Convolutional neural networks with dynamic convolution for time series classification

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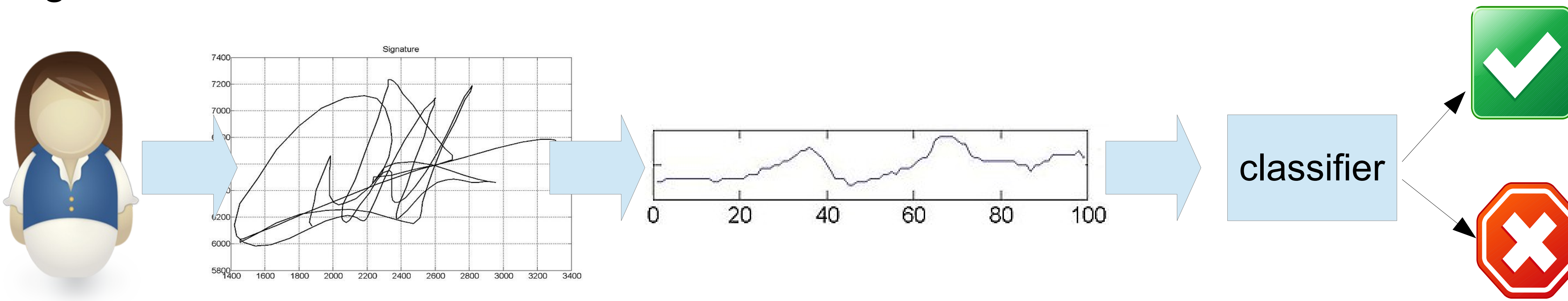
Introduction: time series classification

Example:
Signature Verification



Anna

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Image:
https://commons.wikimedia.org/wiki/File:Online_signture.jpg

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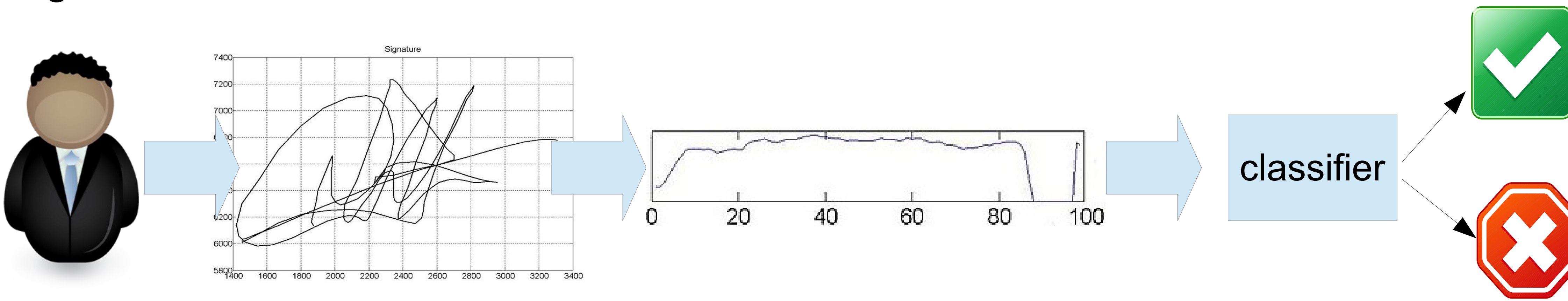

Peter

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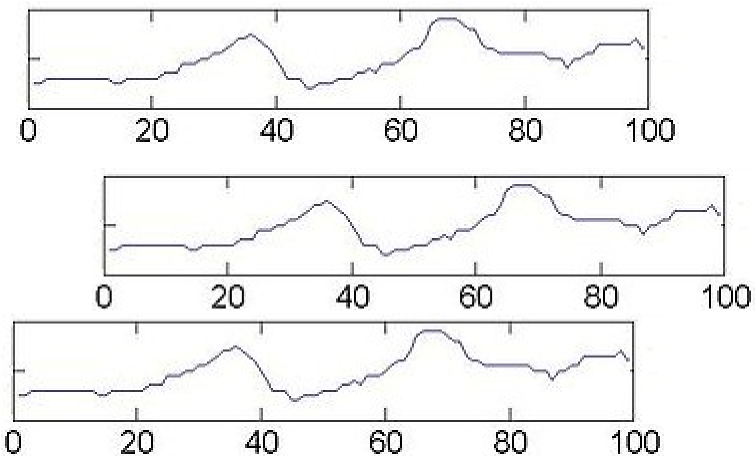
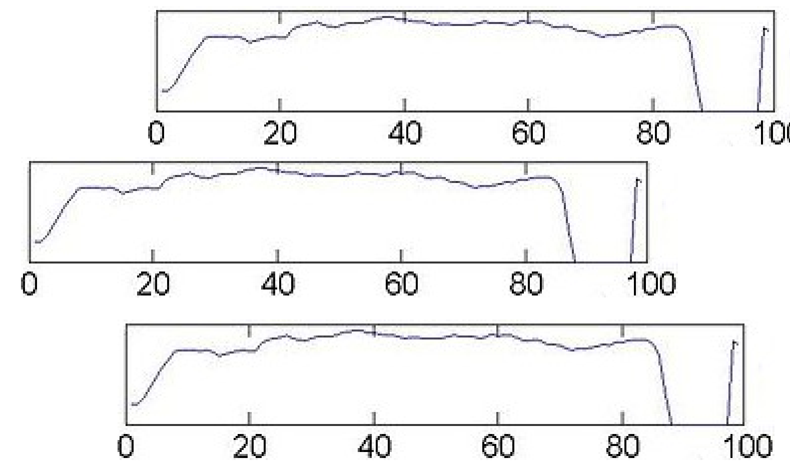
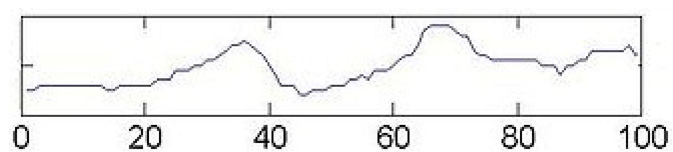




