The natural input memory model (Extended abstract)

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The natural input memory model (extended abstract)

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A new recognition memory model, the natural input memory (NIM) model, is proposed which differs from existing models of human memory in that it operates on natural input. A biologically-informed pre-processing method, which is commonly used in artificial intelligence [8], takes local samples from a natural image and translates these into a feature vector representation. Existing memory models (e.g., the REM model, [9]; the model of differentiation, [5]) lack such a pre-processing method and often make simplifying assumptions about item representations. These models represent an item by a vector of abstract features. The feature values are usually drawn from a particular mathematical distribution, which describes the distributional statistics of real-world perceptual features. Since these models artificially generate representations, they do not address the informational contribution of the similarity structure intrinsic to natural data. However, we believe that the similarity structure of natural data contains important information. Therefore, the NIM model operates on natural input and represents the similarity structure of the input.

The NIM model encompasses the following two stages: (1) a perceptual pre-processing stage, and (2) a memory stage. The perceptual pre-processing stage derives the similarity structure from high-dimensional natural images by applying a multi-scale wavelet decomposition followed by a principal component analysis. This is an often applied method in the domain of visual object recognition to model the first three stages of processing of information in the human visual system (i.e., retina/LGN, V1/V2, V4/LOC; [7]). Pre-processing a high-dimensional image, results in a number of low-dimensional feature-vectors, which reside in a so-called 'similarity space' [1]. In this space, representations of perceptually similar images reside in close proximity of each other. The memory stage comprises two processes: (a) a storage process, and (b) a recognition process. The storage process simply stores feature vectors. The recognition process compares feature vectors of the image to be recognized with previously stored feature vectors.

Simulations with the NIM model showed that it is able to produce a number of recent findings from experimental recognition memory studies that relate to the similarity of the input. In our simulations we investigated the ability of the NIM model to produce the following effects found in experimental recognition memory studies [6, 4, 2]: the effect of the similarity between targets and lures on the list-strength effect, the effect of the similarity between targets and lures on the list-length effect, and the false memory effect. The NIM model successfully replicated these effects. Moreover, simulation results reported elsewhere [3] showed that the NIM model also produces a strength-mirror effect and a length-mirror effect, two effects memory models are often tested for.

Our results increase the validity of the proposed model by by-passing assumptions about distributional statistics of real-world perceptual features. We show that a single straightforward process for recognition can accommodate a wide range of recognition memory effects when using the similarity structure of natural input.

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