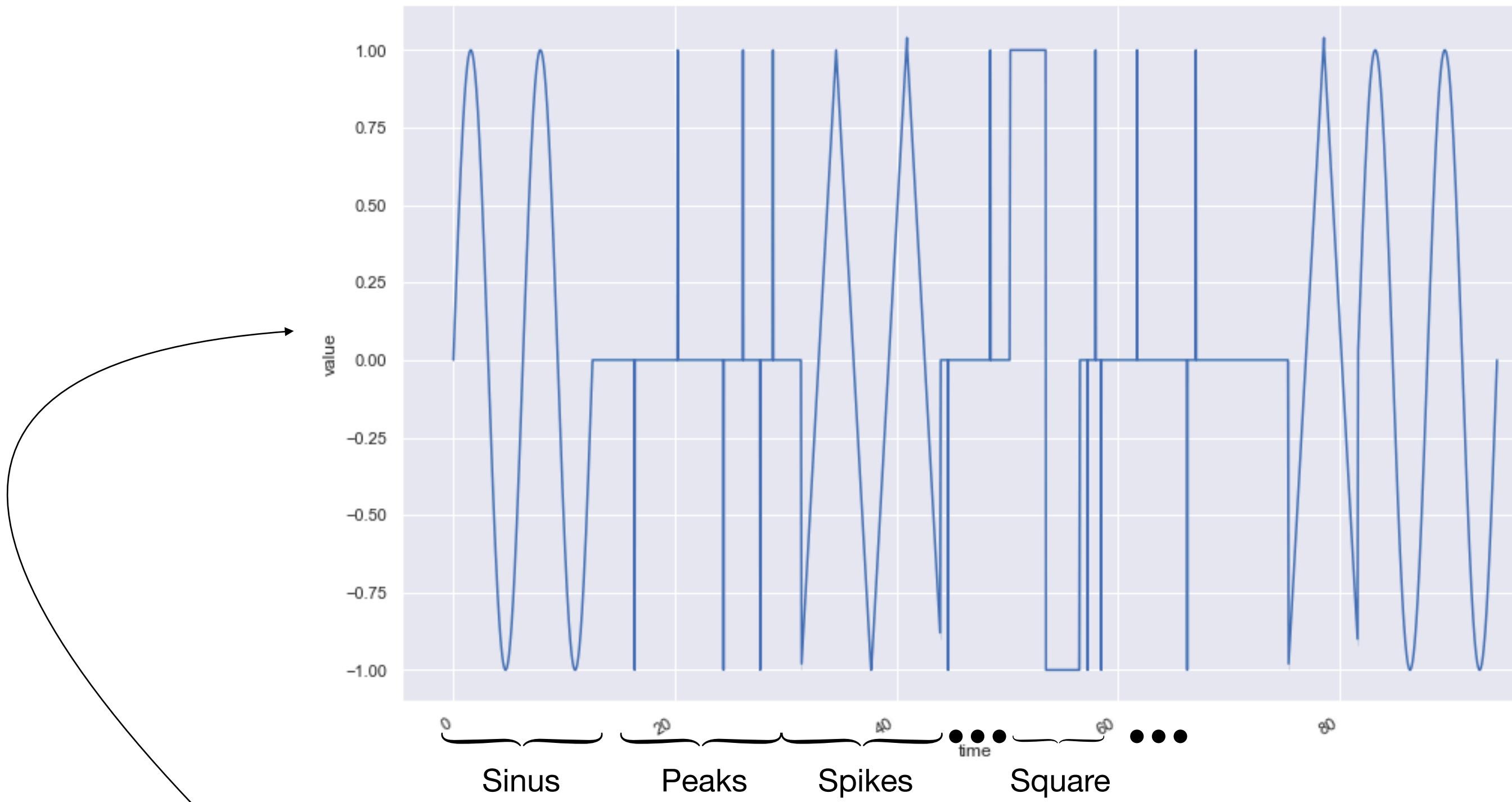
Much more noise!

