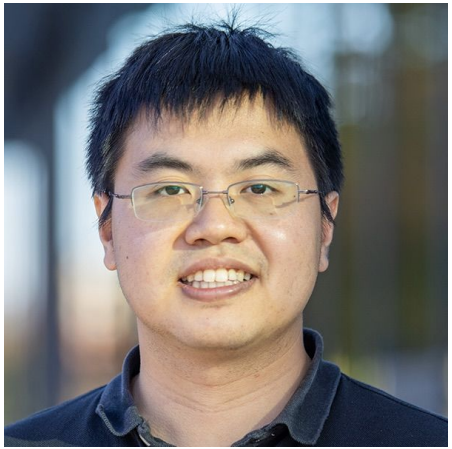
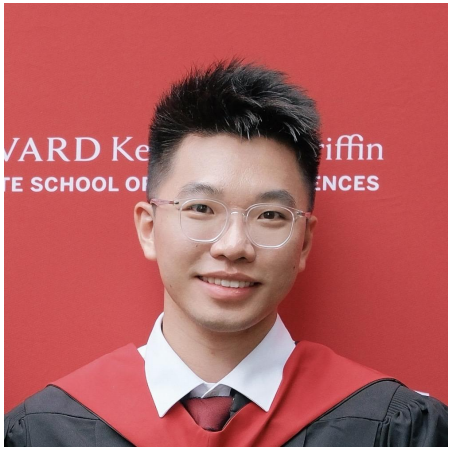
Inside Out

Decentralized Multi-agent Memory

Courtesy of Harvard Embodied Minds Lab



Yilun Du



Zhenting Qi

Jack Fan

I. What do we take from human memory?

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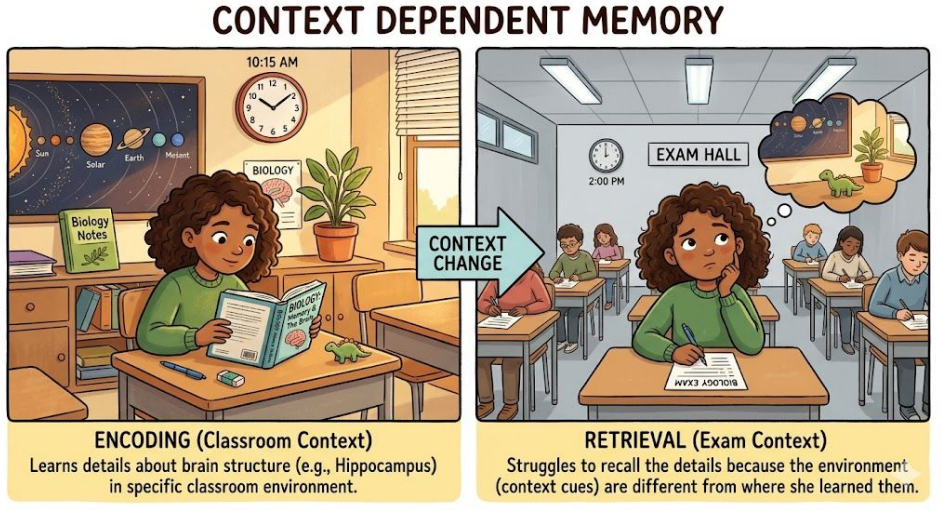
Memory is...

- **context-dependent**
- multifaceted
- distilled/selective



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II. Existing limitations

Existing limitations

- **Lack of portability**: Memory is overfit to the system it operates in.
- **Monolithic:** in a world of perfect precision and recall, it’s hard to find the needle in the haystack; also, it’s hard to synthesize heterogeneous cross-domain associations

III. Our design

(inspired by Inside Out, all credits to Disney-Pixar)

