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

"criticisms include inequity of who can access help"
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 $c = \{s_1 : v_1 ... s_n : v_n\}$ into memory, retrieve the entire chunk with a cue $q = \{s'_1 : v'_1 ... s'_m : v'_m\}$, 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?

Architecture Ingredients
Holographic Reduced Representations

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


\[ O_i = \sin(\phi + t\theta_i) \]  
(1)

\[ \theta_i = 10^{-5} R 2^i \]  
(2)

\[ R \sim \mathcal{N}(0, 1) \]  
(3)

\[ \phi \sim \mathcal{U}(0, \pi / \theta) \]  
(4)

\[ T_i = \prod_{j=1}^{4} \sin(O_j) \]  
(5)
Putting it all together

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

\[
\tilde{T} = F^{-1} \left\{ \sum_{t=1}^{320} F(e_{t1}) T(t) \right\} \quad (6)
\]

\[
mt \leftarrow mt + \tilde{T} \otimes \sum_{c=1}^{n} s_c \otimes v_c \quad (7)
\]

\[
Q = \sum_{c=1}^{m} s'_c \otimes v'_c \quad (8)
\]

\[
\tilde{T} = mt \otimes Q^{-1} \quad (9)
\]

• 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!
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?