# Key topics

- Time series and M4/5 competition

- ES Hybrid method

- Facebook Prophet

- GluonTS

- N-Beats

- Tsetlin machine

- Hands-on session

# Forecasting - summary

- Dynamical development and new methods

- Efficiency of prediction significantly higher than statistical methods

- Many areas for applications.

- For financial time series accuracy over 60% for long term

This gives a significant edge in many areas.

# Time series - definitions

- Time series - ordered in time list of values of given attribute

- Time series forecasting - forecasting of future, not known values of time series

- Machine learning time series forecasting methods - methods of time series forecasting based on machine learning methods, trained (usually) with stochastic backpropagation.

# Review of fundamental statistical forecasting methods

- ARMA, ARIMA and different variants

- Exponential smoothing - Holt-Winters

- ARCH/GARCH - and different variants

- Theta method

- Ensemble of methods

# M4 and M5 Competition - breakthrough in forecasting

- M Competition - most prestigious and scientifically backed competition in time series forecasting

- Organised by University of Nicosia and prof. Spyros Makridakis

- First and second place of M4 was won by hybrid methods

- M5 dominated by machine learning methods

☑ The most comprehensive study related to time series forecasting.

# ES Hybrid Method - winning method from M4

- Data preprocessing - Exponential Smoothing

- Parameters of preprocessing per each series, shared models

- Neural networks: LSTM - residual, dilated, attentions

- Model's ensembling

✅ Smyl, Slawek. "A hybrid method of exponential smoothing and recurrent neural networks for time series forecasting." International Journal of Forecasting 36.1 (2020): 75-85.