Unifying Sensor-Recordings for later Supervised Training



Fantasy device
generating Signal

Unifying Sensor-Recordings for later Supervised Training

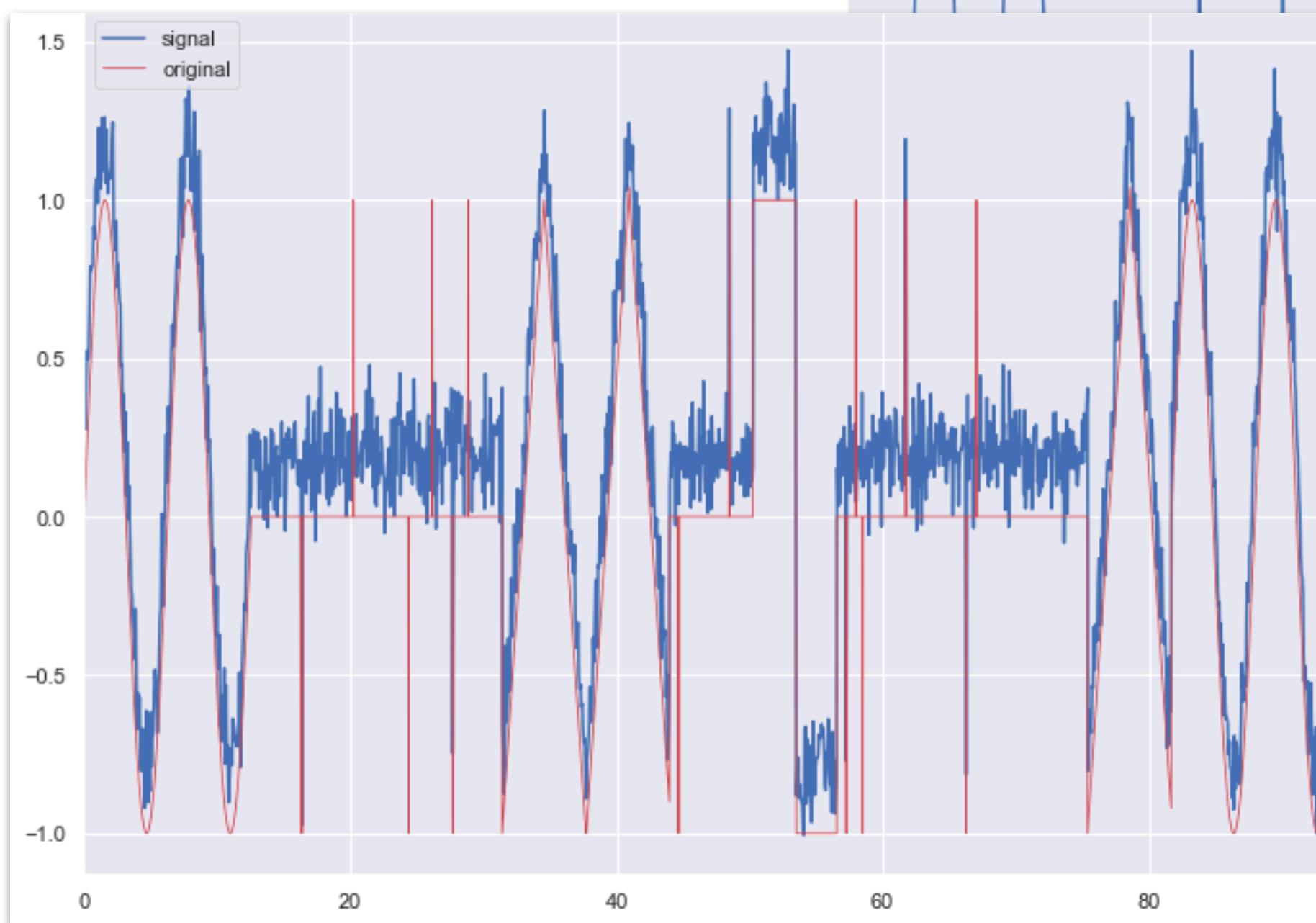


Fantasy device
generating Signal

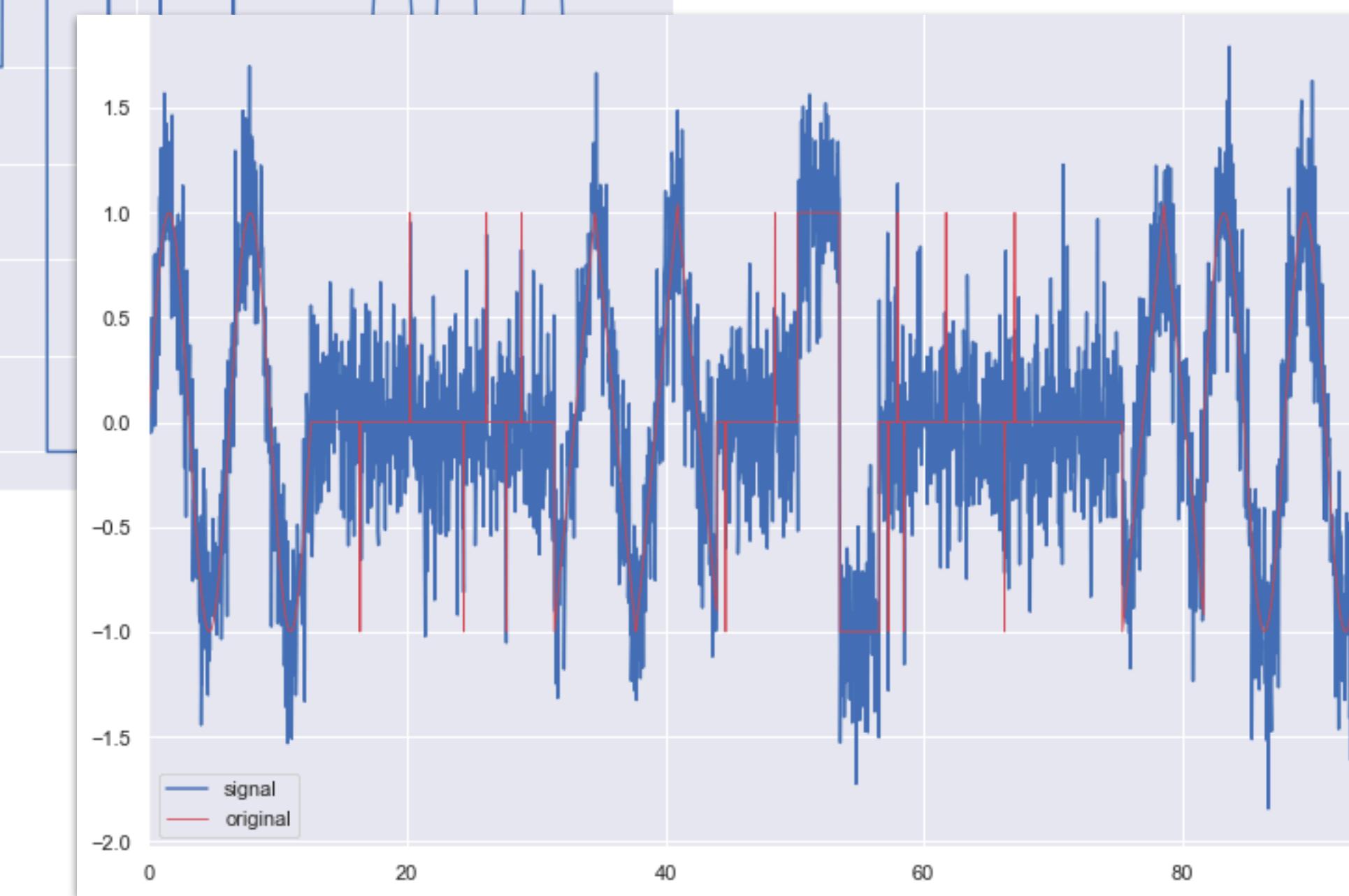
[examples/different-sensors-jsimon/problem-description.ipynb](#)

