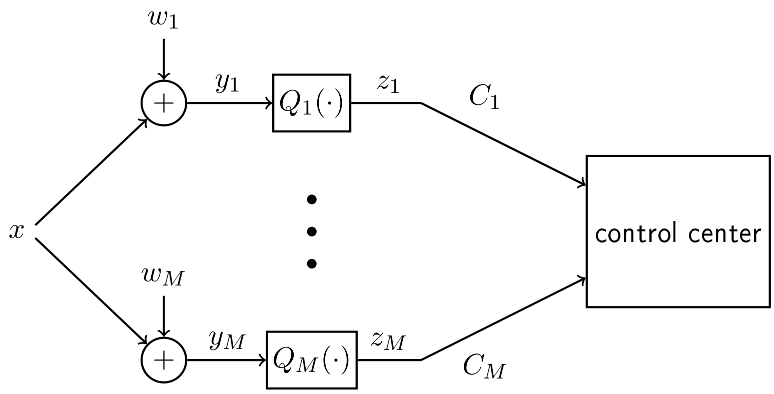
## Master Project

**Reconstruction of Signals Compressed by Distributed, Information Bottleneck Optimized Quantizers**

## Description:

Distributed sensing systems consist of a set of sensors transmitting their measurements to a common control unit. The controller processes the received measurements $z_i$ and determines commands for the actors to control the process. Depending on the processes to be observed, the signals $x_i$ measured by different sensors can be highly statistically dependent, in particular if many sensors scan the same process. Originally, the measured signals $y_i$ are analog, i.e. continuous in time and amplitude. Before transmitting them to the control unit, they are generally PCM (pulse coded modulation) encoded, i.e. they have to be sampled and quantized. The resulting stream of bits is delivered to the control unit via a wireless link by applying appropriate coding and modulation techniques.




The quantizers $Q_1, \ldots, Q_M$ are optimized by the alternating Information Bottleneck (aIB) method such that the compression rates $I(\mathcal{Y}_m; \mathcal{Z}_m | \boldsymbol{\mathcal{Z}}_{\tilde{m} \neq m})$ of each quantizer fulfill the given rate constraints $C_m$. This optimization approach applies the Information Bottleneck (IB) principle, which minimizes the required data rate by quantization while preserving as much relevant information as possible. Moreover the aIB method sequentially optimizes one sensor while keeping the others fixed and using their mappings as side-information. As a result $Q_1, \ldots, Q_M$ are jointly optimized scalar quantizers which work autonomously during runtime.

For later data processing, the common control center needs to reconstruct the signal $x$. We assume that the sensors measure a sequence of values $\boldsymbol{y}_m = \boldsymbol{x} + \boldsymbol{w}_m$. To simplify the reconstruction, the quantizers $Q_1, \ldots, Q_M$ are designed as deterministic quantizers. Since $H(\mathcal{Z}_m|\mathcal{Y}_m) = 0$ holds for deterministic quantizers, the compression rate results in $I(\mathcal{Y}_m; \mathcal{Z}_m) = H(\mathcal{Z}_m)$. Hence, entropy encoding can be applied to encode the output-clusters and no further compression is necessary to transmit the data over the channels with capacities $C_1, \ldots, C_M$.

In this thesis an existing implementation of the aIB algorithm, written in Matlab, shall be extended to design deterministic quantizers. Afterwards the reconstruction for deterministic quantizers shall be investigated for different strategies like MMSE (Minimum Mean Squared Error) and MAP (Maximum a posteriori).

The required tasks for this thesis are:

- Literature research on Information Bottleneck and familiarization with the provided alternating IB algorithm
- Extension of the alternating IB to design deterministic quantizers
- Investigation of different reconstruction strategies like MMSE and MAP

**Chair:** Prof. Dr.-Ing. Volker Kühn
**Supervisor:**
Dipl.-Ing. Steffen Steiner **Email:** steffen.steiner@uni-rostock.de