Adapting Holographic Declarative Memory for a Disaster Agent

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Domain

FEMA overhauls disaster assistance program as climate crisis fuels more destructive extreme weather

By Ella Nilsen, CNN
4 minute read · Updated 9:09 AM EST, Fri January 19, 2024

> “criticisms include inequity of who can access help”

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Motivation

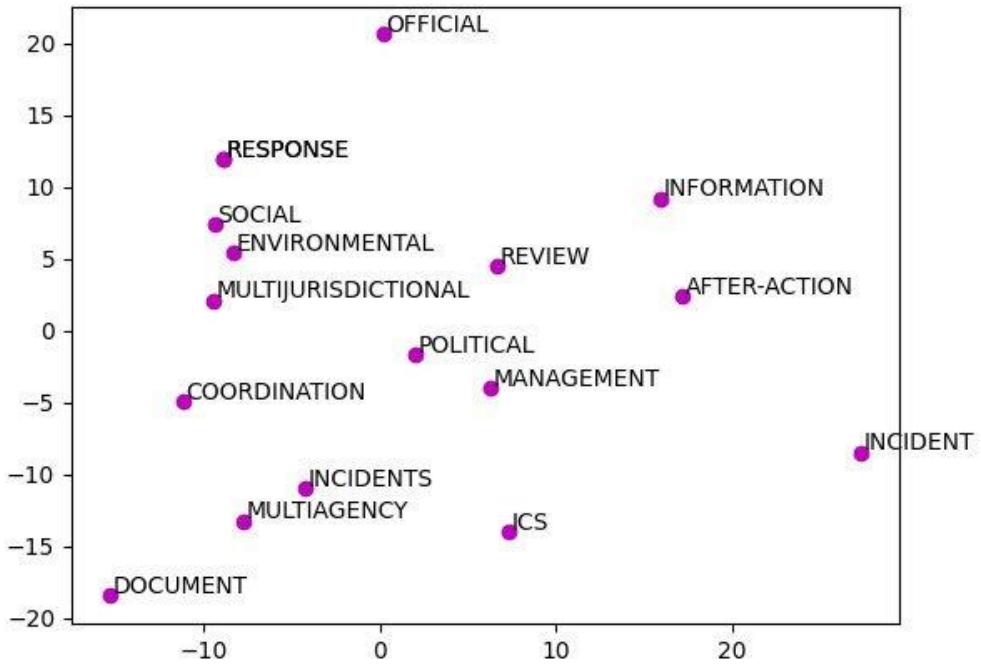
- Model the decisions disaster survivors make in accessing recovery resources, such as choosing shelters
- Incorporate social context by reading corpora into HDM
- HDM doesn't store entire chunks like DM → can't recall chunks → harder to write productions
- Want to "pull" slots associated with a chunk without sacrificing scalability and similarity gradation in vector representation
  - How to associate slots when adding to memory?
  - How to recall slots associated with a chunk?