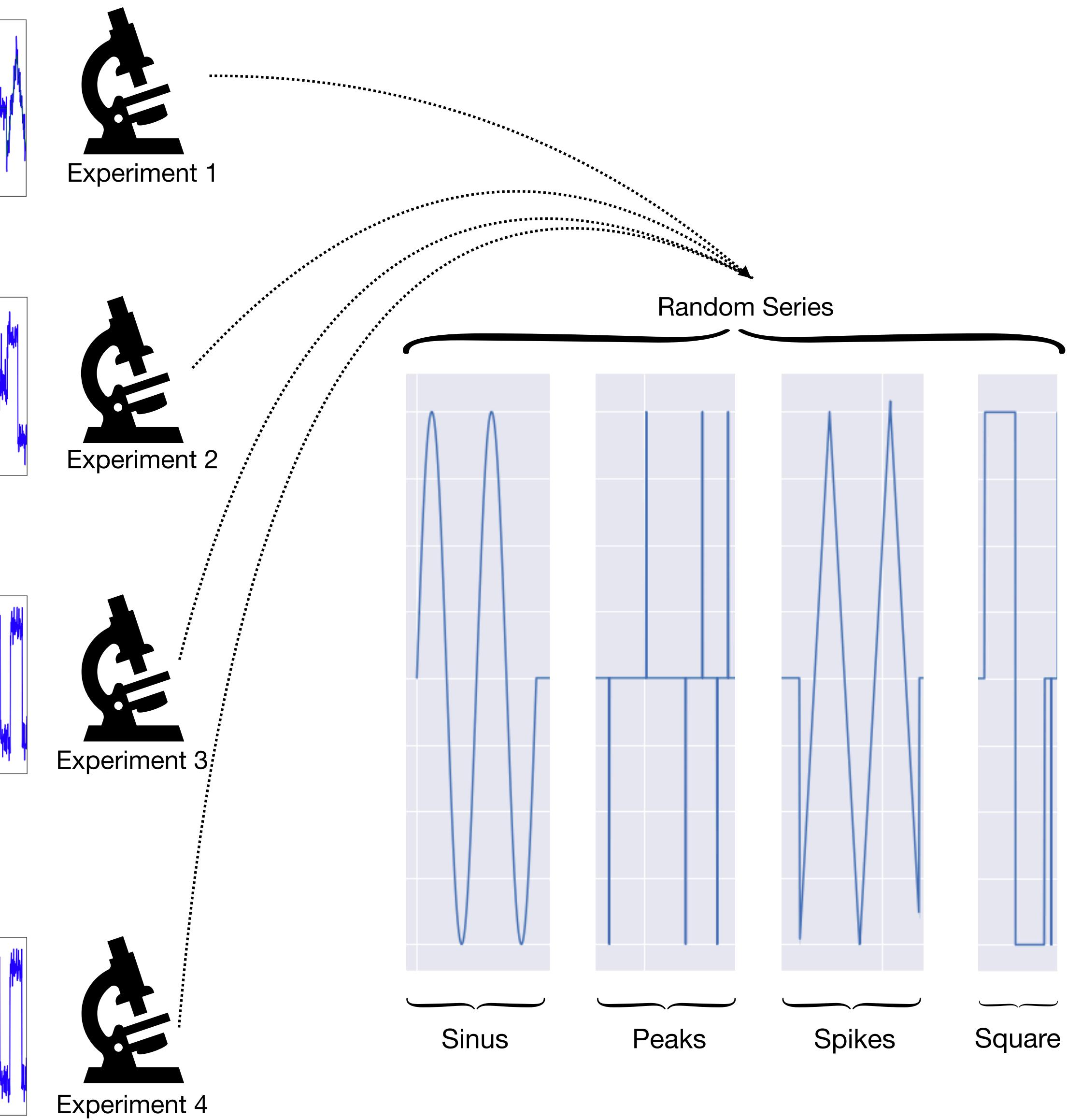
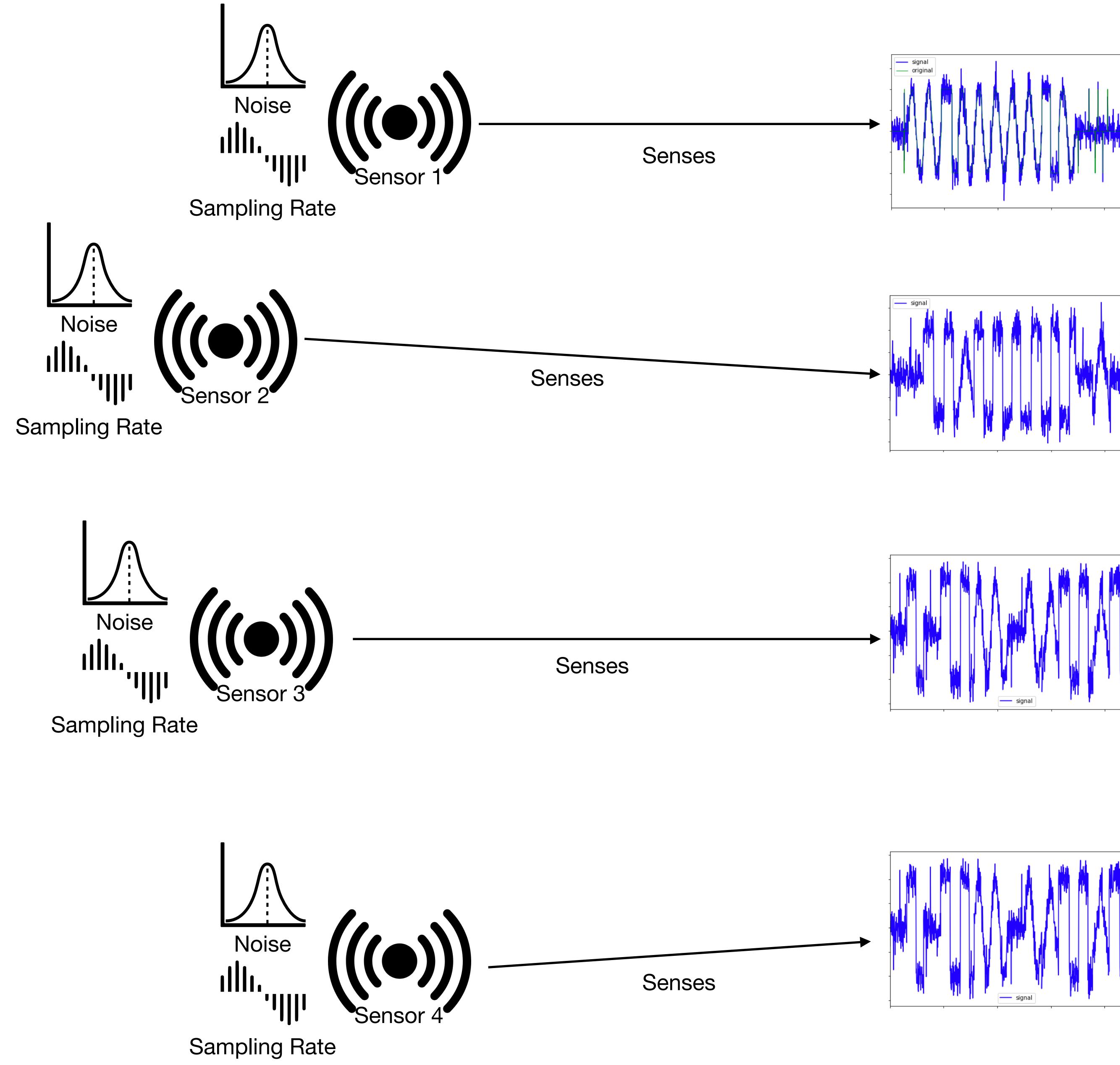
Unifying Sensor-Recordings for later Supervised Training