A Multiagent Memory System

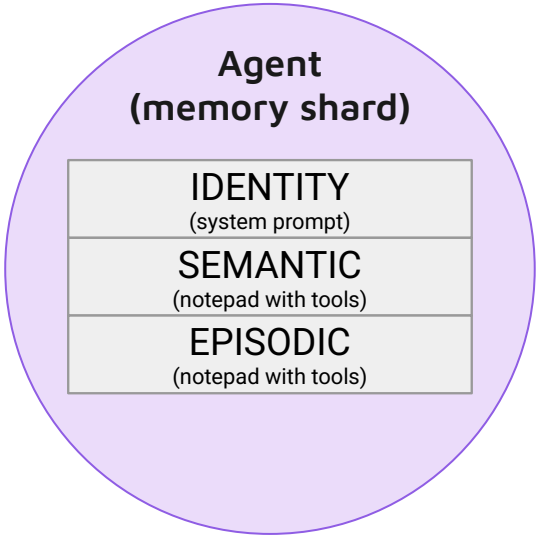
- **Decentralization**: hierarchical organization and heterogeneous construction of memories
- **Modularity:** different agents have unilateral control over different aspects (“shards”) of memory
- **Dynamism:** adaptability to different domains and simple memory management (create, update, delete)

Example use case: Education

- **Multiple learning settings:** where/when each student is learning; preparing exams, working on research projects, etc.
- **Capturing learning preferences:** “I learn by doing with hands-on examples”, “I need clear summaries of lectures”
- **Cross-session:** surfacing new connections across previously siloed projects (shoutout exocortex)

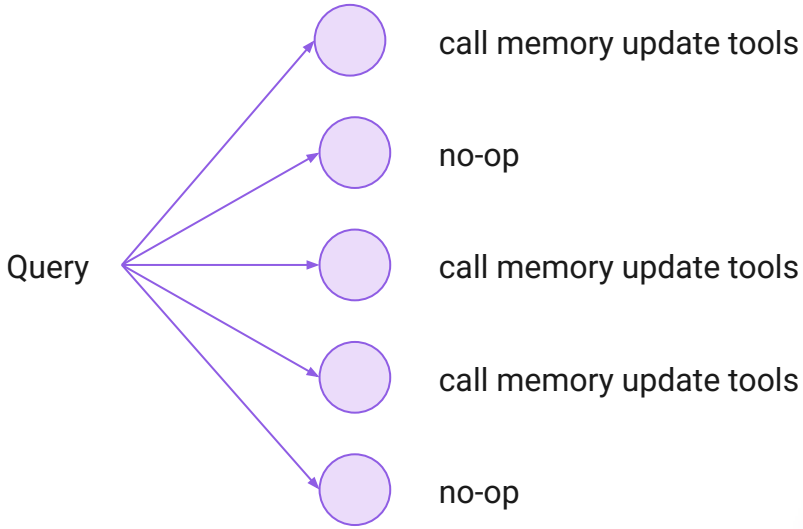
System Architecture

Atomic unit: Agent with a “Memory Shard”



