Towards Holographic "Brain" Memory Based on Randomization and Walsh-Hadamard Transformation

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The holographic conceptual approach for cognitive processes in human brain is investigated by neuroscientists due to the ability of holography to describe sophisticated phenomena of human perception and cognition. In this work we suggest a new mathematical description for Pribram's holographic or "holonomic" representation approach for the mind. Namely, we consider: (i) randomization of information, and (ii) Walsh-Hadamard spectral representation of holograms, rather than the well-known Fourier transform representation. The randomization reflects the belief that perceptual processes are not direct, but depend on the perceiver's expectations and previous knowledge as well as the information available in the stimulus itself. The use of Fourier transform and in our case Walsh-Hadamard transform reflects the belief that each neuron or group of neurons encode some information about the entire image rather than the whole information about a part of the image. We show that Walsh-Hadamard coefficients have benefits over the Fourier transform. The encoding is performed on randomized information that is then represented by a set of spectral Wash-Hadamard coefficients that have holographic properties. Namely, any portion of the set of coefficients defines a "blurry image" of the original data. The values of the coefficients of the Walsh-Hadamard transformation are distributed approximately normally when the information is randomized, ensuring, with high probability, that growing sets of coefficients implies a monotonic gain of information. Moreover the randomization of the original information yields robust code that is able to cope with missing coefficients. The holographic representation enables dynamic memory behavior with progressive encoding, where a mental/graphical image starts blurry, and then becomes sharper with time and processing, until it is fully loaded. Our experiments show that the image sharpens as the size of the symbol set increases. The bridge between the randomization and holographic encoding with the well-known holographic human brain assumption may bring an interesting interpretation of the perception phenomena. In particular, holographic encoding fits the mystery of the human memory encoding, where damage of portions leaves a blurred image and memories. Finally, we give an example of a simple implementation of our approach using neural networks.