Sensor 1



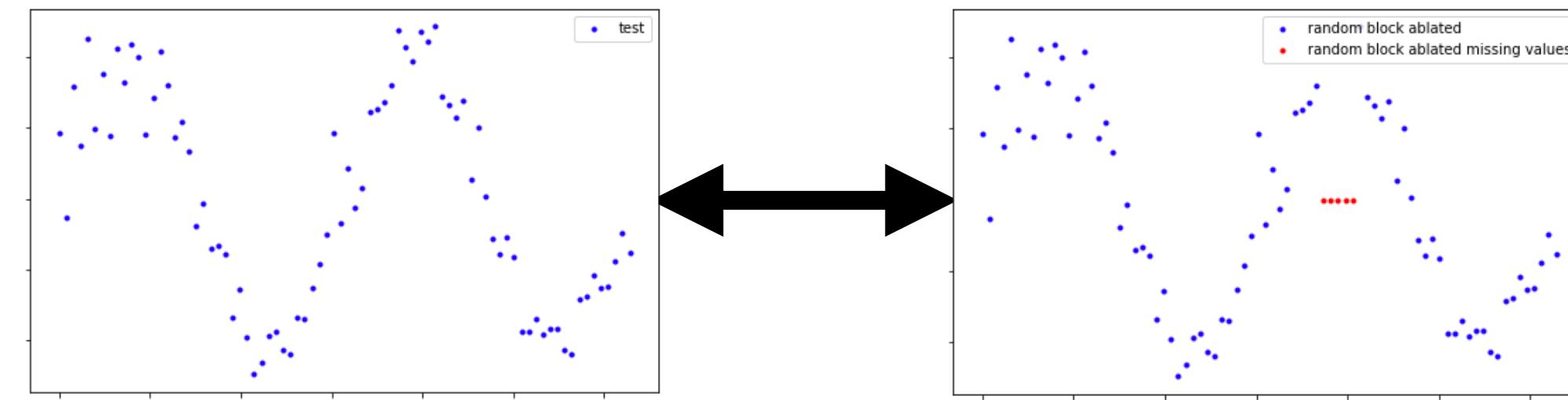
Sensor 2



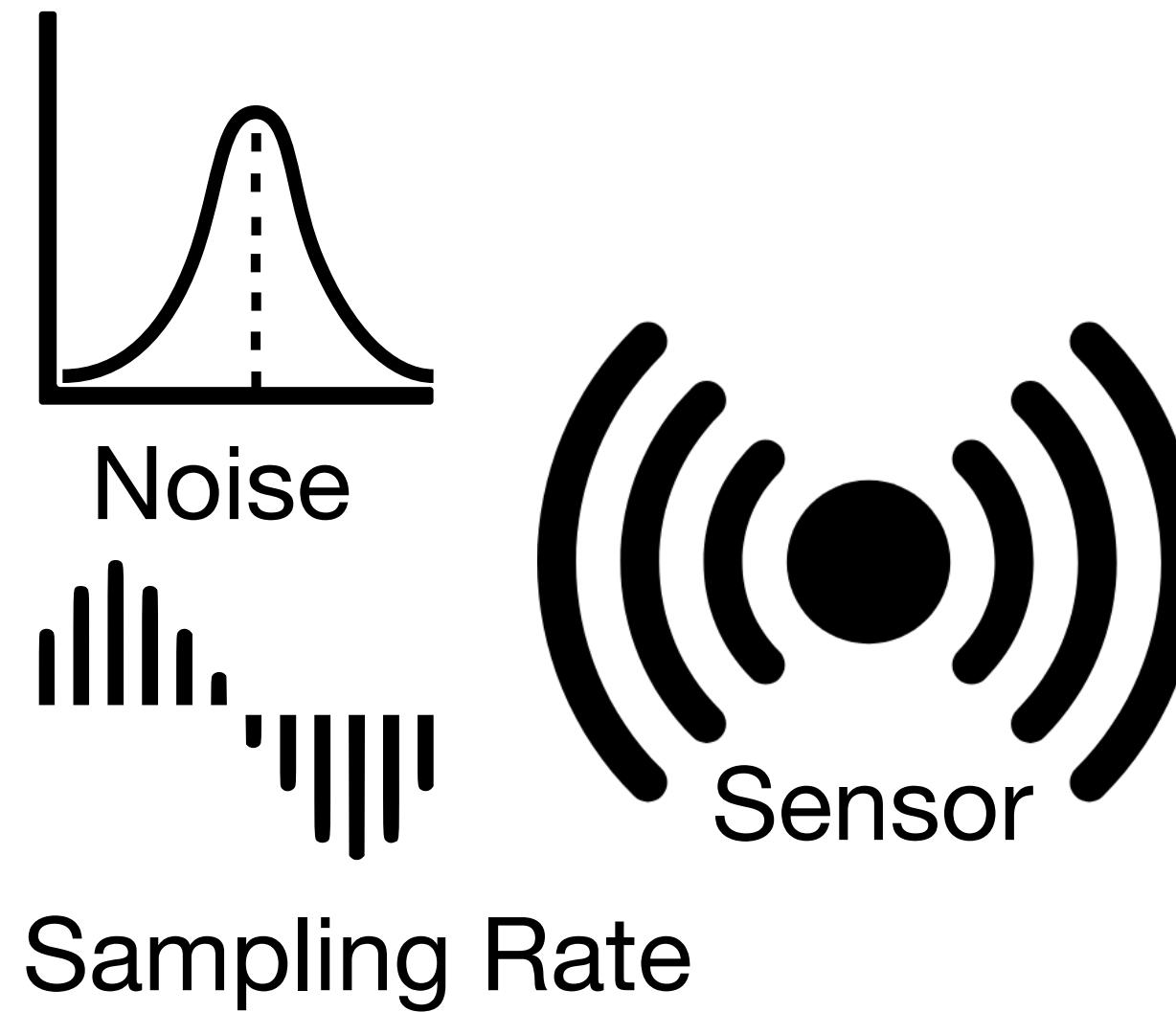


**This means we can
not directly calibrate
sensors**

Because we do not know when they sensed the same



$$\vec{x} = \begin{bmatrix} 0.932 & 0 \\ 0. & 1 \\ 0.031 & 0 \\ 0. & 1 \\ 0.618 & 0 \end{bmatrix}$$

