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Joint Geometric and Probabilistic Constellation Shaping with MOKka

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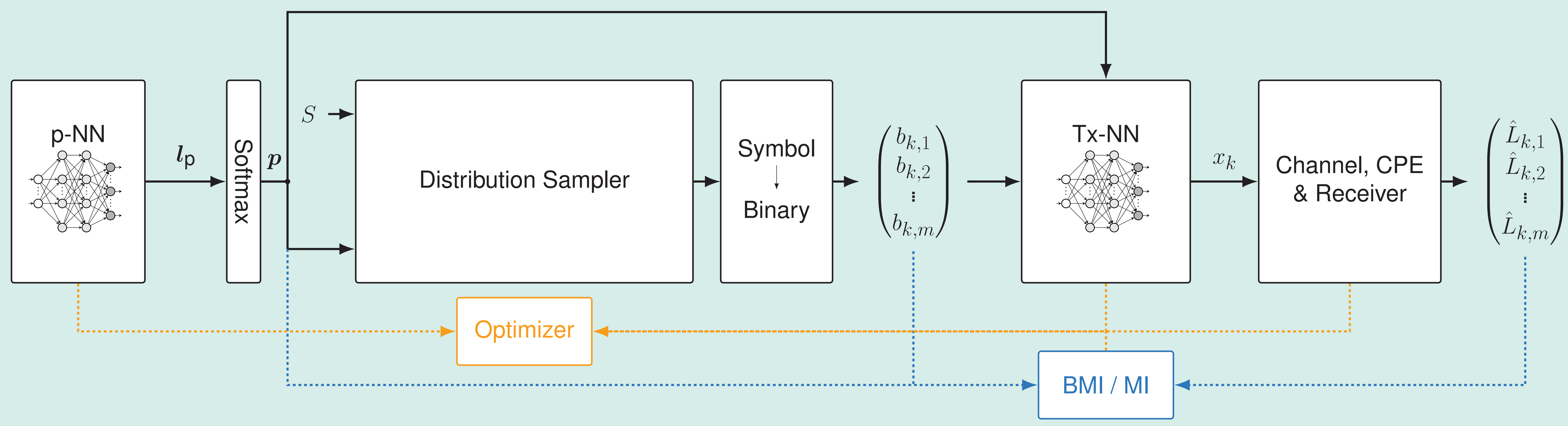
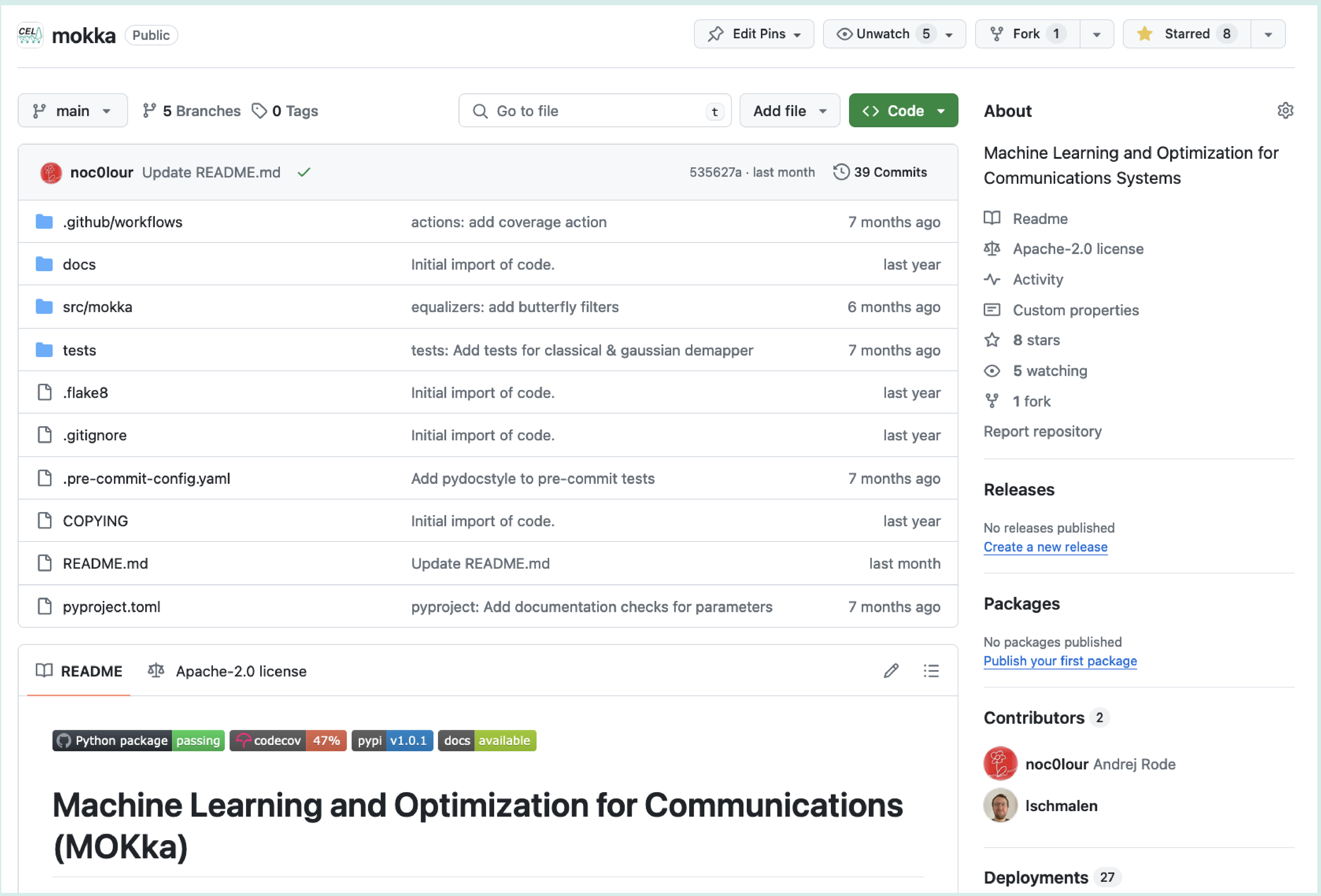
System Model for End-to-end Optimization of Geometric and Probabilistic Constellation Shaping