Other users

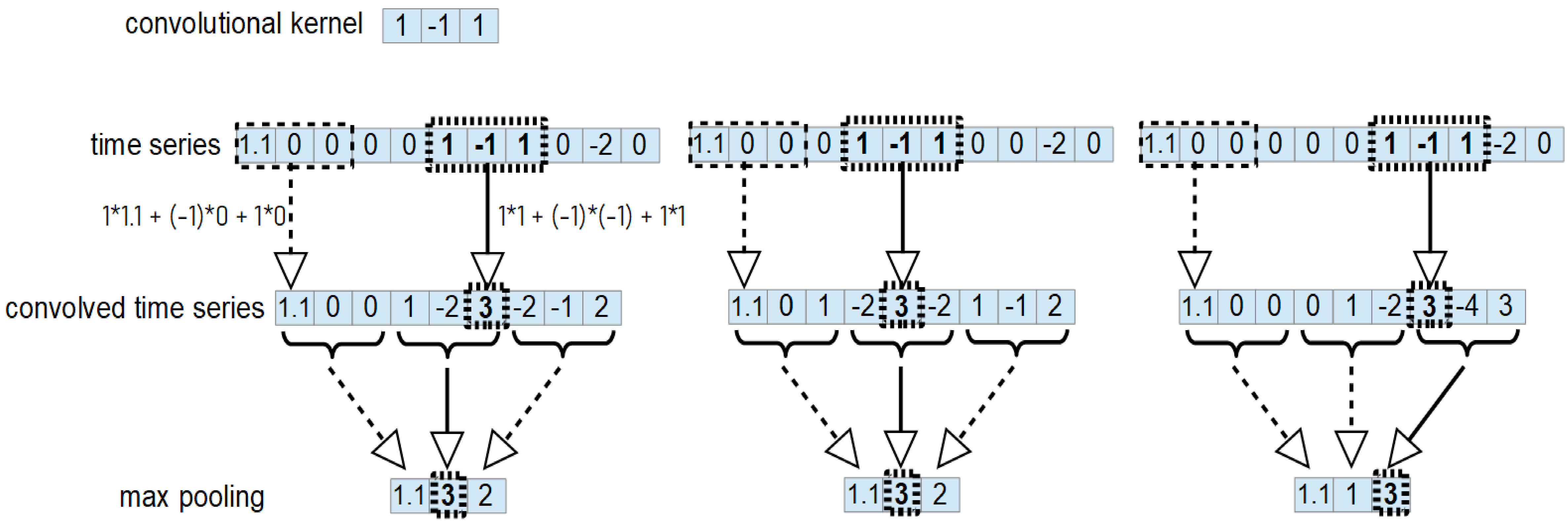


Time series classification methods

Fawaz, H.I., Forestier, G.,Weber, J., Idoumghar, L., Muller, P.A.: Deep learning for time series classication: a review. Data Mining and Knowledge Discovery 33(4), pp. 917 – 963 (2019)