# ES Hybrid Method - winning method from M4
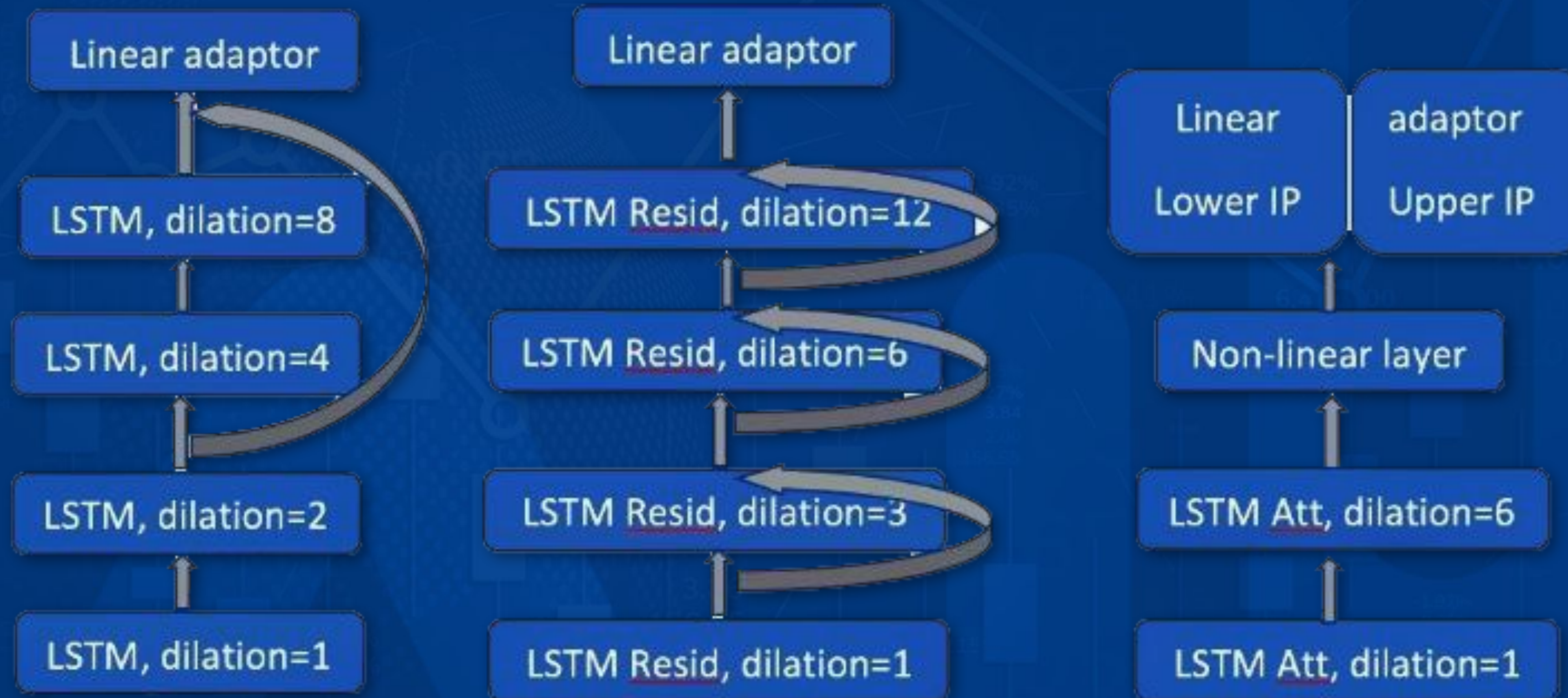


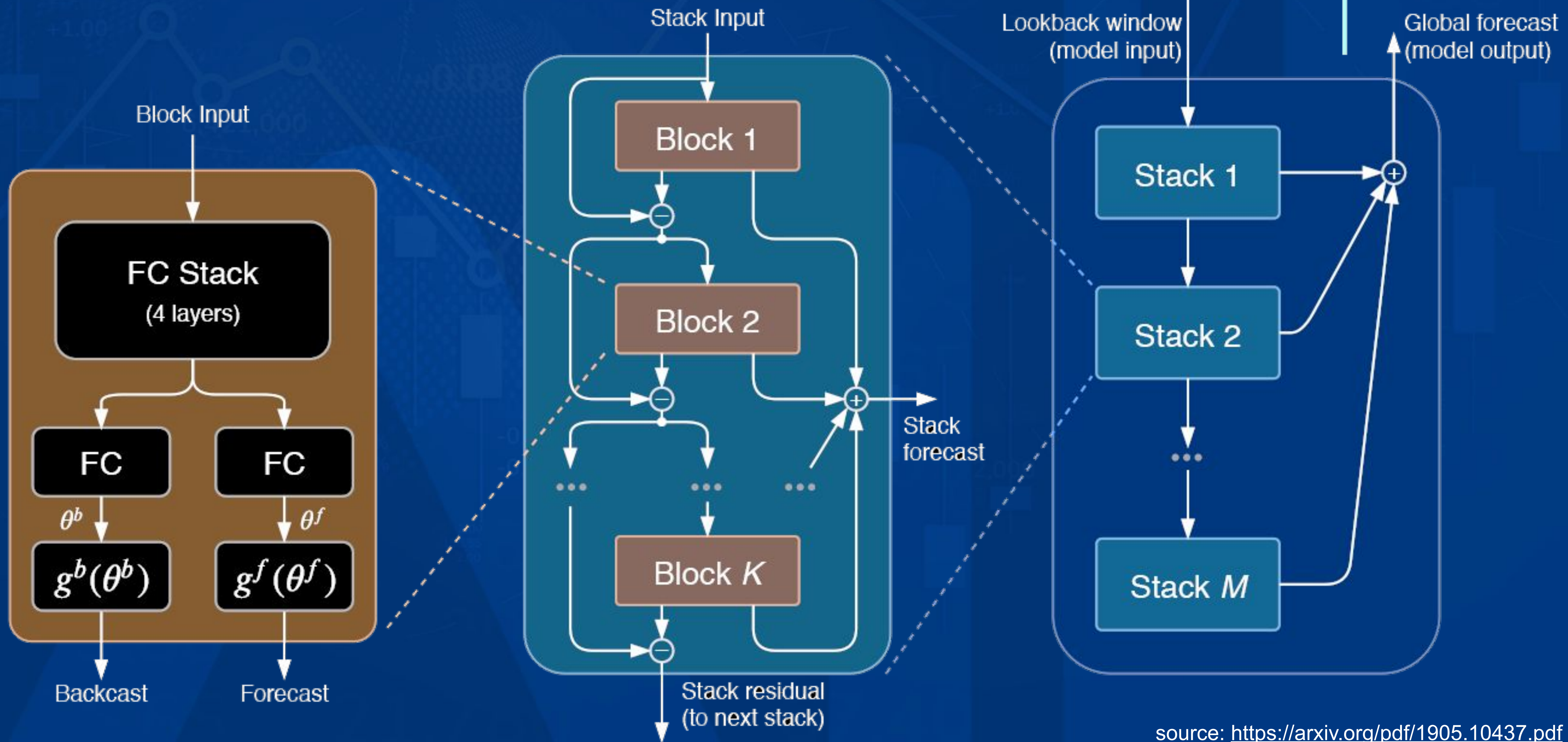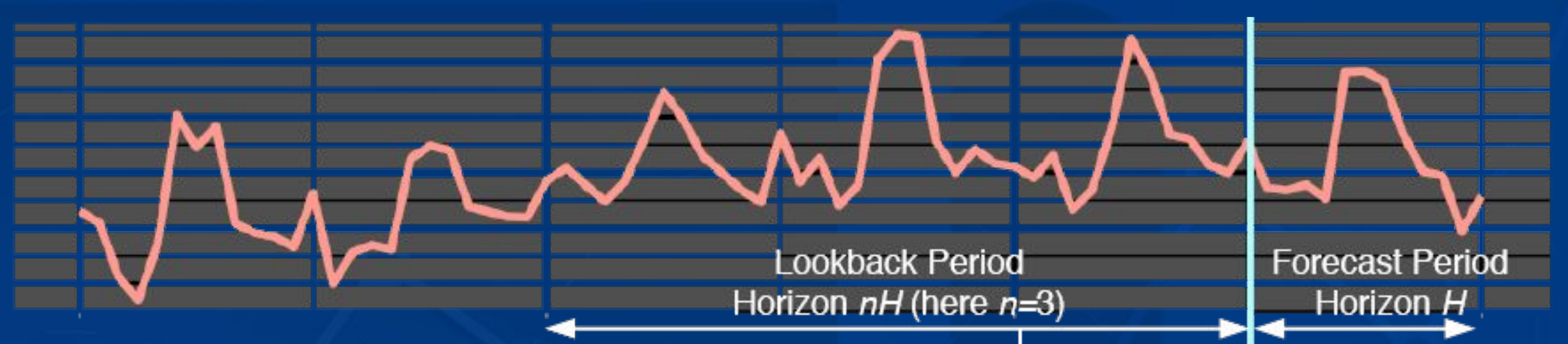| (1,2)-(4,8) Std | (1-3-6-12) Residual à la Kim | (1,6),NL |
|---|---|---|
| Quarterly | Monthly | Yearly, Pred. Intervals |

# N-Beats

- Machine learning only methods

- Unique stack/block based architecture

- Different types of blocks: trend, seasonality, generic

- Explainability and transfer learning features

- Advanced models ensembling

Oreshkin, B. N., Carpov, D., Chapados, N., & Bengio, Y. (2019). N-BEATS: Neural basis expansion analysis for interpretable time series forecasting. arXiv preprint arXiv:1905.10437.

# N-Beats



Lookback Period Horizon $nH$ (here $n=3$)

Forecast Period Horizon $H$

Stack Input

Lookback window (model input)

Global forecast (model output)

Block Input

Block 1

Block 2

Block K

Stack forecast

Stack residual (to next stack)

FC Stack (4 layers)

FC

FC

$\theta^b$

$\theta^f$

$g^b(\theta^b)$

$g^f(\theta^f)$

Backcast

Forecast

Stack 1

Stack 2

Stack M

source: https://arxiv.org/pdf/1905.10437.pdf

# Facebook Prophet

- Generalized Additive Models based method.

- Easy to use and enrich with additional variables.