- Define which parameters are trainable
- Sample S training symbol indices according to the distribution $\boldsymbol{p}$
- Generate bits $\boldsymbol{b}_k$ (bit-wise) or one-hot vectors (symbol-wise) from symbol indices
- Perform mapping with Tx-NN to obtain complex transmit symbols $\boldsymbol{x}_k$
- Propagate $\boldsymbol{x}_k$ through differentiable channel models, signal processing algorithms and demappers to obtain q-values (symbol-wise) or LLRs (bit-wise)
- Calculate objective function MI (symbol-wise) or BMI (bit-wise)
- Perform back propagation and update trainable parameters

The MOKka Package

- Python package for machine learning in communications engineering
- German: **M**aschinelles Lernen und **O**ptimierung für **K**ommuni**ka**tionssysteme
- Modularized signal processing and machine learning functionality
  - `channels` – Channel models
  - `e2e` – End-to-end system simulation
  - `equalizers` – Channel reversal and equalization
  - `functional` – Signal processing functions
  - `inft` – Information theoretic functions
  - `mapping` – Bit-to-symbol and symbol-to-bit conversion
  - `normalization` – Signal normalization
  - `pulseshaping` – Filters and windowing functions
  - `synchronizers` – Receiver synchronization algorithms
  - `utils` – Various utilities not necessarily related to signal processing