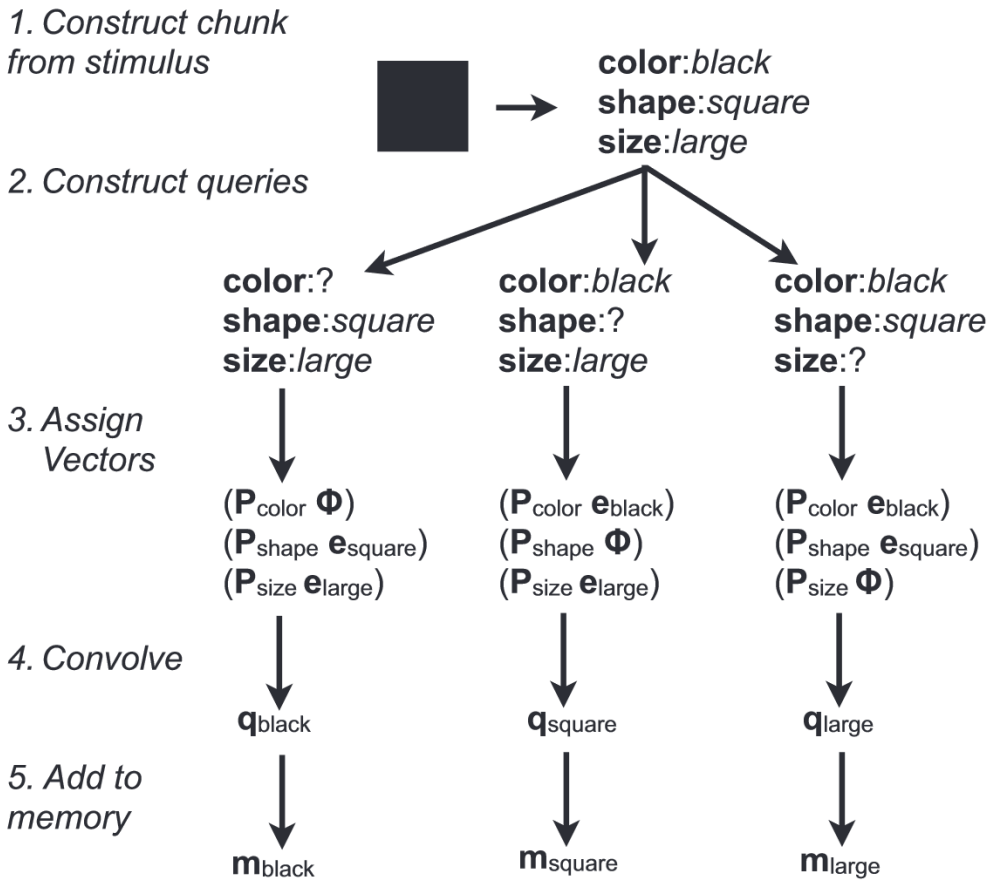
Problem Statement

- Goal: After adding chunk $c = \{s_1 : v_1 \ldots s_n : v_n\}$ into memory, retrieve the entire chunk with a cue $q = \{s'_1 : v'_1 \ldots s'_m : v'_m\}$, where $q \subseteq c$.
- Constraint: maintain HDM's memory complexity O(u), u = number of unique words
- Avoid: O(n) memory complexity, n = number of words added to memory

What is Holographic Declarative Memory?

Kelly, M. A., Arora, N., West, R. L., & Reitter, D. (2020).





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Architecture Ingredients

Holographic Reduced Representations

- Plate, T. A. (1995)
- Theory behind HDM: noisy relative reconstruction
- $C=A \circledast B+\ldots,\ B \approx C \circledast B^{-1}$
- Can store memory traces and recall them based on a memory cue containing partial info

Oscillators for Temporal Memory

- Brown, G. D. A., Hulme, C., & Preece, T. (2000).

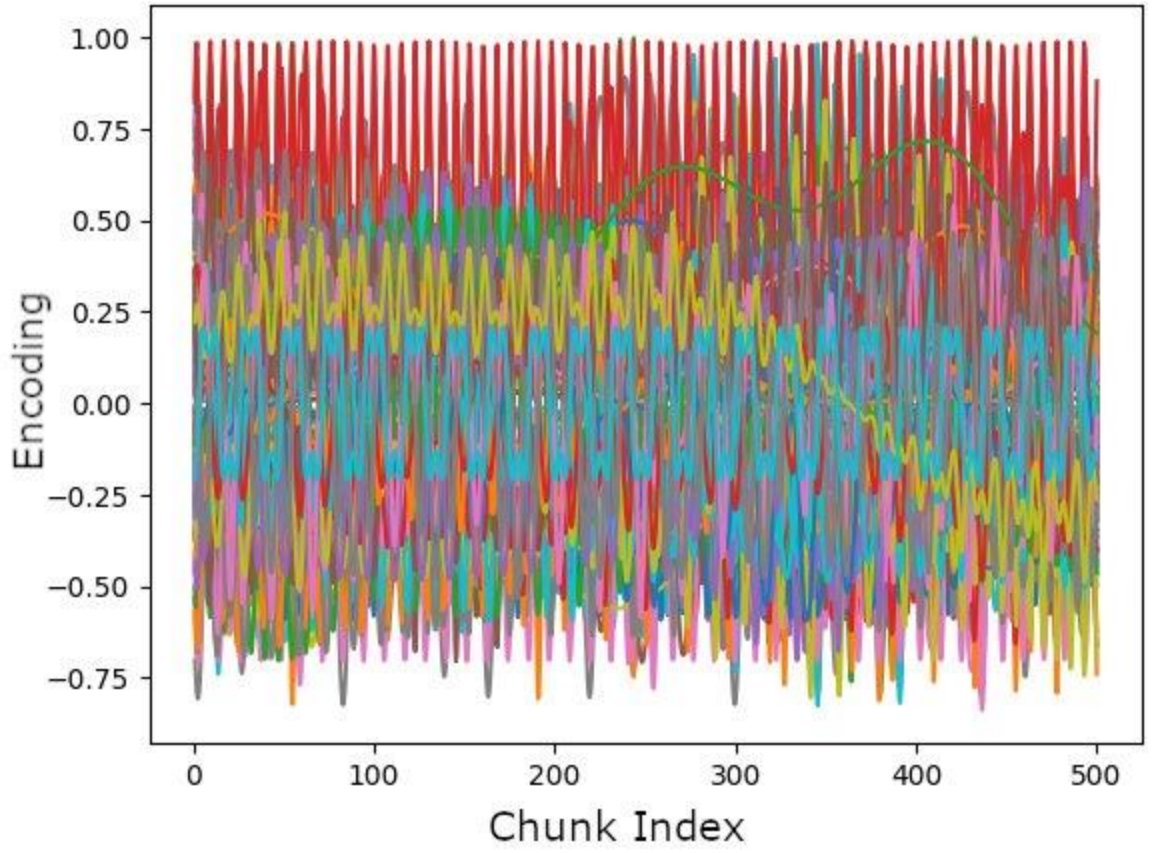
$$O_i = sin(\phi + t\theta_i) \quad (1)$$

