Information Combining: Models, Bounds, and Applications

— A Tutorial —

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Abstract

In the decoding process for a channel code, reliability is gained by combining information on individual code symbols when exploiting code constraints. From the viewpoint of information theory the most concise way to specify the information provided by the individual code symbols is mutual information between channel input- and output symbols. For time-invariant memoryless channels the transmission of the code symbols may be modelled by independent parallel channels. In this context three essential questions arise: i) What is the mutual information (capacity) of a substitute channel defined by the exploitation of a check equation, the so called extrinsic channel, for a code symbol and w.r.t. a specific check equation? ii) What is the mutual information for a substitute channel defined by several parallel channels driven by identical input symbols? This situation arises when combining information from several check equations (extrinsic information or substitute channels corresponding to i)) and the transmission of the code symbol itself. iii) Can the knowledge on mutual information of these substitute channels help to predict performance of a coding scheme and/or to analyze iterative decoding procedures?

During the last years, very simple upper and lower bounds on mutual in formation of the substitute channels defined in questions i) and ii) have been derived by two groups of researchers (Land, Höher, Hüttinger, Huber) and (Sutskover, Shamai, Ziv) using different analytic tools. The benefit of these bounds is that no detailed knowledge or modelling of the corresponding substitute channels is necessary to derive most optimistic and pessimistic performance expectations for iterative decoding procedures on codes as long as there are no cycles in its factor graph. In special cases this bounding technique is even successful in more general situations. The method of information combining may also be applied to derive bounds on the information processing characteristic (IPC) of a channel coding scheme which is a very general tool for performance characterization.

The authors present the concept of information combining and the derivation of the bounds in a tutorial way, such that listeners yet being not familiar with these topics should be able to understand the general methods, techniques of proofs and scopes of applications.