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UNIVERSAL HOPFIELD NETWORKS: A GENERAL FRAMEWORK FOR SINGLE-SHOT ASSOCIATIVE MEMORY MODELS

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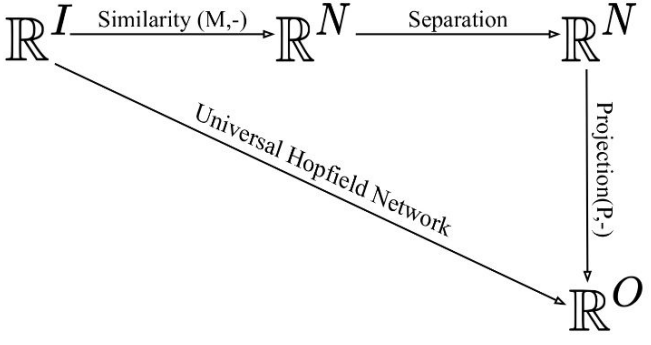
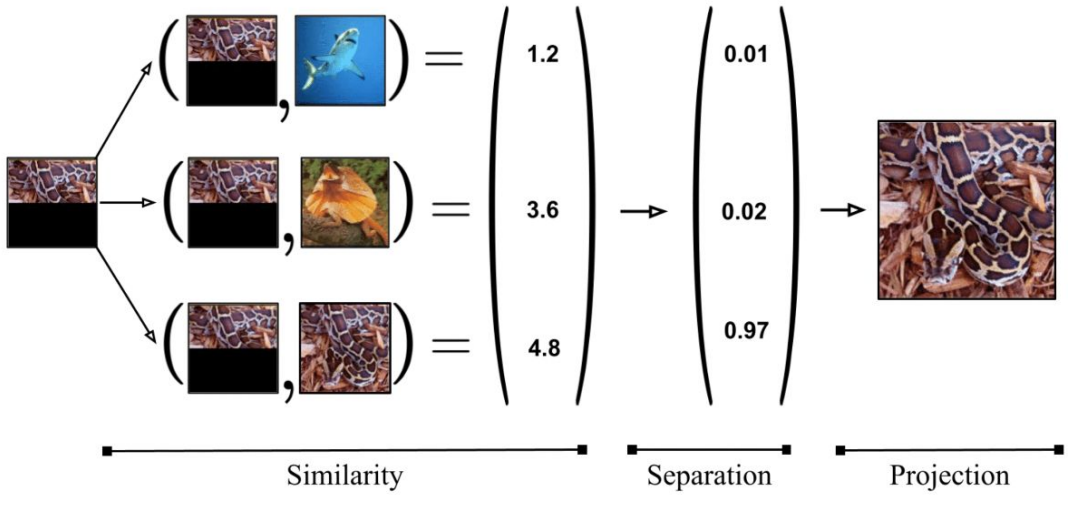
General Framework

$$z = \underbrace{P}_{\text{Projection}} \cdot \underbrace{\text{sep}}_{\text{Separation}} \underbrace{(\text{sim}(M, q))}_{\text{Similarity}}$$