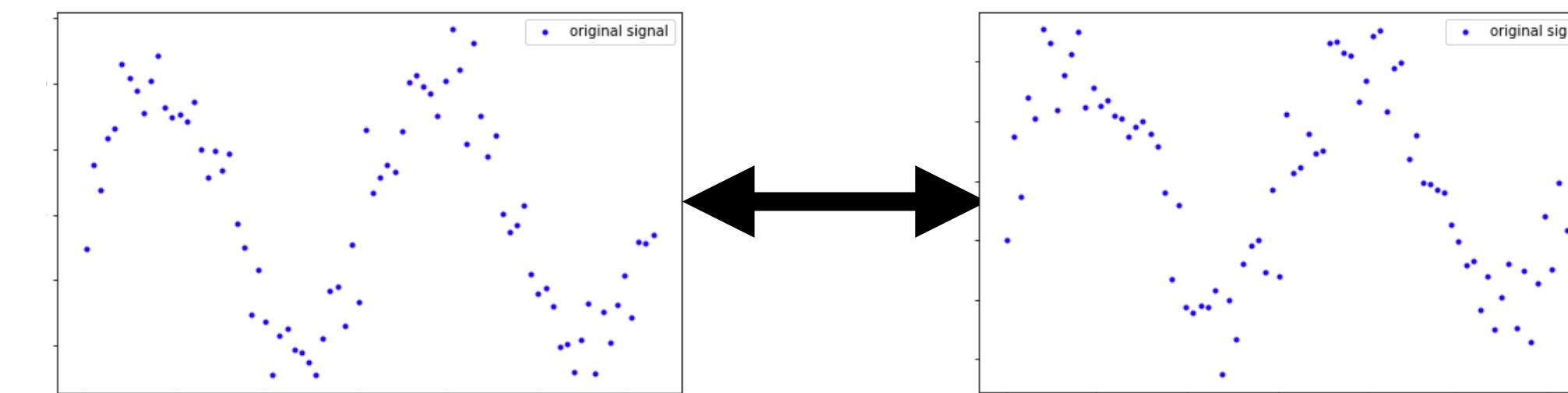
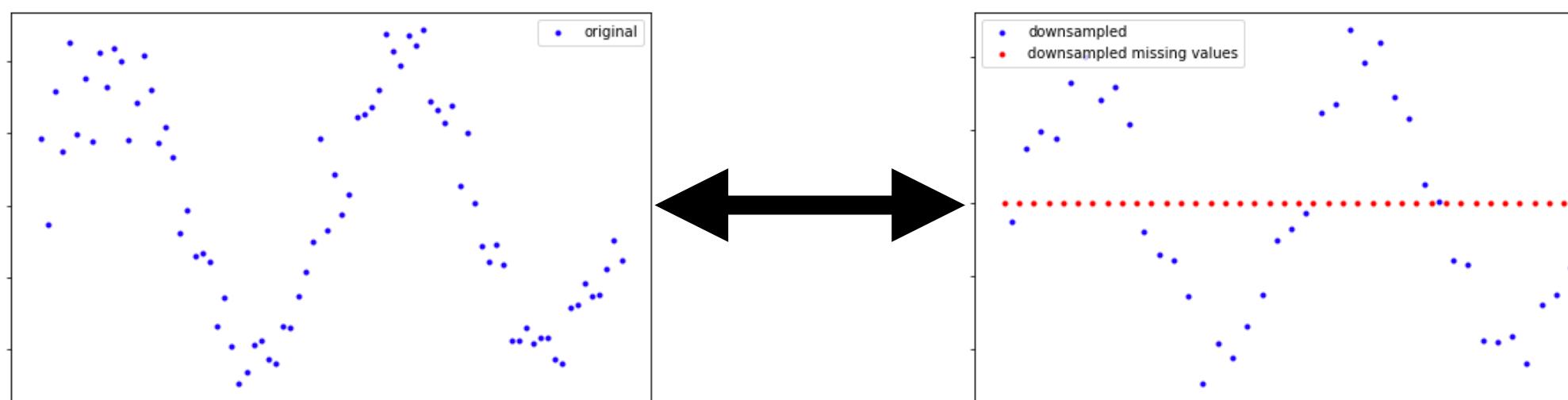


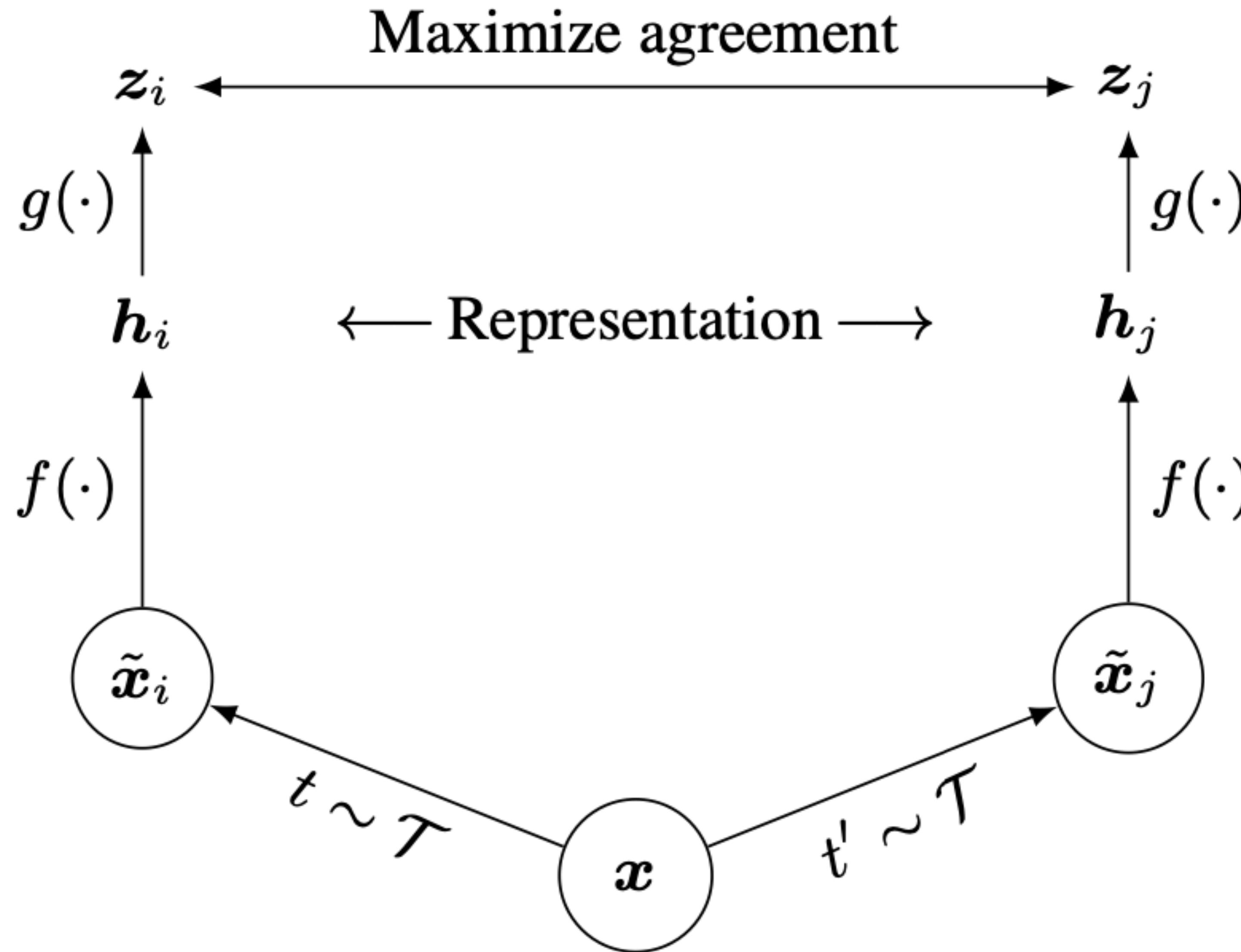
Common Representation (100Hz)