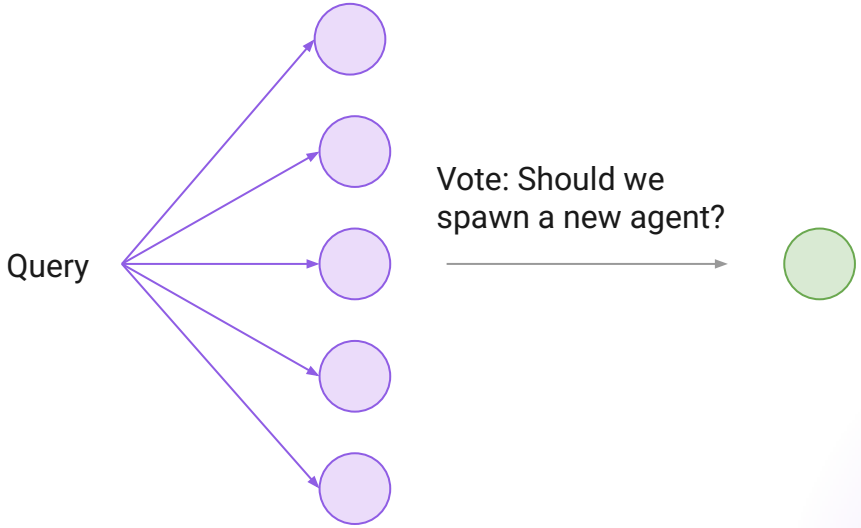
System Architecture

Phase 1: User input + agents (maybe) update memory



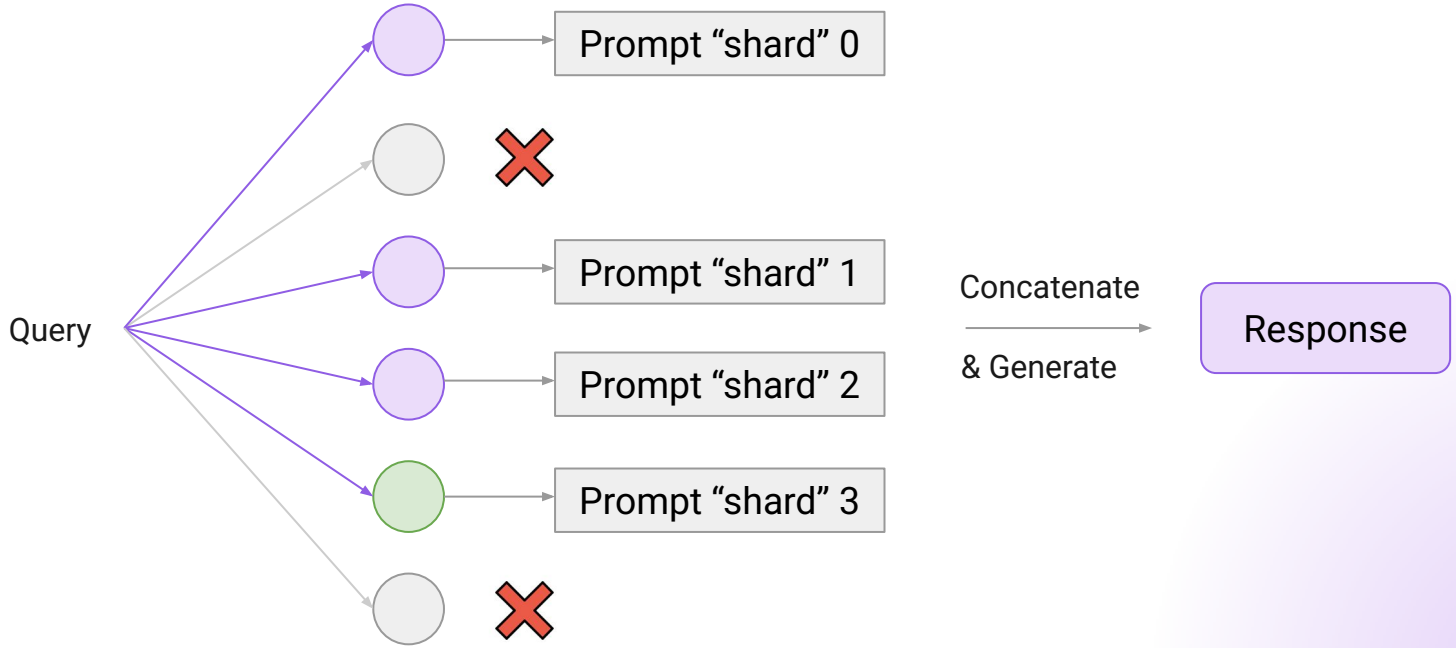
System Architecture

Phase 2: Voting for Spawning New Agent



System Architecture

Phase 3: Assembling (Activated) Shards



DEMO!

Reflections

- Governance considerations
- Portability and interoperability
- Scalability pathways
- Pathways to real-world piloting

IV. Future work

Future work: experimental directions

- **“The Society of Mind”:** forming hierarchical structure between shards, dynamic deconstruction of memories
- **Self-assembly:** different memory “shards” can evolve, specialise, conglomerate and work together; think stem cell-like growth (or microbots in *Big Hero 6*)
- **Continual learning:** weight-space (RL/LoRA/etc.) and token-space (context management)

Future work: guiding principles

- **Generalizability:** extensibility + composability → effective memory system for any domain + across domains
- **Efficiency:** modularity + composability = smaller models, portable and edge-viable systems

Thank you!
Questions?