- Automatic trend changepoint detection.

- Seasonality and holiday effects.

- Uncertainty intervals.

- Low computational cost of training and evaluation.

http://facebook.github.io/prophet/docs/quick_start.html
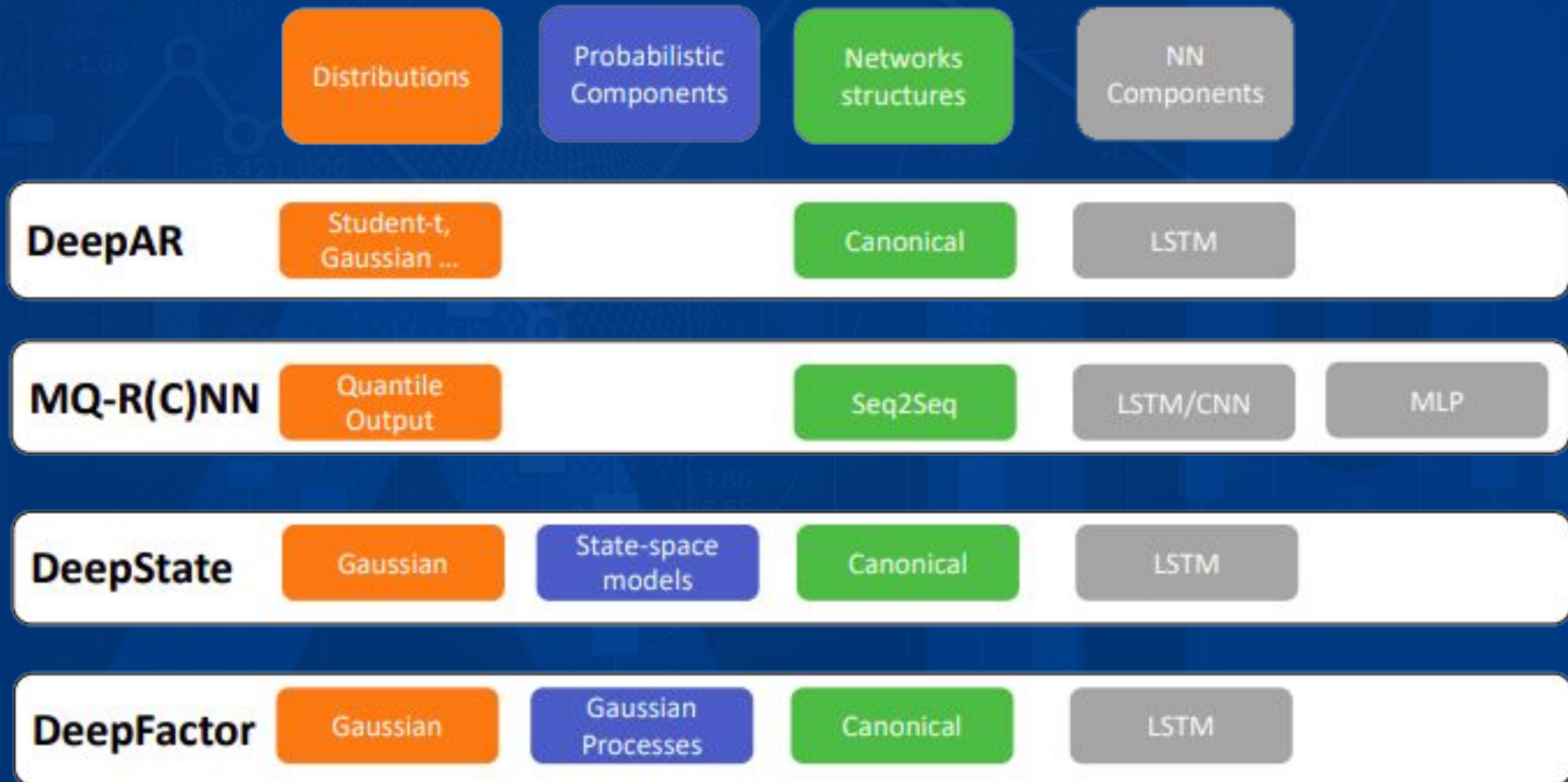
# Facebook Prophet - examples
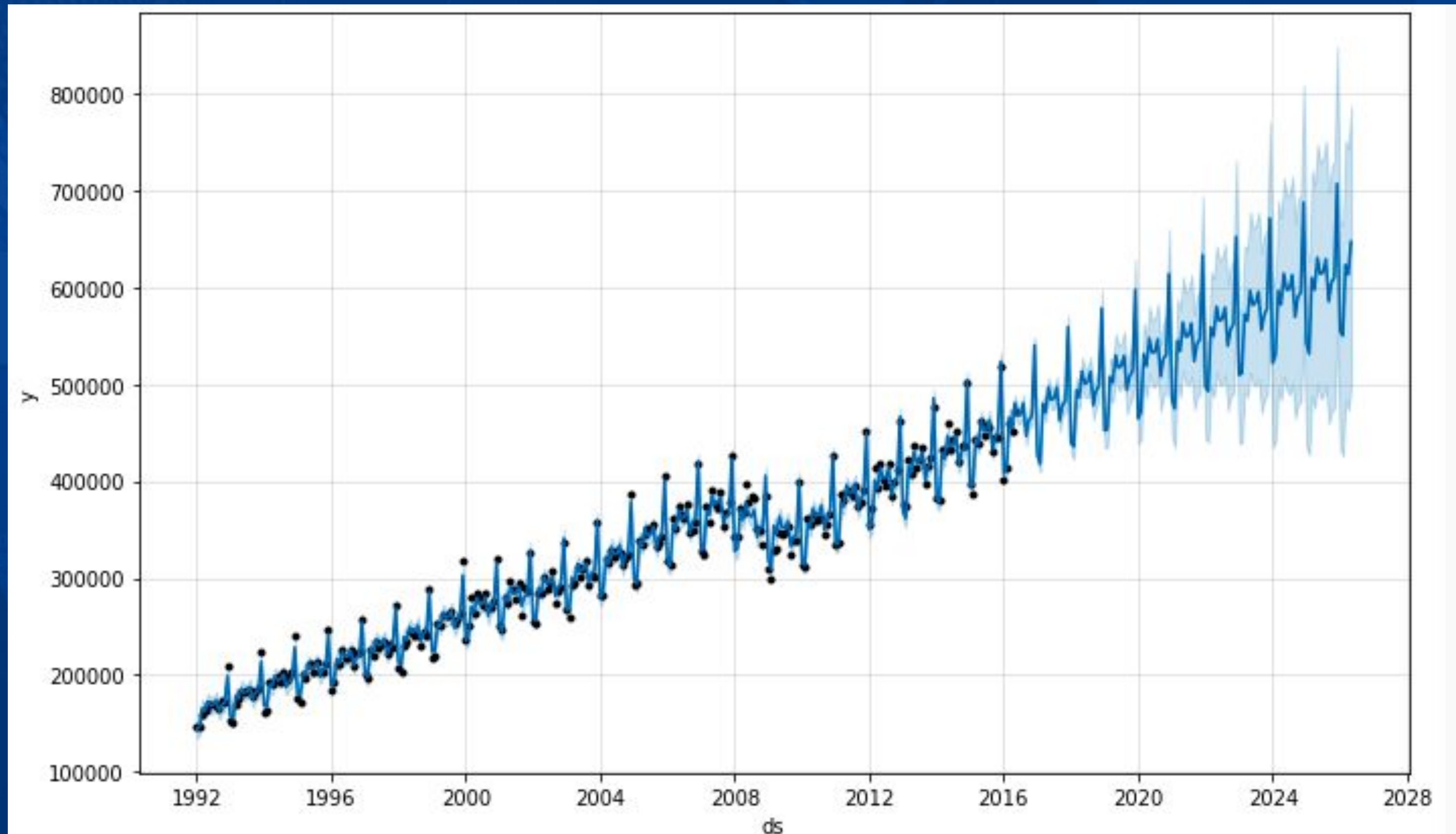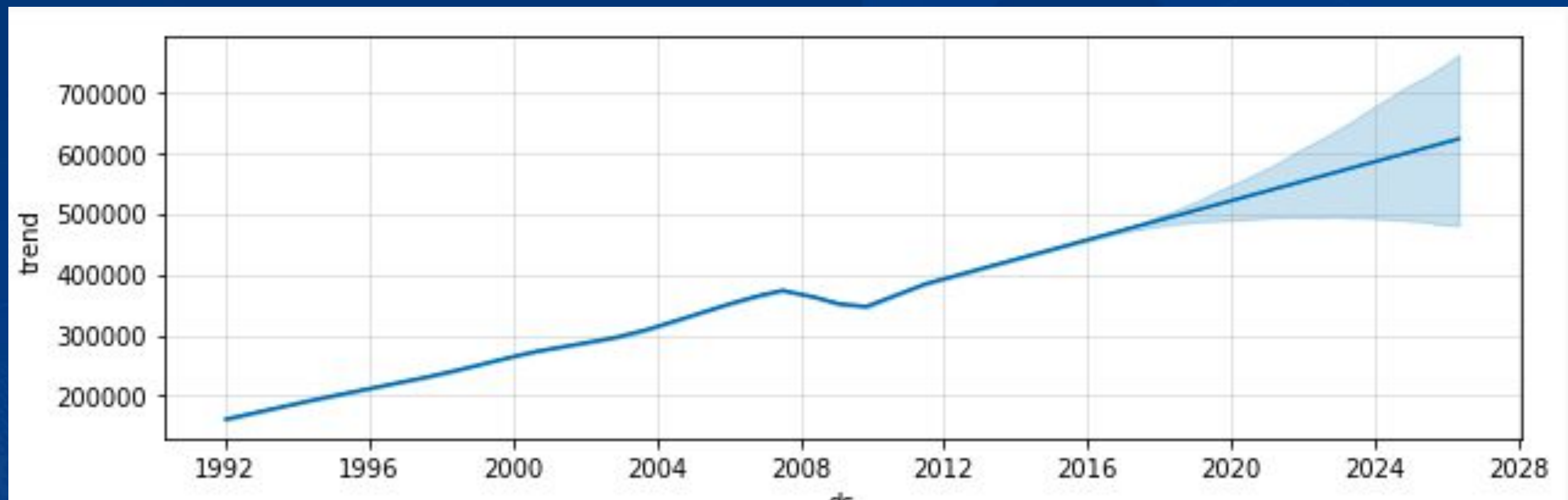
# GluonTS

