Core of Multi-Agent Systems

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Agenda

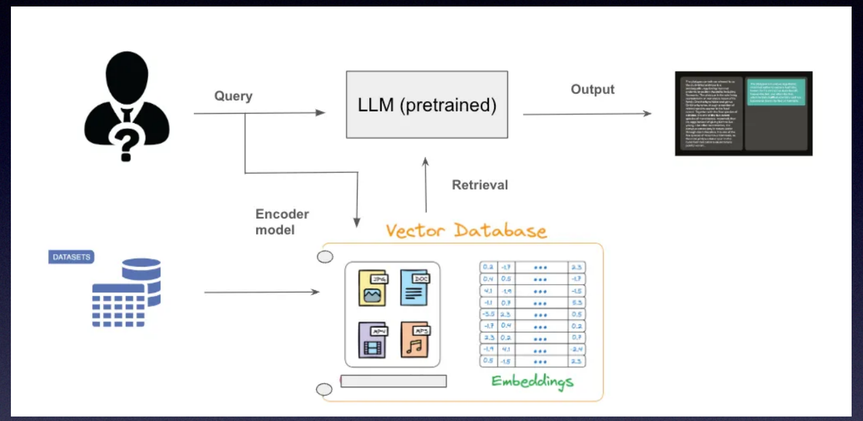
- Background
- Intro. to Agentic AI
- Multi-agent system (MAS)
- Advanced Topics
- Demo of Deep Research Agent

Background

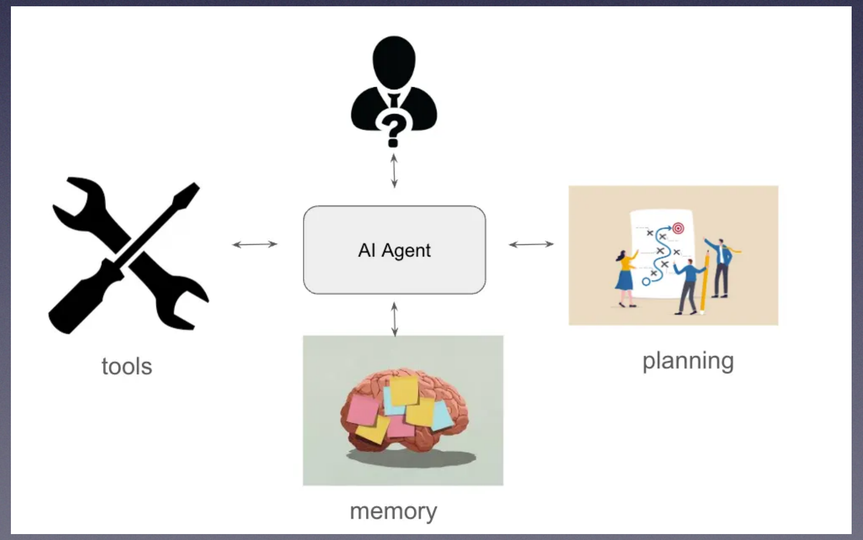
- Preliminaries: Know what is large language models
- Personal research area: cognitive computation
- This talk focuses on:
  - Core techs of multi-agent systems
  - How to build a MAS

From RAG to AI Agent

- Both built on LLM
- Core of RAG
  - Vector store & Embed model
- Core of AI Agent: **ReAct**
  - Planning (orchestration)
  - Tools (e.g., MCP)
  - Memory (short & long term)



