Universität Rostock Traditio et Innovatio

FAKULTÄT FÜR INFORMATIK UND ELEKTROTECHNIK

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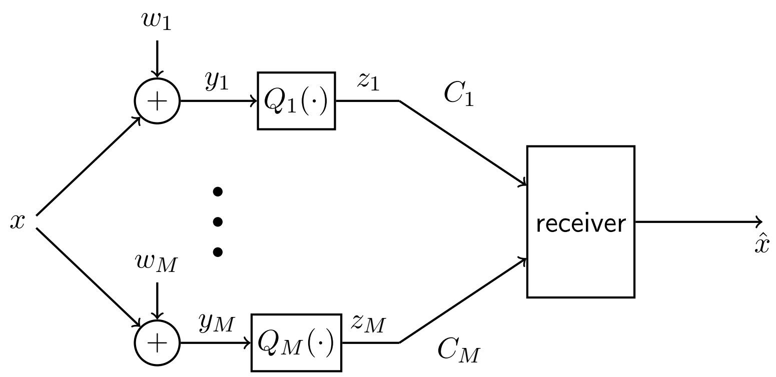
Master Thesis

Distributed Quantization with Deterministic Mappings

Description:

This thesis considers a distributed sensing system as depicted in the figure below. The sensors acquire noisy measurements of a relevant process and have to forward them to a common receiver over capacity limited links. In order to meet the capacity limitations the measurements have to be compressed, i.e. they are locally quantized at the sensors. The quantization indexes are then forwarded to the receiver without any cooperation among the sensors. As the quantization distorts the measurements, the quantizers have to be jointly designed to infer as much information about the relevant process as possible. This task is known in information theory as the chief executive officer (CEO) problem.



One clustering/quantization approach originates from information theory and is called "Information Bottleneck (IB) Method". It tries to quantize a noisy observation such that it preserves most of a predefined relevant information. For the scalar case, this problem can be posed as a Lagrangian optimization task

$$\mathcal{F}\{p(z|y)\} = I(\mathcal{Y};\mathcal{Z}) - \beta I(\mathcal{X};\mathcal{Z}), \tag{1}$$

where the Lagrangian multiplier β serves as trade-off parameter between maximum preservation of relevant information ($\beta \to \infty$) and maximum compression ($\beta \to 0$). In order to fulfill possible rate constraints in subsequent channels, the value for β can be used to adjust the compression rate $I(\mathcal{Y};\mathcal{Z})$. The popular iterative Information Bottleneck method delivers for finite β a *stochastic* clustering $p(z|y)$. As stochastic quantization is challenging from

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an implementation point of view it might be preferable to design a deterministic quantizer. However, the iterative IB algorithm achieves this only for $\beta \to \infty$ and the compression is obtained by choosing an appropriate cardinality $|\mathbb{Z}|$.

Other algorithms like sequential or agglomerative Information Bottleneck algorithms deliver deterministic solutions of the IB funcional in (1) even for finite β. In this thesis, the IB algorithms delivering deterministic mappings shall be implemented in Python and their performance shall be investigated. In particular, a comparison to the iterative IB algorithm with $\beta \to \infty$ shall be performed. Starting with the scalar case, the implementation shall be extended to the distributed scenario described above.

The required tasks for this thesis are:

- Familiarize with the IB framework and distributed compression by reviewing the literature
- Familiarize with Python and the provided simulation environment
- Implement IB algorithms for deterministic mappings for scalar and distributed scenarios
- In depth analysis of performance and convergence behavior of the algorithms

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