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The sheaf-theoretic approach to contextuality

The goal of this paper is to establish a strong link between two apparently unrelated topics: the study of information in the formal framework of valuation algebras, and the phenomena of non-locality and contextuality in quantum theory. In particular, by adopting Abramsky & Brandenburger's sheaf-theoretic description of contextuality, we show that this highly non-classical phenomenon is in fact mathematically equivalent to an incoherent solution to an inference problem. This result further proves that contextuality is not a phenomenon limited to quantum mechanics, but pervades various domains of mathematics and computer science. Moreover, the connection allows us to apply the well-studied efficient algorithms for single-query inference problems to the task of detecting contextuality in empirical models. Finally, we can use this result to end the quest for a full cohomology invariant for non-locality and contextuality. More specifically, we present a sheaf cohomology complete invariant which is ultimately inspired by the valuation algebra framework and based on network codings.

Part I will introduce the sheaf-theoretic approach, including the use of cohomology to detect contextuality, and the connections to constraint satisfaction and other computational problems.

Part II will develop the connection with valuation algebras, and the results on complete cohomology invariants for contextuality.