Quantum Structures in Computational Information Retrieval (Search)

Sachi Arafat and Keith van Rijsbergen
University of Glasgow

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Abstract

In this paper we investigate the feasibility in using both the mathematical formality and physical philosophy of the Copenhagen interpretation of quantum mechanics to describe the computational search process. A search process consists of a user expressing their information need to an interface which is then interpreted and used to fetch from the available information items, those deemed to be relevant to this need. The user element requires the notion of uncertainty in any theory modelling the process. Traditionally these uncertainties are collectively inscribed in a relevance concept, the representation and use of which defines the character of an overall retrieval model. Unfortunately information retrieval is limited in its understanding of how to best model relevance, a key factor adding to the ad-hoc nature of this discipline. To further detriment, current models are unable to consider all aspects of search; in particular they fail in formalising user behaviour and the relation between user behaviour & subsequent decisions about modifying the time varying variable of relevance. This introduces problems in justifying comparisons between retrieval models, and in general reduces the strength of experimental evaluation. In essence retrieval requires to be formalised in the sense Hilbert viewed the corresponding axiomatization problem in mathematics. For any such formalisation we propose that a unified representation space is required, complimented with the appropriate logics, and we propose that the theory of quantum mechanics provides us with the tools to define such a system.

In mapping the macro level search process to micro level physics we were required to make generalizations to the interpretation of some foundational concepts in QM including the wave function description of state and observables & measurements. We propose several ways of expressing relevance (and other retrieval concepts) within the QM framework arguing that it gives us more expressive power to deal with this complex uncertain concept. It is hoped that the analytical superiority of QM theory over current theoretical frameworks for retrieval will aid in minimizing the ad-hoc understanding and use of relevance (and other concepts) thereby creating the potential for a sound retrieval theory.