Noise

Sampling Rate

Ablations (sections of sensor failure)





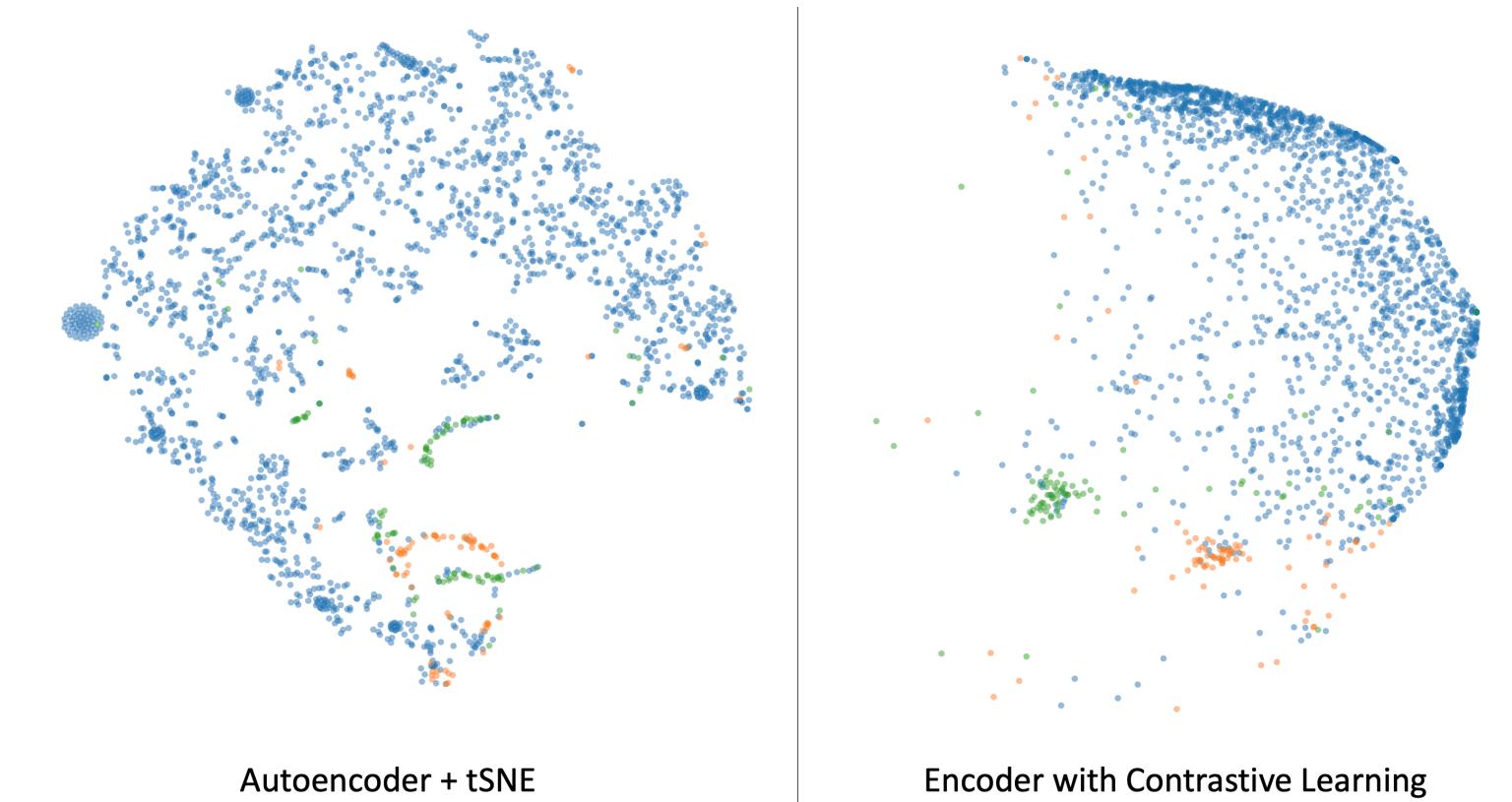
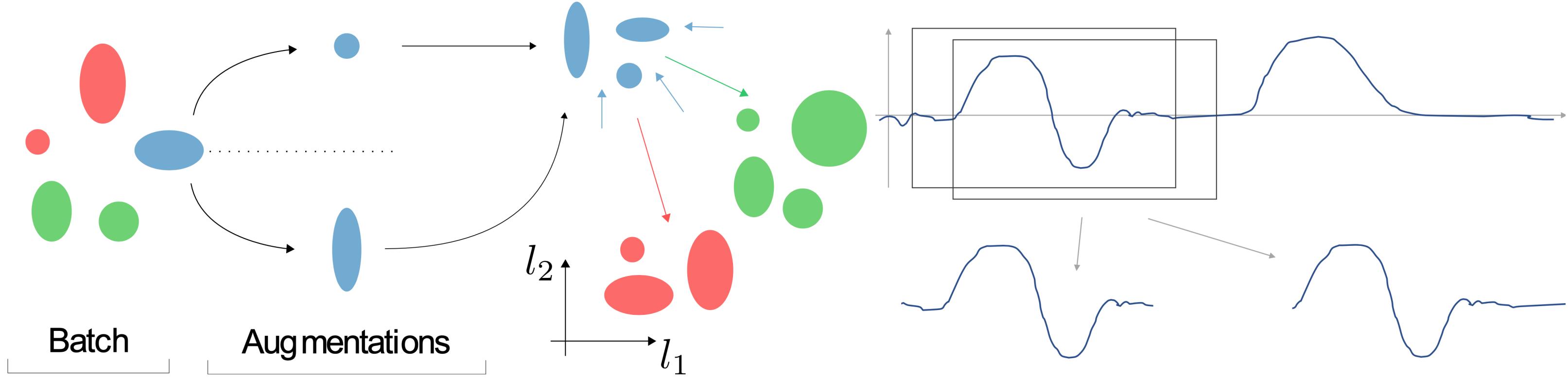
Demo Time

