The potentials of the so-called **Information Bottleneck (IB)** method as an information-preserving data compression scheme have already been well recognized in the communications engineering society. This fact can be readily confirmed by the miscellaneous list of applications in which the IB method has been utilized, from the design of analog-to-digital converters for receiver front ends to the construction of polar codes and low-complexity discrete channel decoding schemes with promising performance and many more.

To put it briefly, its principal idea is to compress a random variable such that its information content w.r.t. a statistically correlated (relevant) variable is mostly retained. This information preservation capability is rather flexible and, in effect, can be tuned by twiddling a parameter that establishes a basic trade-off between the *compactness* and *informativity* of the resultant outcome. The IB method accomplishes this by utilizing the same concept of Mutual Information (MI) to quantify both sides of this trade-off. From a pure learning perspective, this can be interpreted as seeking to strike a right balance between the *datafit* and the *generalization* by exploiting the MI both as the cost function as well as the regularizer.

Within the scope of the dissertation "**Source & Joint Source-Channel Coding Schemes Based on the Information Bottleneck Framework**", the main idea and the mathematical methodology of the IB approach have been extended (over generic setups that frequently appear in a diversity of applications) to devise novel compression schemes for both the centralized and distributed (noisy) Source and Joint Source-Channel Coding scenarios. More specifically, the *Variational Calculus* has been exploited to address the *Lagrangian Reformulations* of the constrained optimization modeling of the design problems.

The main problem setup that this dissertation aimed to tackle can be described (in its most general format) as follows: A set of observations from a remote source signal have to be compressed *locally* (yet following a *joint* design) before getting transmitted to a (distant) processing unit via several *rate-limited* forward channels. Depending on presuming either *error-free* or *error-prone* forward links, one principally deals with the Source and Joint Source-Channel Coding problems wherein the goal is to suitably design the set of local quantizers to maximize the *overall transmission rate* (from the source to the sink) while meeting a set of restrictive constraints on *compression rates* of individual (forward) links.

The considered (distributed) setup shows up in a diversity of applications, i.a., the distributed inference sensor networks in which the measured (sensed) values should be quantized ahead of transmission to the fusion center, the Cloud-based Radio Access Networks with several rate-limited fronthaul channels to the (central) processing unit, and the cooperative relaying schemes with the *quantize-and-forward* strategy.

The IB method was originally developed as a scheme of Source Coding, i.e., maximizing the information content at the output of the quantizers. In this dissertation, the full-format generalization of the IB method has been developed for the Joint Source-Channel Coding wherein the quantizers aim to maximize the information content at the output of the error-prone forward channels. These Joint Source-Channel Coding schemes reveal their practical importance, especially in applications where stringent latency requirements must be met. Moreover, they show a high theoretical relevance since the separation of Source and Channel Coding does not necessarily lead to optimal results, e.g., in transmission systems with finite block lengths.

The derived extensions of the IB method in this dissertation were meant to lay the theoretical basis for the successful realization of the envisioned (distributed) communication model satisfying the stipulated requirements of *low-latency* and *high-reliability* for industrial systems within the application scopes of the BMBF project TACNET 4.0 wherein the (Department of Communications Engineering at) University of Bremen was heavily involved as an academic member of its consortium.