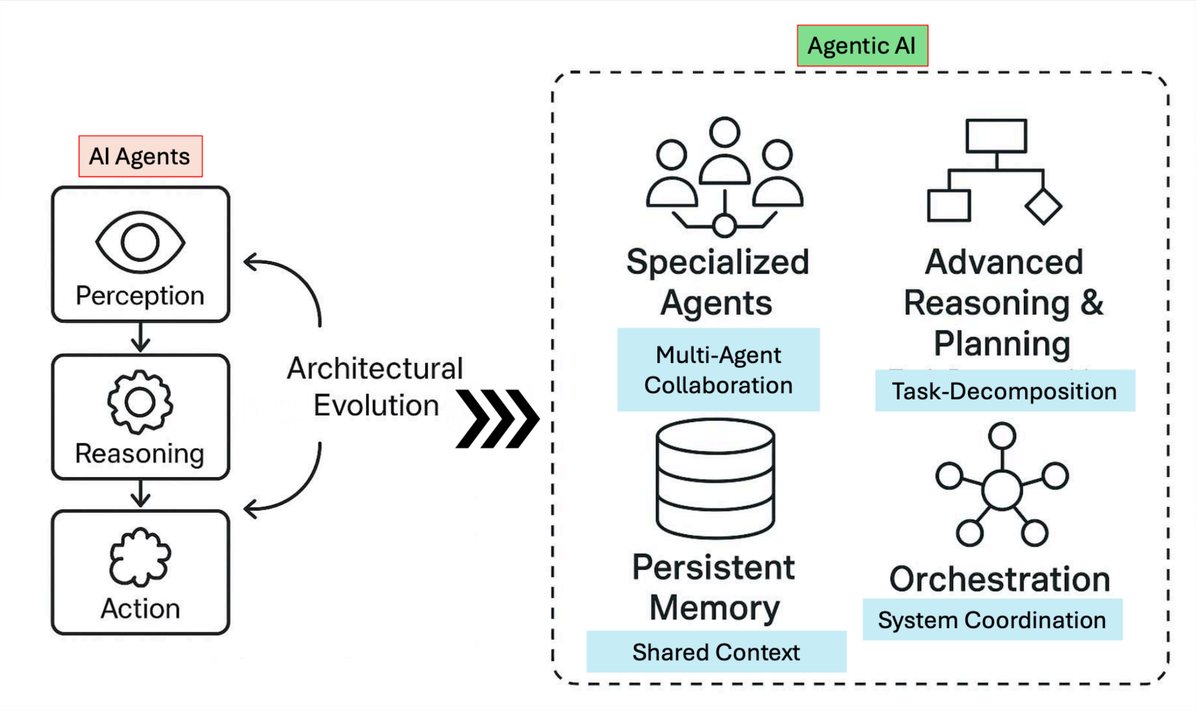
RAG

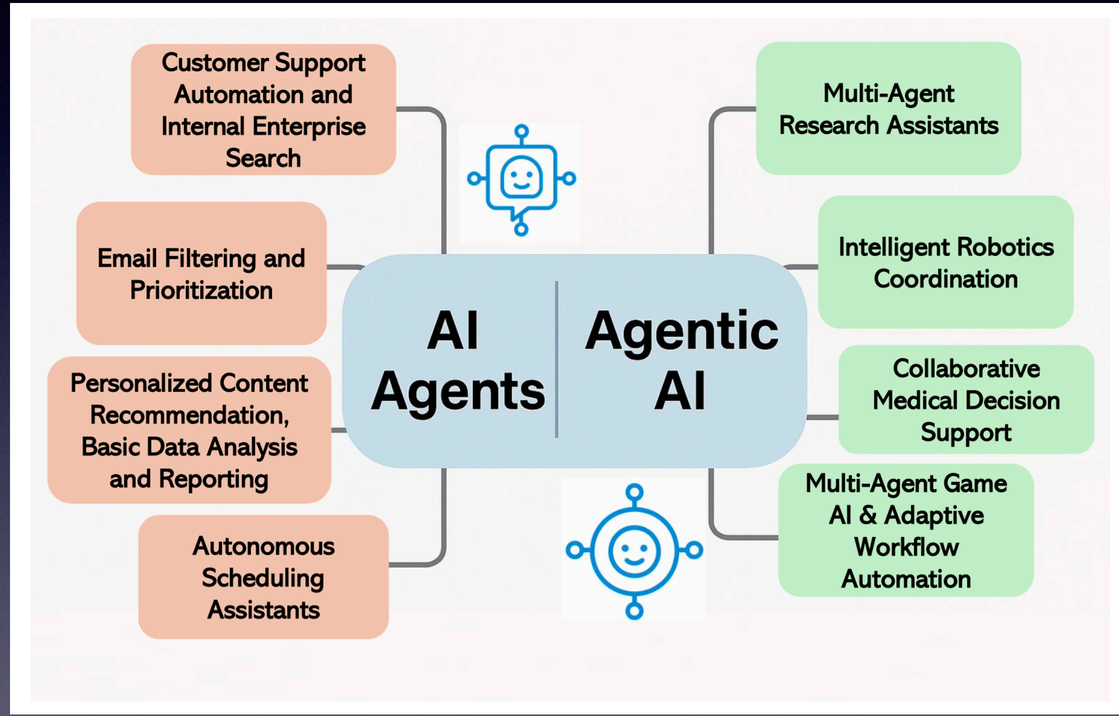


Agent

ReAct: Synergizing Reasoning and Acting in Language Model, ICLR 2023

AI Agent vs. Agentic AI





Agentic AI -> Multi-agent system

AI Agents vs. Agentic AI: A Conceptual Taxonomy, Applications and Challenges, arXiv, 2025

An informal def.

- Agent: a system that uses an LLM to decide (reasoning) the control flow (action) of an application.
  - In brief, a piece of code powered by LLM
- Multi-agent system: a computerized system comprising multiple intelligent agents that interact within a shared environment (context).
  - Not even new

Advances and Challenges in Foundation Agents: From Brain-Inspired Intelligence to Evolutionary, Collaborative, and Safe System, arXiv, 2025

2025 AI Agents Infrastructure Stack

Powered by Agency AI + AgentOps

PLATFORM

PaaS/BaaS

fly.io | griptape | Render | netlify | NEON | supabase | Vercel | Railway | AXIOM

Logging

Grafana | RAYGUN

Observability, Tracing, and Evaluation

AgentOps | Metoro | LangSmith | Langfuse | braintrust | Patronus AI | COVAL | opik

Agent Frameworks

AgentStack | LangGraph | crewai | AG | Boundary | AG2 | CAMEL-AI | ControlFlow | LlamaIndex | Prosus | smolagents | OpenAI Agents SDK | Microsoft

ORCHESTRATION

Persistence

inngest | hatchet | Trigger.dev | Temporal

Agent Routing

LangGraph | crewai | Letta

Model Routing

Martian | arcee.ai

DATA

Memory

cognee | mem0 | zep

Storage

NEON | supabase | Pinecone | chroma | Weaviate | mongoDB. | Fireproof | MotherDuck | neo4j | qdrant | tinybird

