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The Relationship between Representational Conflicts, Generalization, and Encoding Requirements in an Instance Memory Network

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Abstract : The properties of memory representations in artificial neural networks have cognitive implications. Distributed representations that encode instances as a pattern of activity across layers of nodes afford memory compression and enforce the selection of a single point in instance space. These encoding schemes also appear to distort the representational space, as well as trading off the ability to validate that input information is within the bounds of past experience. In contrast, a localist representation which encodes some meaningful information into individual nodes in a network layer affords less memory compression while retaining the integrity of the representational space. This allows the validity of an input to be determined. The validity (or familiarity) of input along with the capacity of localist representation for multiple instance selections affords a memory sampling approach that dynamically balances the bias-variance trade-off. When the input is familiar, bias may be high by referring only to the most similar instances in memory. When the input is less familiar, variance can be increased by referring to more instances that capture a broader range of features. Using this approach in a localist instance memory network, an experiment demonstrates a relationship between representational conflict, generalization performance, and memorization demand. Relatively small sampling ranges produce the best performance on a classic machine learning dataset of visual objects. Combining memory validity with conflict detection produces a reliable confidence judgement that can separate responses with high and low error rates. Confidence can also be used to signal the need for supervisory input. Using this judgement, the need for supervised learning as well as memory encoding can be substantially reduced with only a trivial detriment to classification performance.

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