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Masterarbeit

Physics-Informed Neural Receivers for Quantum Illumination

Description

Develop a physics informed convolutional neural receiver that extracts covariance and phase space structure from simulated homodyne/quadrature data produced by Two Mode Squeezed Vacuum sources to detect targets at extremely low SNR. You will build realistic degradation models (loss, thermal noise, detector inefficiency, phase noise) and produce standardized datasets so that results are statistically meaningful and reproducible. Beyond raw performance, the project emphasizes interpretability: the network should exploit known physical symmetries and provide understandable decision cues (e.g., saliency on covariance features).

Tasks:

1. Implement a parametric simulator in Strawberry Fields or PennyLane with tunable squeezing r, channel loss, thermal noise and detector nonidealities.
2. Generate datasets: raw quadrature time series, covariance matrices as 2D representations, and metadata across an SNR sweep.
3. Design and train physics informed CNN modules (covariance aware convolutions, symmetry preserving blocks).
4. Implement classical baselines (Matched Filter, GLRT) and classical ML baselines (SVM, Random Forest).
5. Run ablation studies (input encodings, network depth, domain randomization) and compute ROC/AUC with confidence intervals.

The work can be done in German or English.

Prior knowledge

- Python proficiency (PyTorch/TensorFlow)
- Signal Processing fundamentals
- Statistical analysis and hypothesis testing
- Experience with simulation tools (e.g., Strawberry Fields)

Research area

- Quantum Machine Learning & Sensing
- Physics-Informed Deep Learning
- Signal Detection in low SNR regimes
- Synthetic Data Generation from physical m
- Covariance-based feature extraction

Studiengang

- [x] Elektro- und Informationstechnik
- [x] Informatik
- [x] Mathematik
- [x] Physik

Alignment

- [x] Research
- [x] Implementation
- [x] Analysis and evaluation
- [x] Method development
- [x] Simulation

Start

At any time

Links

Mitarbeiterseite

Ansprechpartner

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