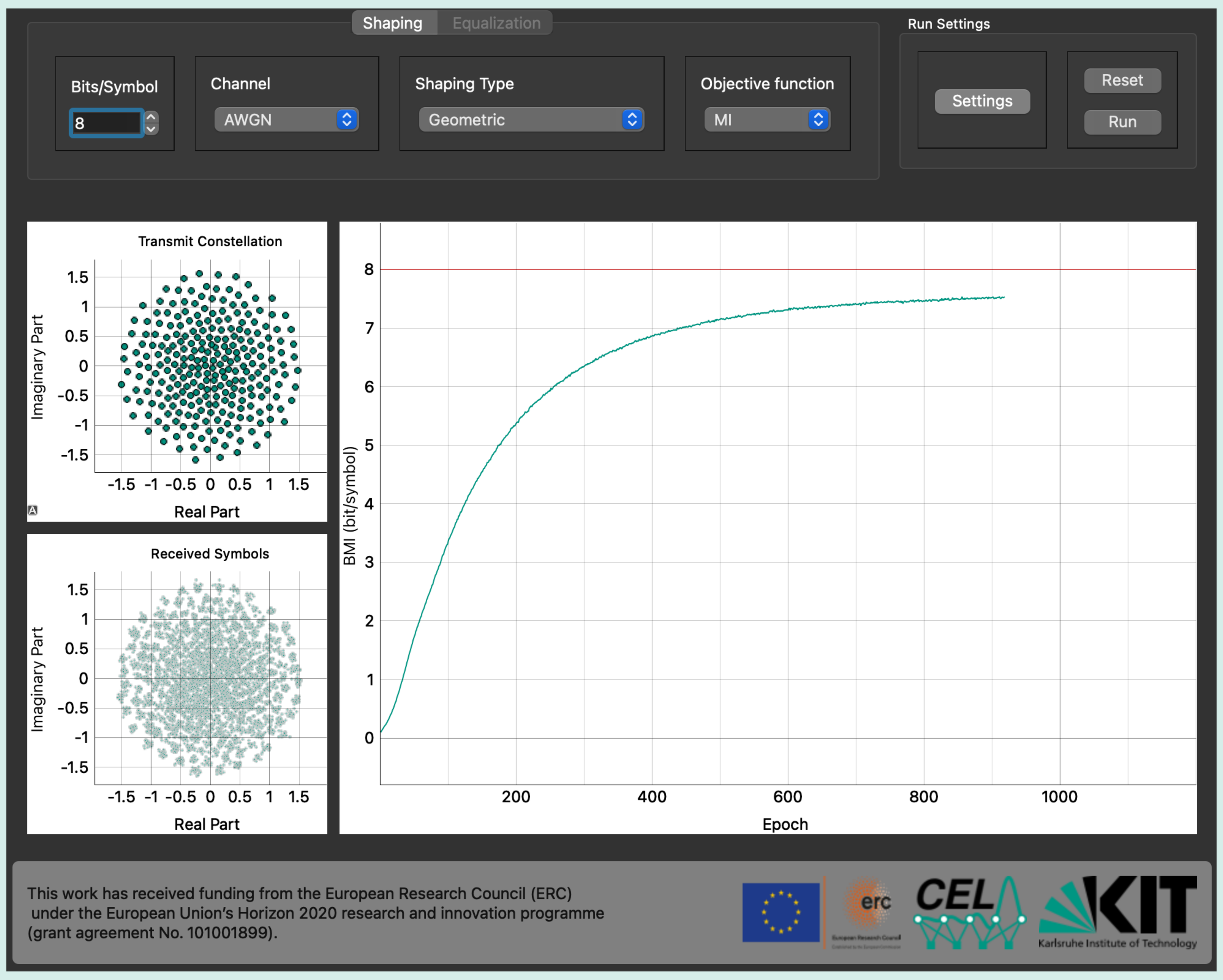


MOKka repository

Demo repository

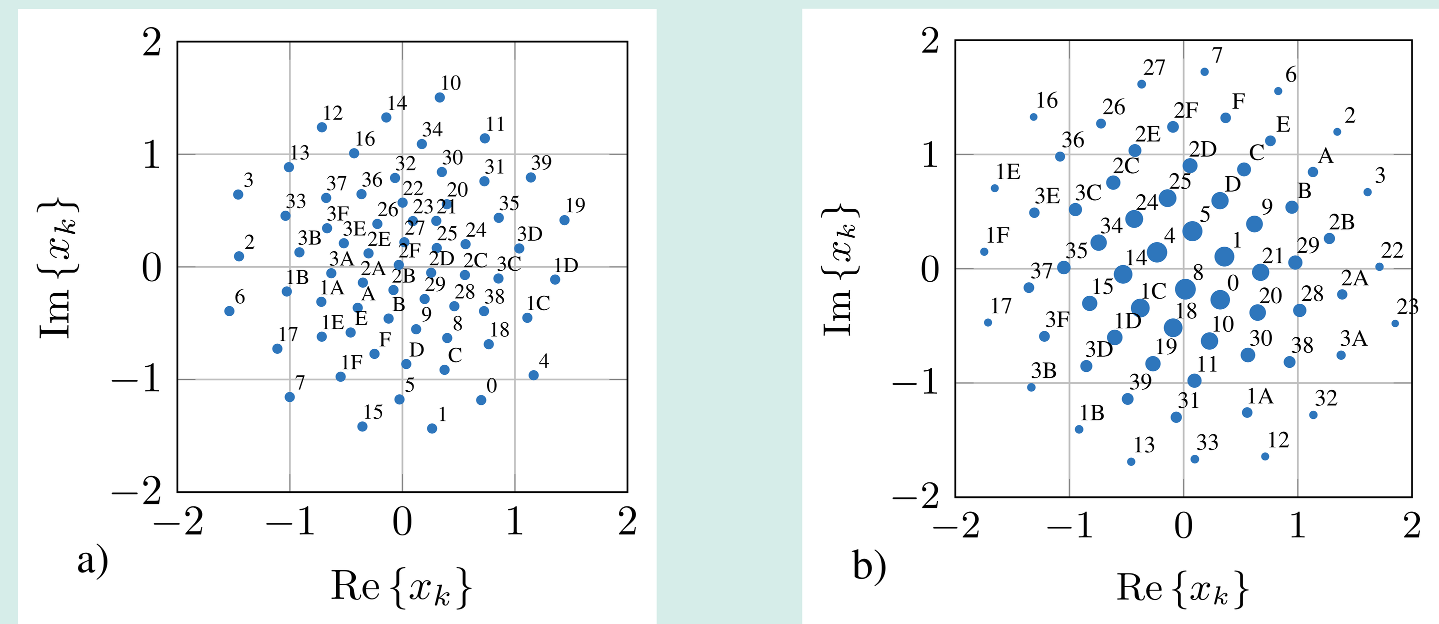
MOKka documentation

Demo GUI



- Interactive visualization of constellation optimization
- Choice of geometric, probabilistic or joint constellation shaping
- Change optimization objective between BMI/MI
- Observe changes in complex optimization problems

64-ary Constellations for the Wiener Noise Channel



64-ary constellations a) geometrically and b) jointly geometrically and probabilistically optimized for the Wiener phase noise channel with the blind phase search algorithm as carrier phase recovery algorithm [1].

[1] A. Rode, B. Geiger, S. Chimmalgi, and L. Schmalen, 'End-to-end optimization of constellation shaping for Wiener phase noise channels with a differentiable blind phase search', Journal of Lightw. Technology, vol. 41, no. 12, pp. 3849–3859, Apr. 2023, doi: 10.1109/JLT.2023.3265308.