ETL

LlamaIndex | reducto | DATAVOLO | verodat

TOOLS

AGENTS AS A SERVICE

Search

sonar | exa | serper | glean | meilisearch | Search1API | Tavily

Data Extraction

Parallel | Firecrawl | TINY FISH | Browse AI | oxylabs | NIMBLE | bright data

UI Automation

Browser Use | Browserbase | bytebot | LaVague | AGI,inc | notte | OS-ATLAS | Open Interpreter | HyperWrite | Anthropic Computer Use | OpenAI Operator | Google Project Mariner

Payments

Open Commerce | payman | Skyfire | protegee | Stripe Agent SDK

Secure Tool Usage

composio | ARCADE | LAYER | Paragon | mcprun | Unified | QL | wildcard | Toolhouse | glean

Auth

Auth0 | clerk | ANON | okta | OpenFGA | authzed

Browser Infrastructure

Browserbase | Anchor Browser | Hyperbrowser | Browserless | APIFY | CLOUDFLARE | platform.sh | Browser Use

Sandboxes

E2B | MODAL | CodeSandbox | Pig | SCRAPYBARA | CLOUDFLARE | RIZA | >>>ForeverVM | Daytona | WebContainers

AGENTS

Next Gen Copilots

perplexity | gradial | Cleric | glean

Canopy

Agent Teammates

Astral | bolt.new | Common Room | DEVIN | Dropzone AI

Agent Swarms

aaru | SOCIETIES

500+ Agents

marketplace.agen.cy

Powered by Agency AI + AgentOps

Source

substack.com/@jonturow & marketplace.agen.cy

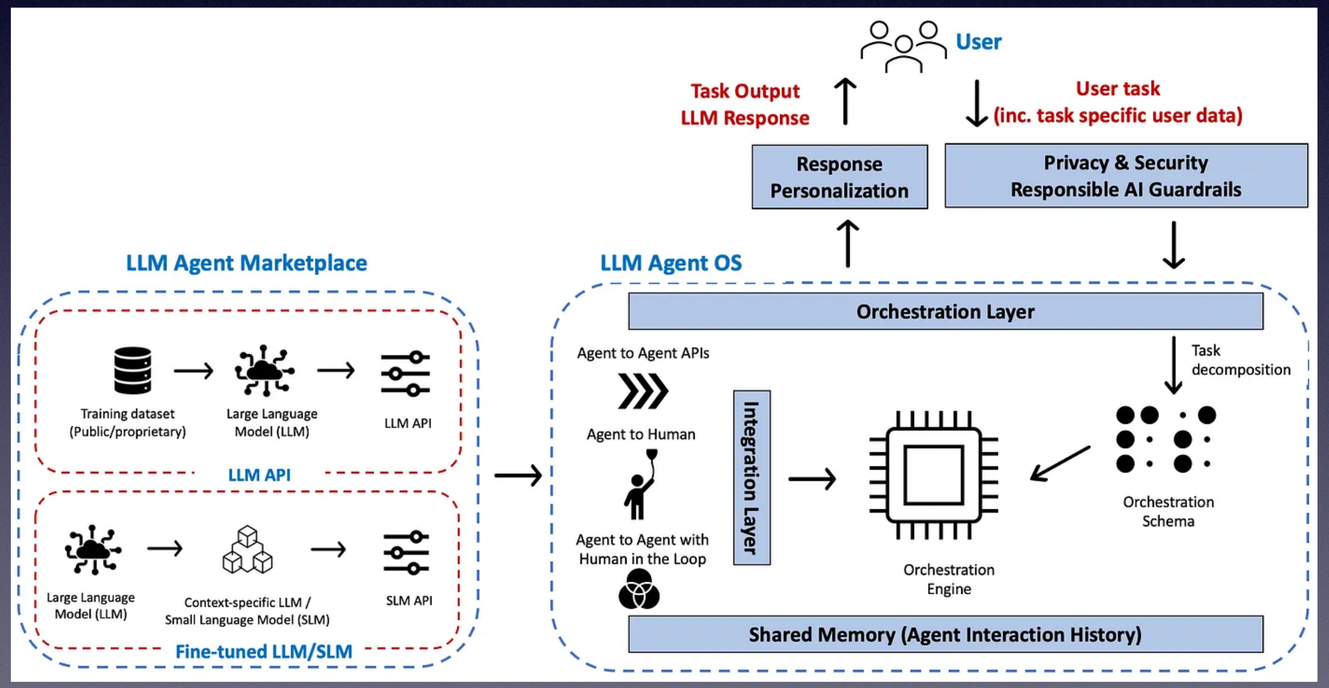
SOTA of MAS

- Vibe Coding: Claude Code, Cursor, Gemini CLI, Windsurf, Jules (Google) etc.
- Designing: Lovable, Sigma, Stitch, Figma etc.
- General domain: Genspark, MiniMax etc.
- Search: Perplexity, Google AI Mode, Fellou, Dia, Sigma, Genspark etc.
- Research: STORM (Stanford), SciMaster, Elicit etc.