- Complete framework for time series forecasting

- Various models (including most advanced neural networks architectures) and methods of data transformation

- Probabilistic time series modeling

- Support for cloud computing training and inference

- Strong community support

Alexandrov, A., Benidis, K., Bohlke-Schneider, M., Flunkert, V., Gasthaus, J., Januschowski, T., ... & Stella, L. (2019). Gluonts: Probabilistic time series models in python. arXiv preprint arXiv:1906.05264.

# GluonTS - elements of the framework

| | Distributions | Probabilistic Components | Networks structures | NN Components | |
|---|---|---|---|---|---|
| **DeepAR** | Student-t, Gaussian ... | | Canonical | LSTM | |
| **MQ-R(C)NN** | Quantile Output | | Seq2Seq | LSTM/CNN | MLP |
| **DeepState** | Gaussian | State-space models | Canonical | LSTM | |
| **DeepFactor** | Gaussian | Gaussian Processes | Canonical | LSTM | |

# Tsetlin machines

- Unique and innovative approach for forecasting

- Stochastic Learning Automata algorithm for forecasting

- Based on propositional logic

- Dynamically managed probabilistic distributions

Granmo, O. C., Glimsdal, S., Jiao, L., Goodwin, M., Omlin, C. W., & Berge, G. T. (2019). The convolutional tsetlin machine. arXiv preprint arXiv:1905.09688.