$$\theta_i = 10^{-5} R 2^i \quad (2)$$

$$R \sim \mathcal{N}(0, 1) \quad (3)$$

$$\phi \sim \mathcal{U}(0, \pi/\theta) \quad (4)$$

$$T_i = \prod_{j=1}^{4} \sin(O_j) \quad (5)$$



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Putting it all together

- Storing continuous time values with fractional binding (Komer 2019)

$$\widetilde{\mathbf{T}} = \mathcal{F}^{-1}\left\{\sum_{l=1}^{320} \mathcal{F}(e_{t_l})^{\mathbf{T}(t)}\right\} \tag{6}$$

$$mt \longleftarrow mt + \widetilde{\mathbf{T}} \circledast \sum_{c=1}^{n} s_c \circledast v_c \tag{7}$$

$$Q = \sum_{c=1}^{m} s'_c \circledast v'_c \tag{8}$$

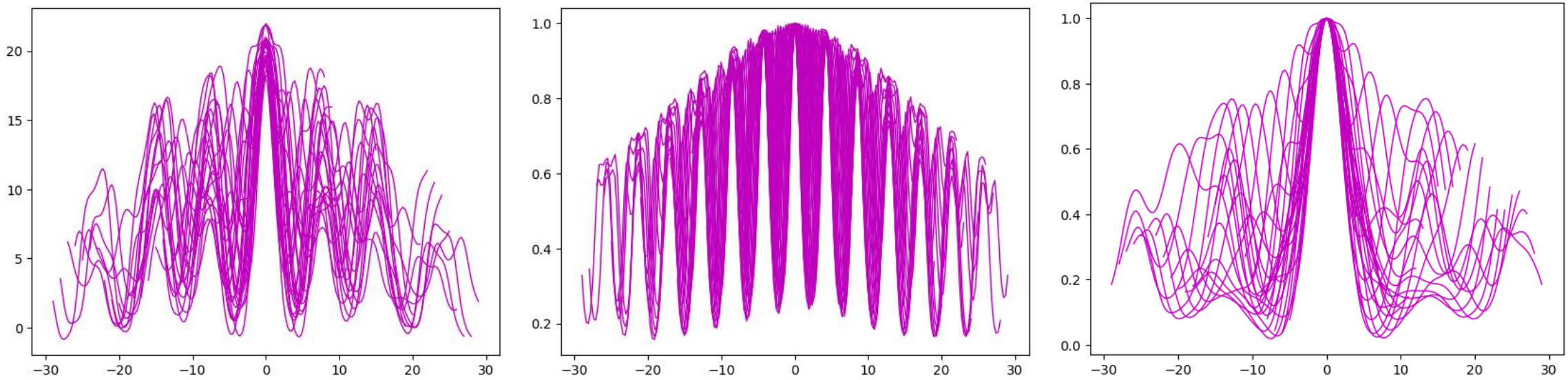
$$\hat{\mathbf{T}} = mt \circledast Q^{-1} \tag{9}$$

- Pick mt's with most similar reconstructed time context vectors

Challenges

Extremely High Variance in Oscillators

Self-Similarity functions



These are multiple draws from the same input parameters!

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Picking Parameters

- oscillators
  - Scale
  - Variance
  - Number of oscillators
  - Size of learning context vector
- Thresholds or top n (see next slide)

Retrieval Criteria

- how to pick which results as acceptable answer?
- Plate 1995 notes that "no fixed threshold will be appropriate for choosing the winning match in every situation" and suggests taking the top result (if above a low threshold)
- HDM takes this approach, but I can't
- Some ideas:
  - Top n
  - picking n same as fixed threshold problem?
  - N = 3, 4, or 5 (Cowan, 2010) and dec region threshold
  - Relative difference threshold
  - Rank similarity scores and pick scores up 4x difference from next
  - Could a fixed threshold work?

Questions and Suggestions?

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