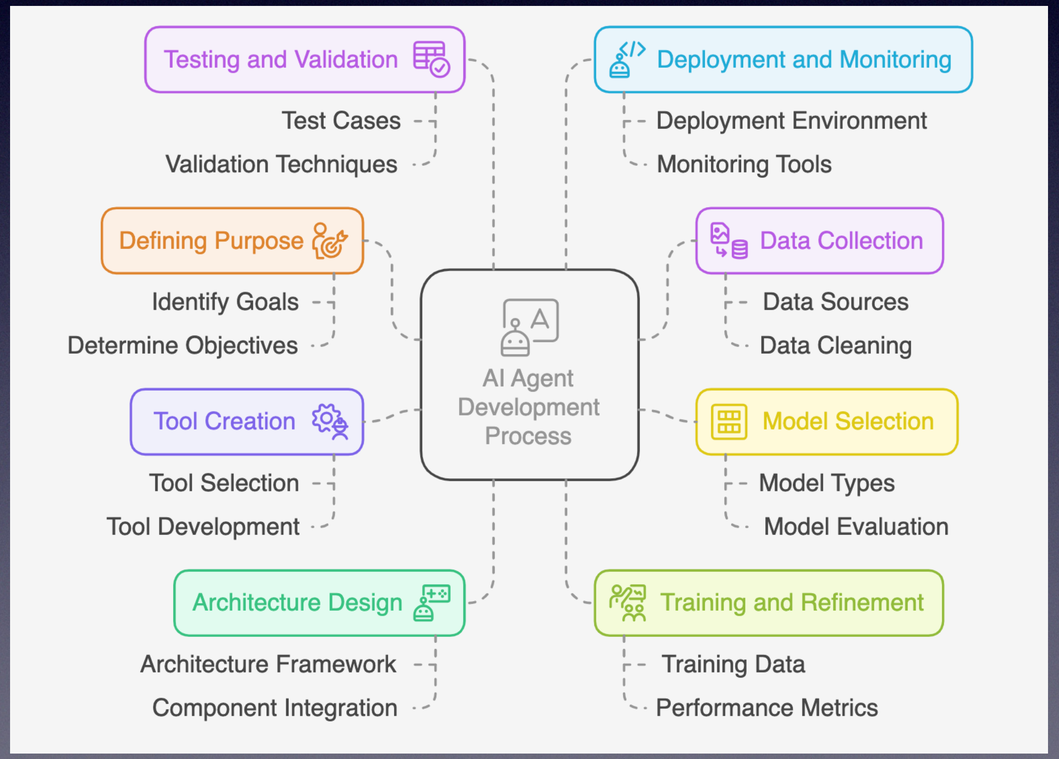
A comprehensive category of AI tools: https://www.toolify.ai/category

Engineering Essentials

Design a MAS…



but start from an agent

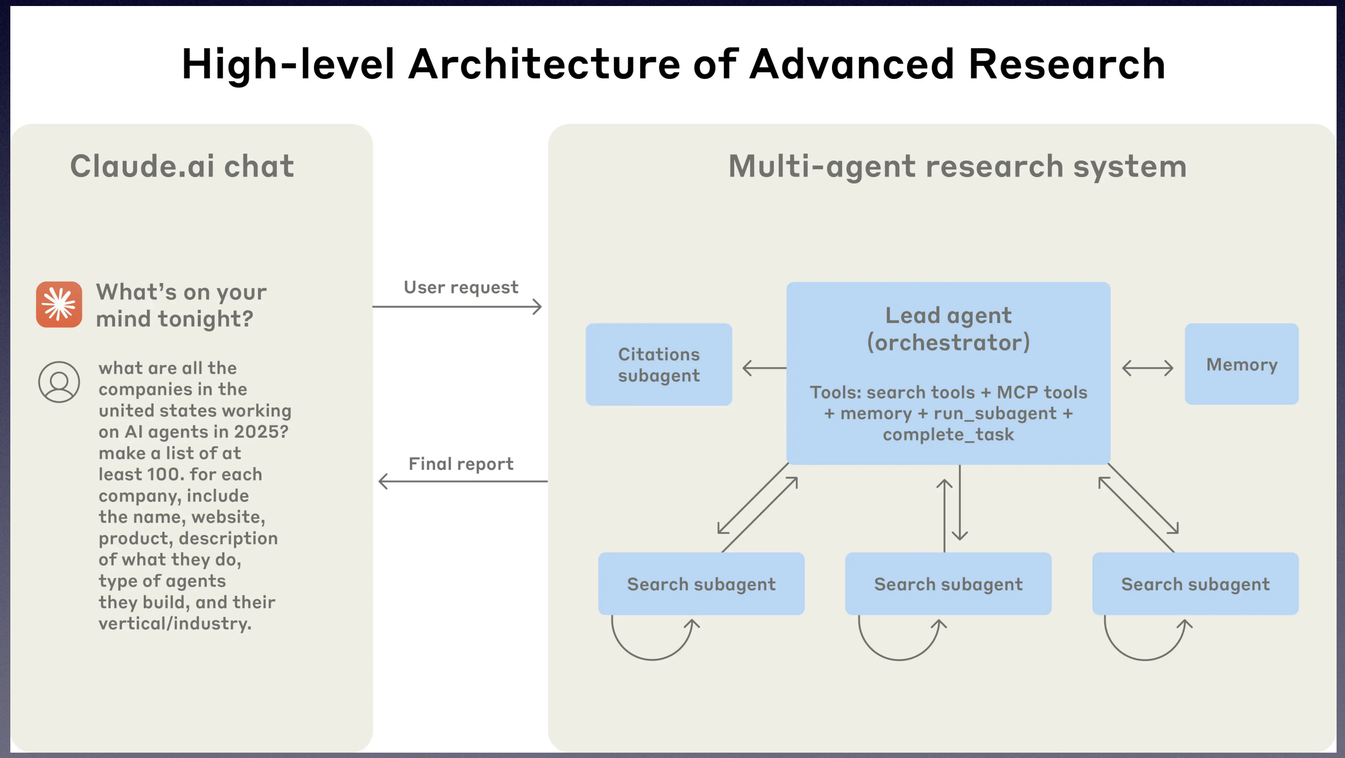


https://medium.datadriveninvestor.com/ai-agent-platform-reference-architecture-0be5b19d0eba

https://relevanceai.com/blog/how-to-build-an-ai-agent-a-comprehensive-guide-for-2025