<https://github.com/grazai/contrastive-learning-june-2020>

examples/different-sensors-jsimon

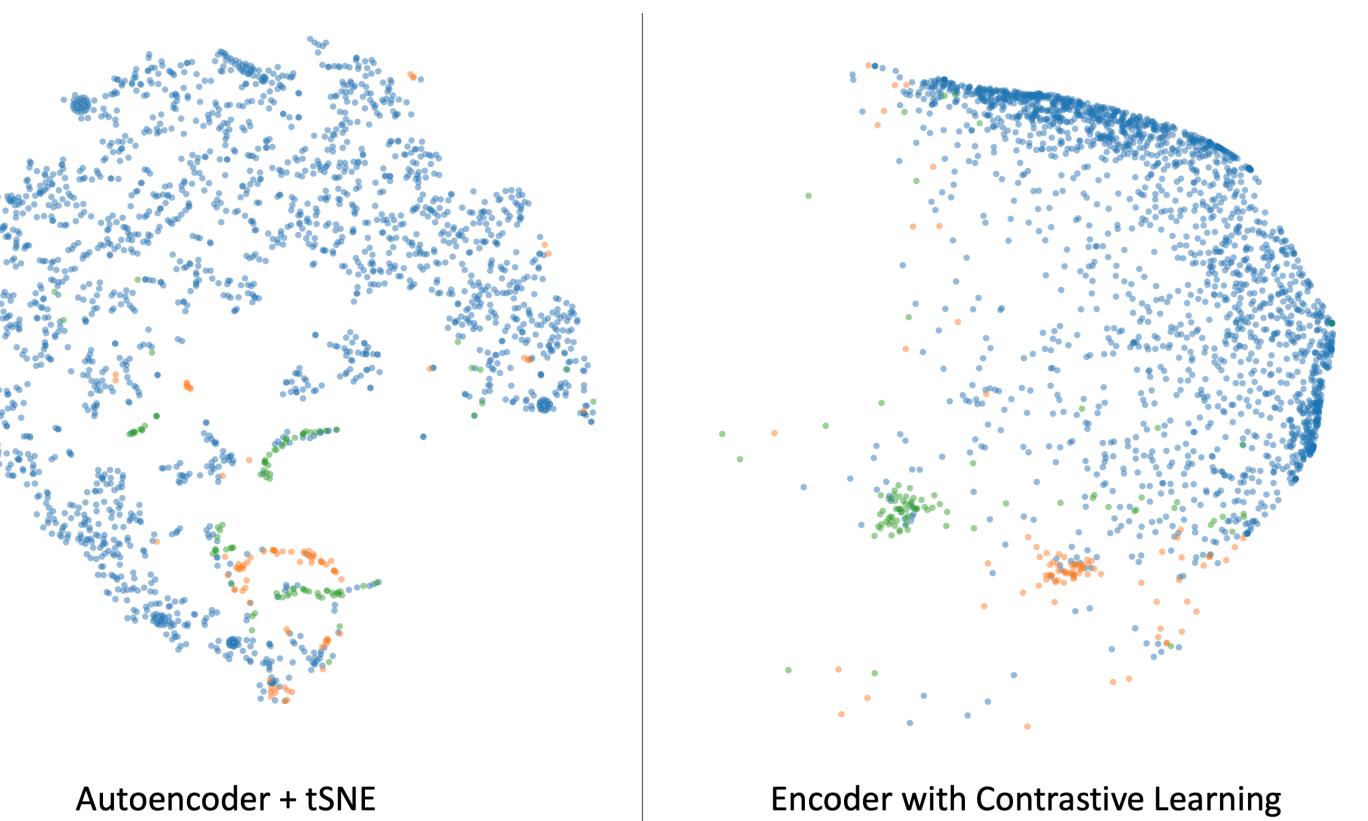
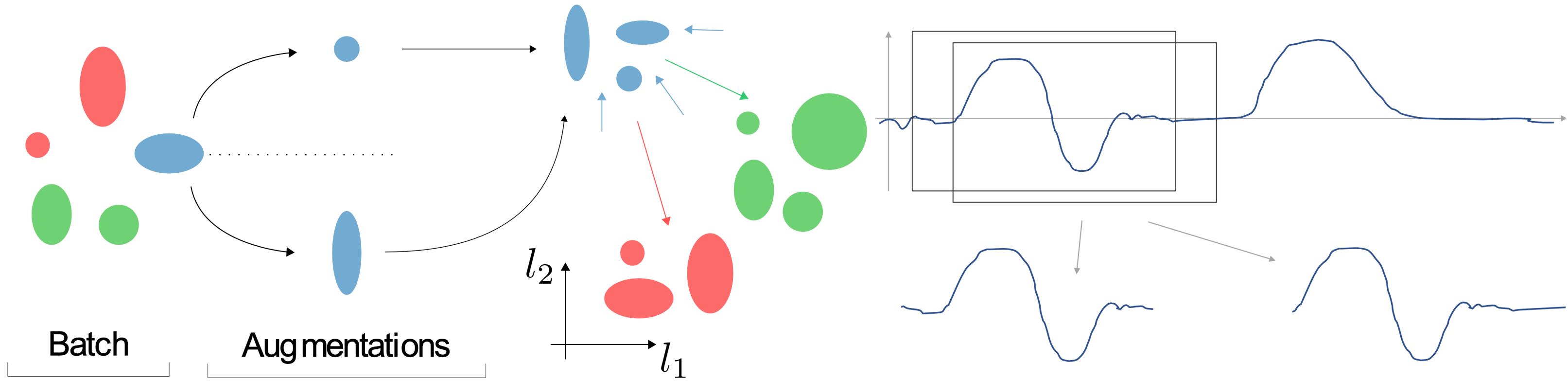
Summary