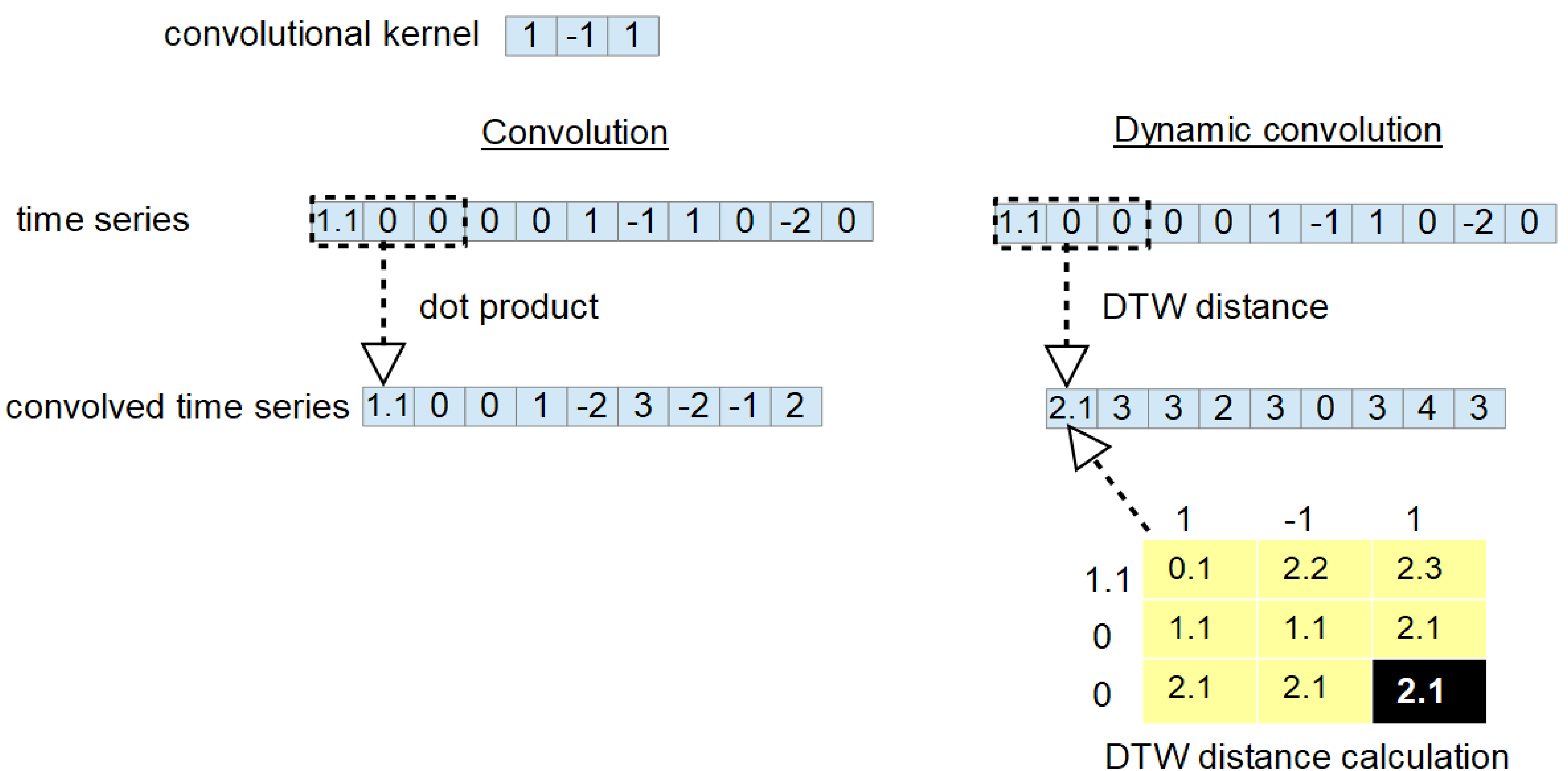
Buza, K.: Time series classification and its applications. In: Proceedings of the 8th International Conference on Web Intelligence, Mining and Semantics, pp. 1 – 4 (2018)

Convolution with max pooling



translations of local patterns: irregular robustness

Dynamic convolution



Our contribution

- Dynamic convolution
  - Replace dot product in convolution by dynamic time warping calculations
- Neural networks with dynamic convolution
  - Replace the first convolutional layer by a *dynamic convolutional* layer

Experimental evaluation

- Data: real-world time series datasets from “The UEA & UCR Time Series Classification Repository” – www.timeseriesclassification.com
- Two convolutional neural network architectures: Net1 and Net2
- Two version of both Net1 and Net2:
    - (a) with conventional convolution
    - (b) with dynamic convolution
- 10-fold cross-validation, t-test
- Codes: https://github.com/kr7/DCNN

Results

Dataset	Net1 CNN	Net1 DCNN	Net2 CNN	Net2 DCNN
Adiac	0.506±0.061	**0.575±0.046** •	0.558± 0.052	**0.640±0.055** •
ArrowHead	0.886±0.064	**0.896±0.083** ◦	**0.900±0.062**	0.887±0.082 ◦
Beef	0.733±0.170	**0.800±0.163** •	0.700±0.180	**0.783±0.130** •
EarthQuakes	0.725±0.042	**0.733±0.069** ◦	0.699±0.072	**0.731±0.063** ◦
ECG200	0.870±0.050	**0.890±0.044** ◦	0.865±0.084	**0.870±0.064** ◦
FiftyWords	0.702±0.033	**0.714±0.045** ◦	0.686±0.034	**0.715±0.027** •
Plane	0.981±0.032	**0.990±0.029** ◦	0.976±0.032	**0.995±0.014** •
SwedishLeaf	0.864±0.041	**0.883±0.027** •	0.862±0.036	**0.881±0.033** ◦
WordSynonyms	0.682±0.031	**0.714±0.050** •	0.681±0.049	**0.727±0.047** •
Yoga	0.951±0.013	**0.960±0.012** •	0.945±0.022	**0.959±0.008** ◦

Conclusions

- Dynamic convolution:
  dynamic time warping calculations instead of dot product
- Our experimental evaluation shows that neural networks with dynamic convolution outperform “usual” convolutional neural networks in case of various time series classification tasks
- Codes: https://github.com/kr7/DCNN