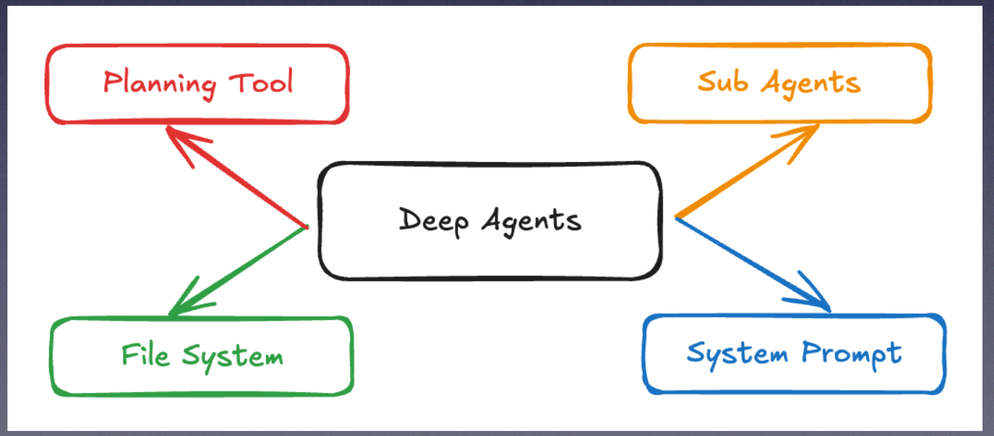
Learning from 1st tier

From Anthropic team



https://www.anthropic.com/engineering/built-multi-agent-research-system

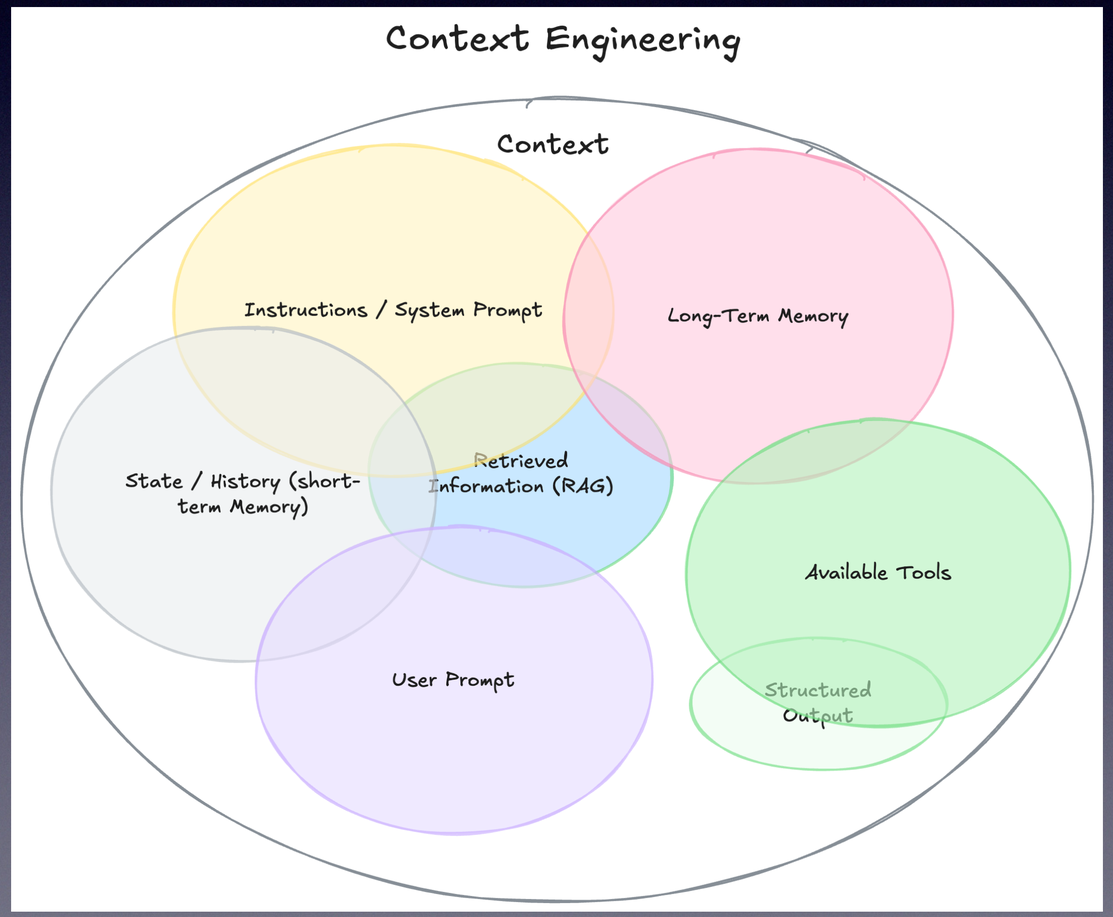
- Main components
  - A planning tool + subagents + file system + delicate prompts



https://blog.langchain.com/deep-agents/

Context Engineering

— the final frontier of agentic AI



- Lacks robust tools for managing evolving context
- No standardized guidelines or best practices yet
- Critical for memory, orchestration, and long-horizon planning

