Statistical mechanics of semantic cognitive maps

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Abstract: Known approaches to geometric representation of semantics (Ritter & Kohonen 1989, Landauer & Dumais 1997, Griffiths & Steyvers 2002, Gärdenfors 2004) lack the ability to capture the sense of antonymy, as opposed to synonymy. Indeed, two antonyms can be related by meaning as closely as two synonyms, and dissimilarity metrics do not allow clearly separating the two relations. Our previously reported semantic cognitive map of English (Samsonovich & Ascoli 2007, 2008), which has the ability to separate synonyms from antonyms geometrically in a low-dimensional vector space, was constructed from synonym-antonym dictionaries using an energy function, and therefore can be interpreted as a ground state of a thermodynamical system. In the present work, the statistical-physics model underlying the formation of semantic cognitive maps is defined formally and studied further, addressing effects of static noise and phenomena like phase transitions with spontaneous symmetry breaking. Potential applications include sentiment analysis and document classification.