# Tsetlin machines



4 positive clauses

4 negative clauses

3 x 3 input image
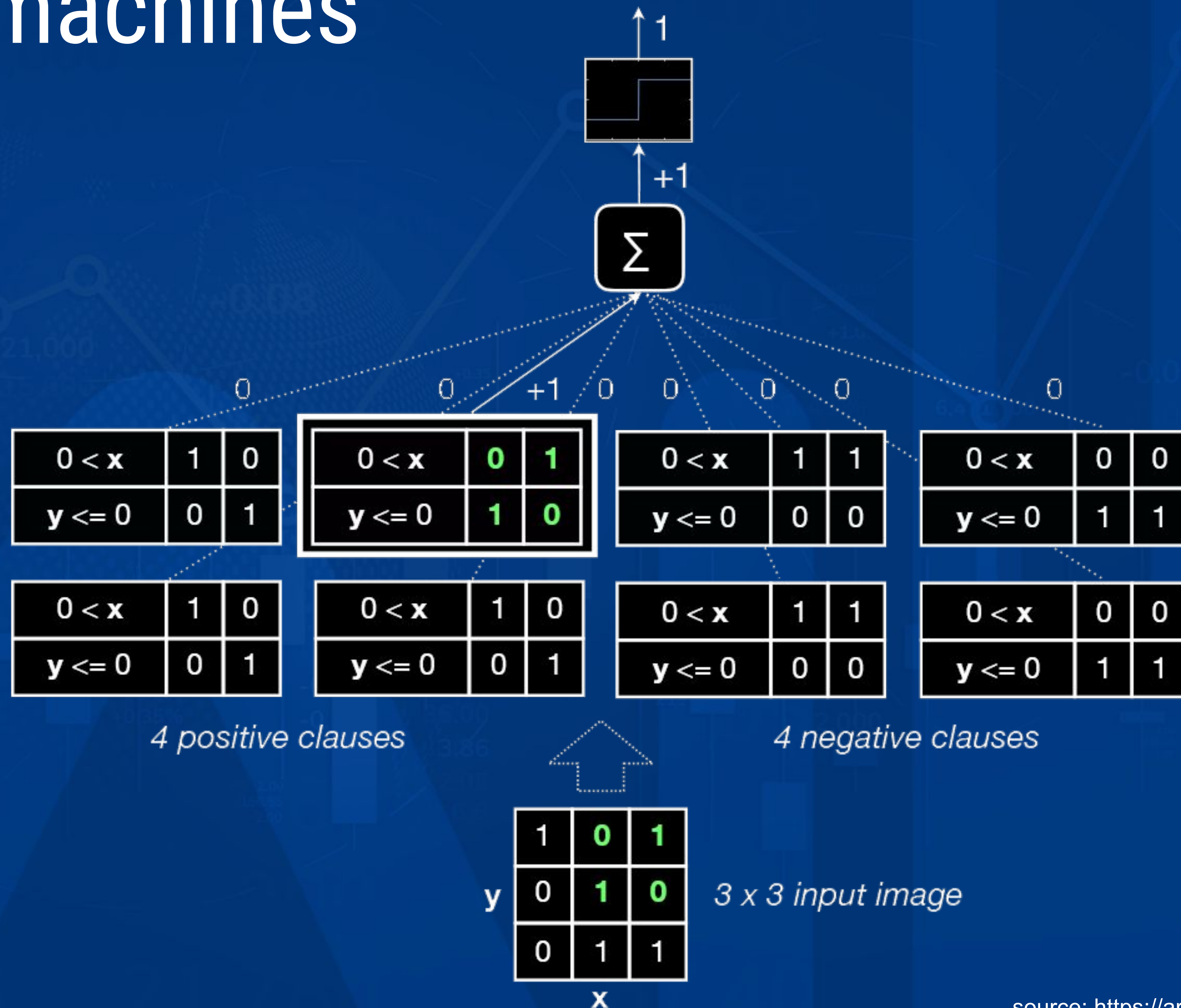
Hands-on session

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