Keep Agents on Track

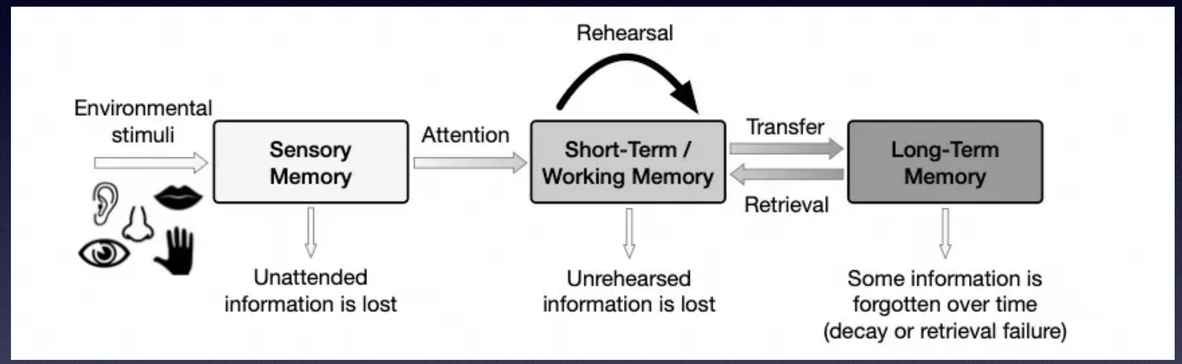
— from a practical perspective

- **Embrace modular design**: easy to test, easy for LLMs to reason.
- **Prompting still matters**: even in the era of “context engineering”.
- **Use a clear coordinator–worker arch:** structure enables scale.
- **Start wide, then narrow down**: validate each agent and tool rigorously.
- **Context engineering begins and ends with memory**

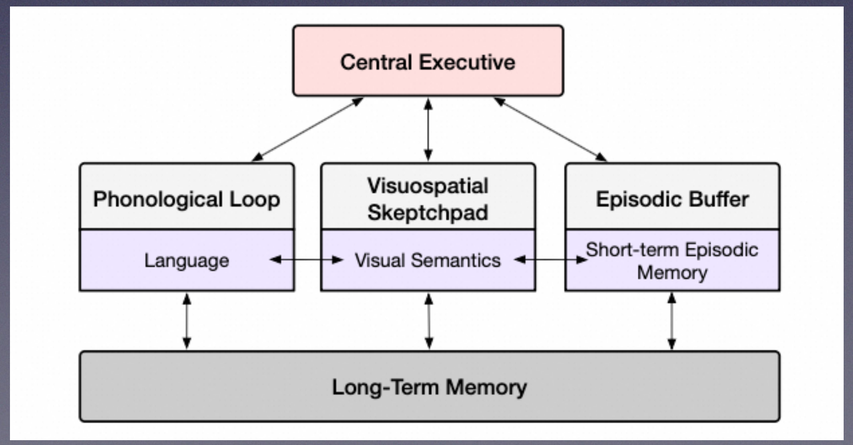
Agentic Memory

— rooted in human cognitive architecture (HCA)

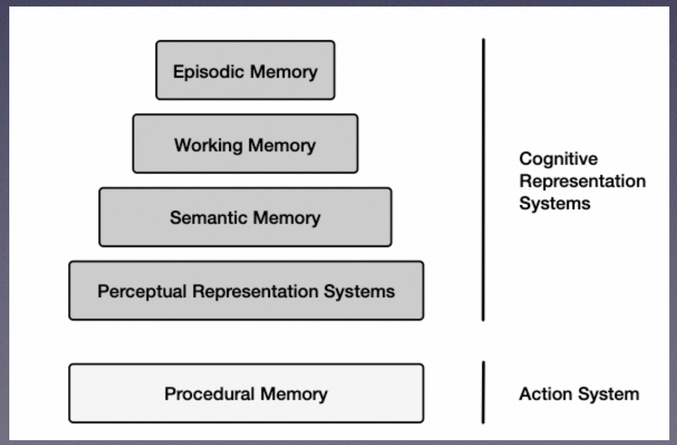
Multi-Store Model, Richard C Atkinson, 1968



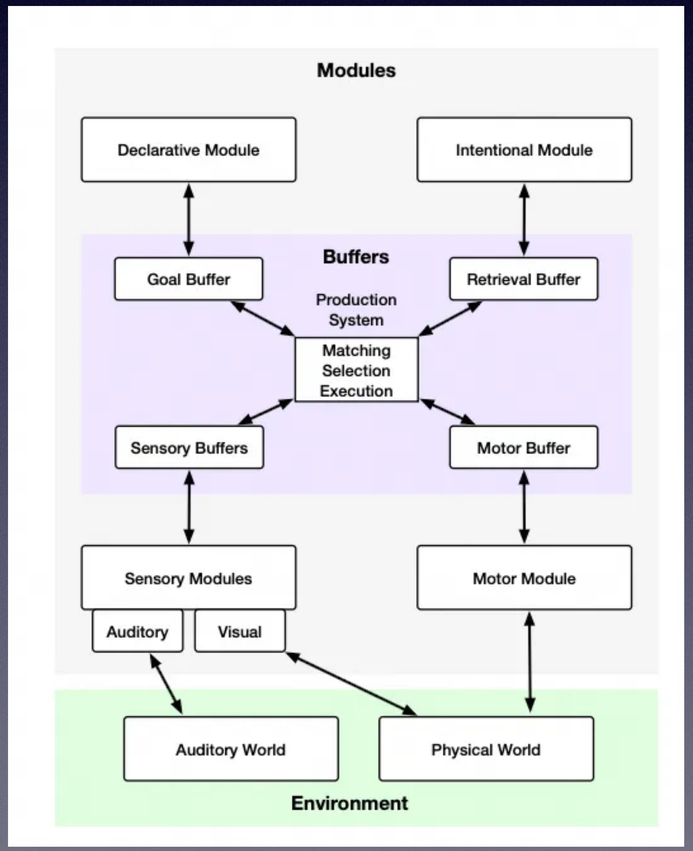
Working Memory Model, Alan Baddeley, 1974