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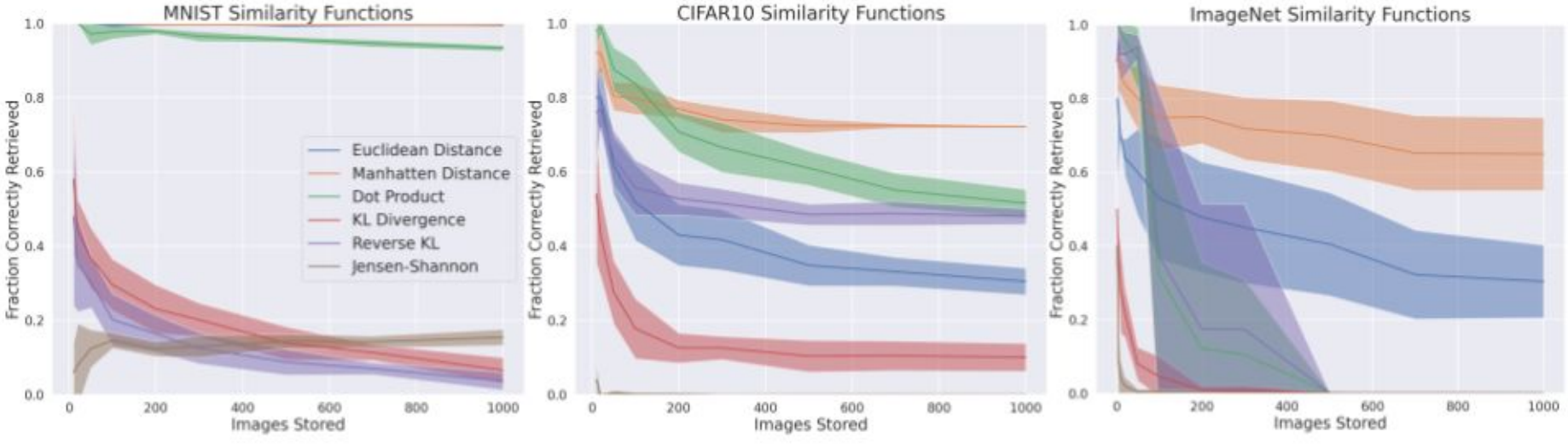
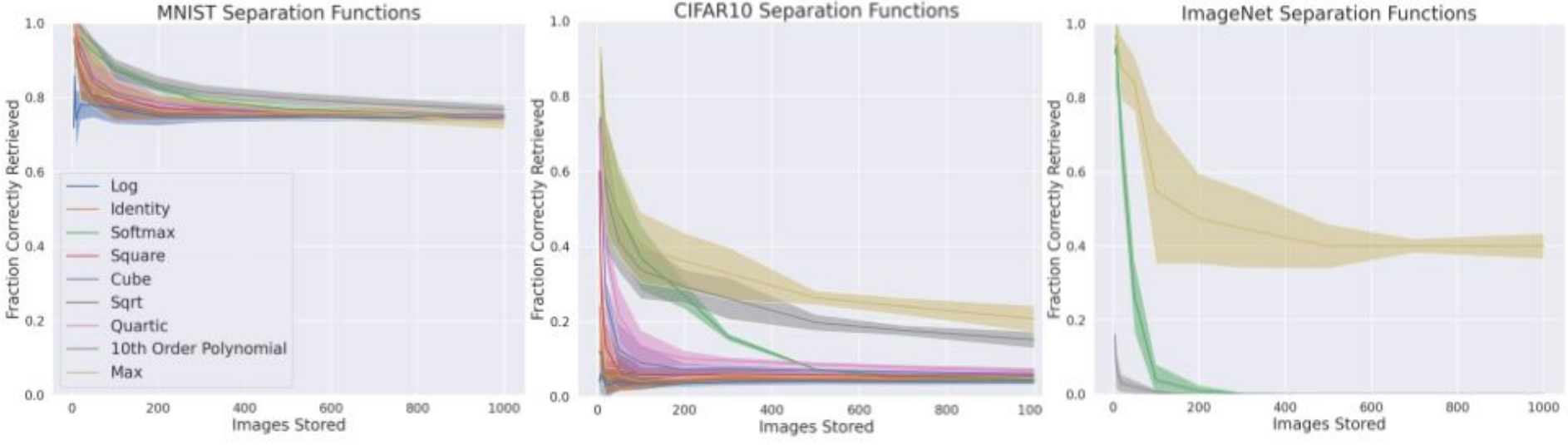
Charting the Literature

Memory Network	Similarity Function	Separation Function
(Classical) Hopfield Network (HN)	Dot Product	Identity
Sparse Distributed Memory (SDM)	Hamming Distance	Threshold
Dense Associative Memory (DAM)	Dot Product	Polynomial
Modern Continuous Hopfield Network (MCHN)	Dot Product	Softmax

Effect of Similarity Function



Effect of Separation Function



Summary and Future Work

- We have devised a general framework that lets us easily understand associative memory models proposed in the literature
- Closely related to transformer attention, and explains difference between heteroassociative and autoassociative memories
- Comes equipped with a neurobiological process theory
- Future work could apply insights into importance of similarity and separation function to transformer networks
- Investigate scaling up associative memories by encoding inputs into a latent space
- Extend the framework to understanding iterative associative memories