Contrastive Learning

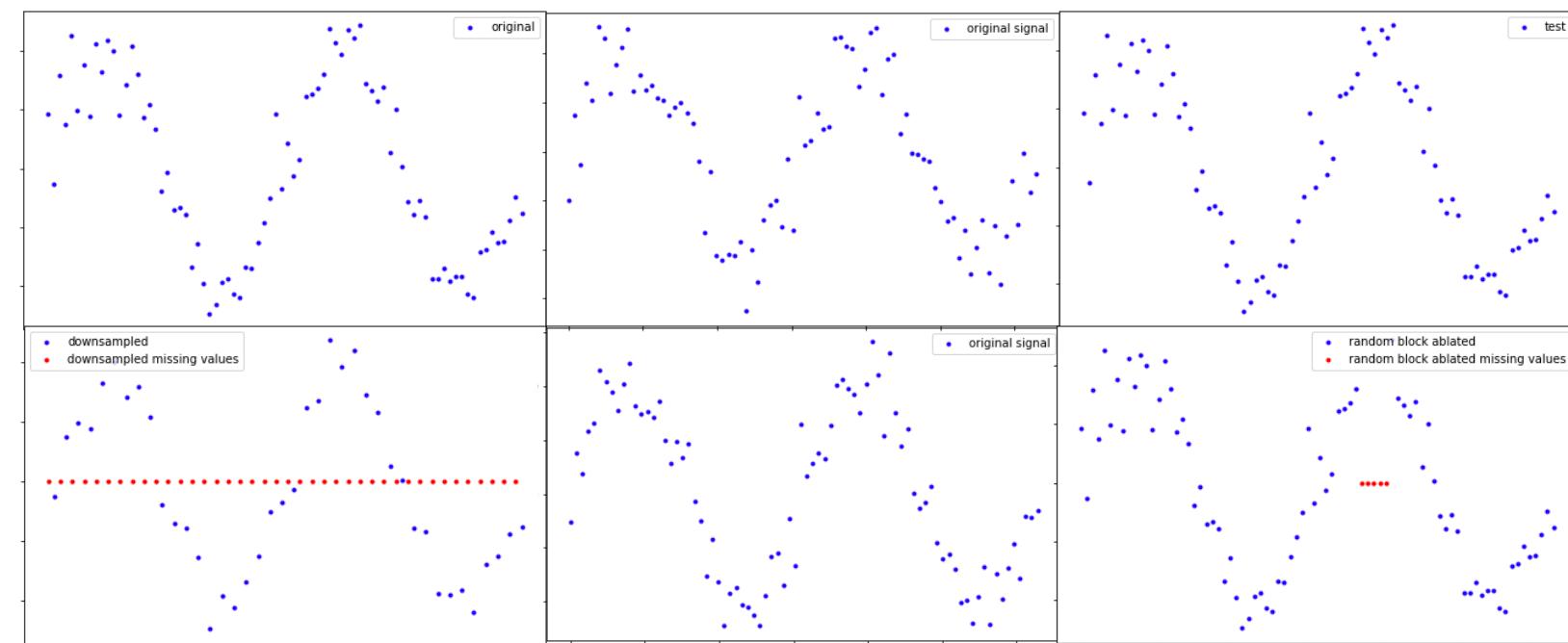
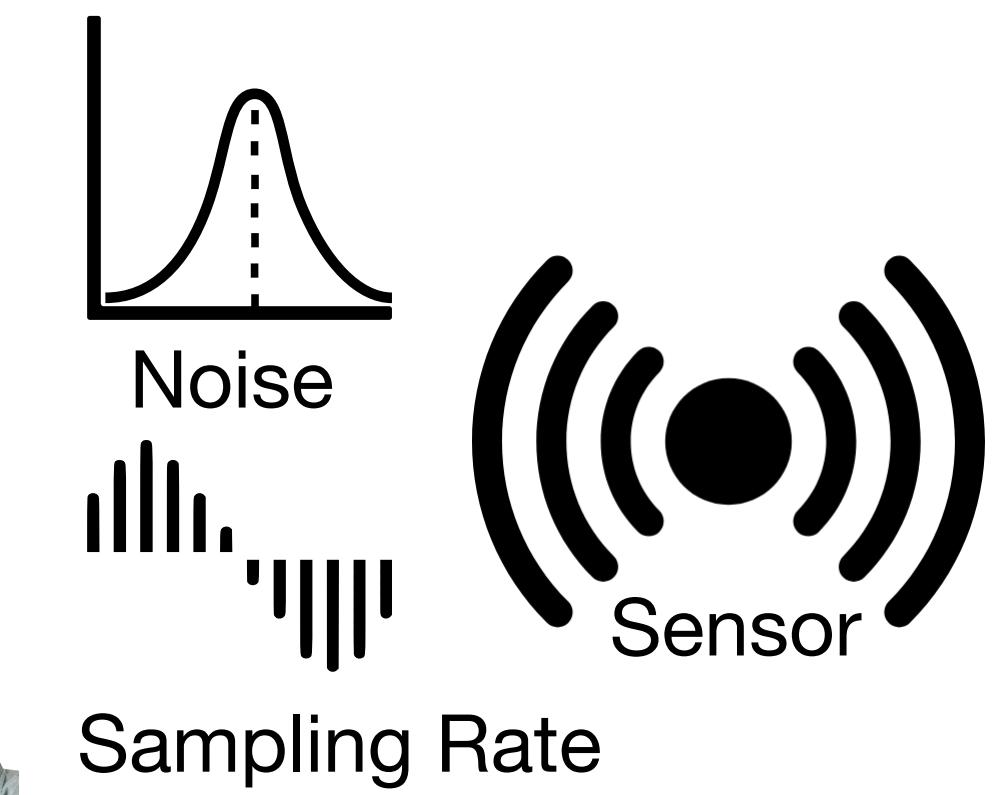


Encoder with Contrastive Learning

Contrastive Learning



2005
2012
2020



Thanks for the Attention

We will continue for an Q&A
in discord (we will post the
link in the twitch chat)