SPI-Model, Endel Tulving, 1985



ACT-R, John R. Anderson, 2009

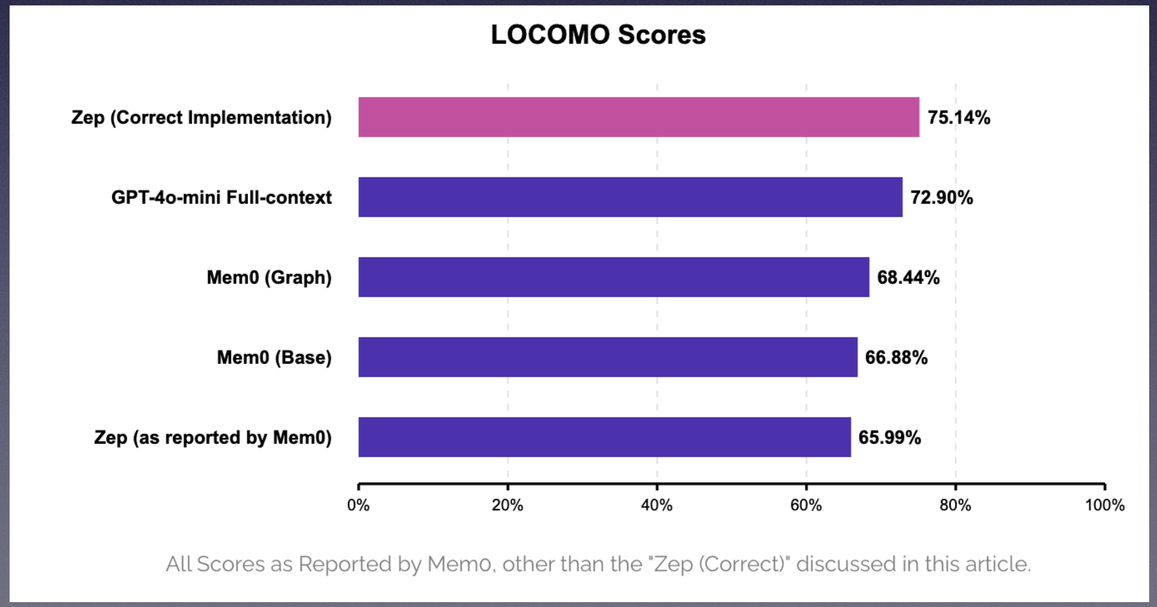


Agentic memory is booming

- We have a bunch of open source projects on agent memory
  - Zep (graphiti), Cognee, mem0, MIRIX, MemOS, Second Me, M+, MemoRAG, MEM1 etc.
- **Under the hood in common**: human memory concepts + RAG + KG

GAIA Leaderboard

Agent name	Model family	organisation	Averag
Su Zero Ultra		Suzhou AI Lab	80.4
h2oGPTe Agent v1.6.33	claude-3-7-sonnet-20250219, gemini-2.5-pro-preview-06-05 (extended thinkin	h2o.ai	79.73
Agent2030-v2.3	o3, GPT 4.1, Gemini 2.5 Pro		79.4
h2oGPTe Agent v1.6.32	claude-3-7-sonnet-20250219, gemini-2.5-pro-preview-06-05	h2o.ai	79.07
Agent_v0.1.0	gpt-4.1		79.07
AWorld (Run Instantly)	GPT-4o, DeepSeek V3, Claude-Sonnet-4, Gemini-2.5-Pro	inclusionAI	77.08
SU AI Zero	Anthropic, Google, openaI	Suzhou AI Lab	76.41
Agent2030-v2.2	o4-mini, GPT 4.1, Gemini 2.5 Pro		76.08



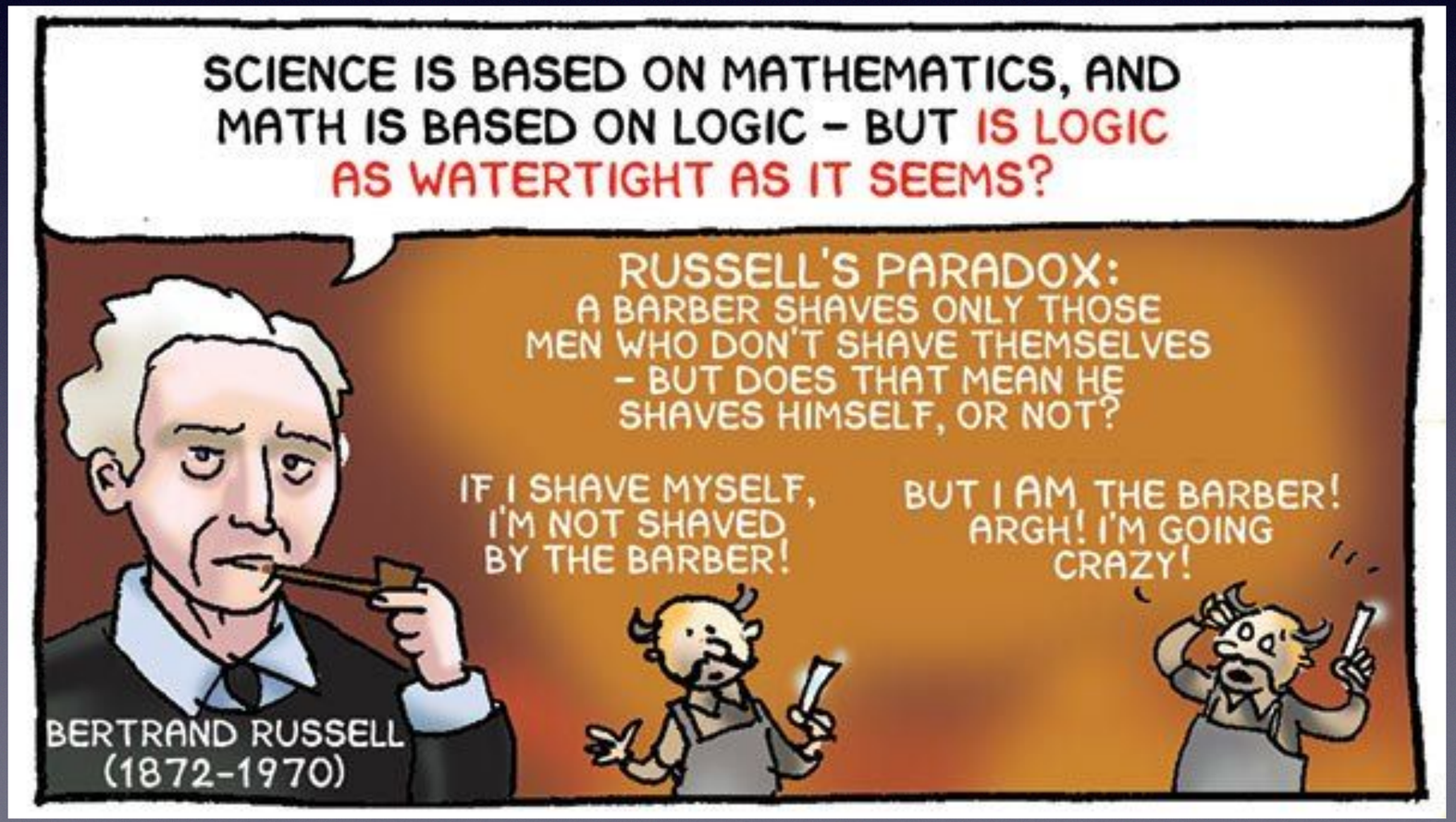
A Survey on the Memory Mechanism of LLM based Agents, ACM TIS, 2025

Advanced Topics

- Foundation innovation of AI
- From ReAct to Proactive agents (discuss)
- Intelligence vs. Memory (discuss)

Foundation Innovation of AI

On of theoretical foundation of agents: Gödel's incompleteness theorems



Foundation Innovation of AI

Example: LLM Dense Model vs. MoE

- A formal system adheres to Gödel's incompleteness theorems.
- A Turing machine is a formal system.
- Neural networks are not Turing-complete.
- However, transformers and recurrent neural networks (RNNs) have been proven to be Turing-complete under specific theoretical conditions.
- So, LLM cannot achieve consistency and completeness simultaneously.

https://www.xiaming.site/2025/02/08/neurosymbolic-part2

Must Read Papers on Agents

On Agent Memory

1. Mem0: Building Production-Ready AI Agents with Scalable Long-Term Memory

2. A Survey on the Memory Mechanism of LLM-Based Agents

3. HippoRAG: Neurobiologically Inspired Long-Term Memory for Large Language Models

4. MemoRAG: Moving Towards Next-Gen RAG via Memory-Inspired Knowledge Discovery

5. Memory^3: Language Modeling with Explicit Memory

Must Read Papers on Agents

On Graph Retrieval

1. From Local to Global: A Graph RAG Approach to Query-Focused Summarization

2. HybridRAG: Integrating Knowledge Graphs and Vector Retrieval-Augmented Generation for Efficient Information Extraction

3. G-Retriever: Retrieval-Augmented Generation for Textual Graph Understanding and Question Answering

4. LightRAG: Simple and Fast Retrieval-Augmented Generation

5. GRAG: Graph Retrieval-Augmented Generation

Must Read Papers on Agents

On Cognitive Architectures

1. Cognitive Architectures for Language Agents

a. Human Problem Solving – Newell & Simon (1972)

2. Consciousness Is Computational: The LIDA Model of Global Workspace Theory

3. Survey on Memory-Augmented Neural Networks: Cognitive Insights to AI Applications

4. A Theory of Consciousness from a Theoretical Computer Science Perspective: Insights from the Conscious Turing Machine

5. Consciousness in Artificial Intelligence: Insights from the Science of Consciousness

Demo

- https://github.com/caesar0301/mas-talk-2508/tree/master/code