

From Method of Loci to Digital Mnemonics: AI, AR, and the Future of Memory

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Motivation

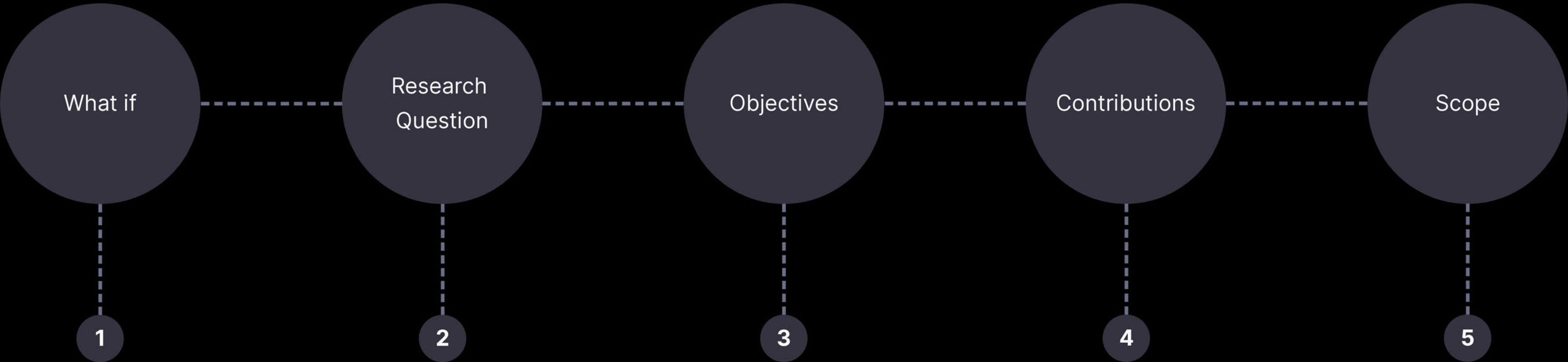
- My background spans working in design, aerospace, defense, and education.
- Across these sectors, I repeatedly encountered the problem of knowledge loss due to forgetting, both in professional practice and in learning environment with students.
- The limits of human memory retention seemed a fundamental barrier to efficiency and sustained creativity.
- Fascinated by how people can improve recall and the potential of new digital technologies, I focused my research on using AI and AR to support memory.



Educators meet, 2023

Research Summary

This research summary includes a what-if statement, research question, objectives, contributions, and scope. Following slides provide a concise overview of the study's purpose and boundaries.



What If

Imagine a world where digital cues overlay our surroundings, transforming spaces into dynamic repositories. Traditional memory techniques like the Method of Loci evolve into AI-powered, AR-anchored enhancements. Walking through a city triggers automatic recall of personal and historical memories, reducing cognitive load and enhancing long-term storage by externalizing memory into our built environment.



What if imagined and visualized.

Research Question

Primary Question

How might we integrate Artificial Intelligence (AI) and Augmented Reality (AR) technologies to utilize spatial memory techniques, such as the Method of Loci, by creating immersive and spatial experiences that enrich human memory retention, recall, and overall quality of life?

Secondary Questions



Aims and Objectives

The primary aim of this research is to investigate how Artificial Intelligence (AI), and Augmented Reality (AR) can enhance human memory retention and recall by integrating spatial memory techniques, such as the Method of Loci, into immersive, world-scale experiences. This study explores technological advancements, existing limitations, and potential future directions for AI-AR-based cognitive augmentation.

Analyze human memory systems and the Method of Loci, examine its effectiveness in memory retention, and identify gaps in current technological adaptations.

Study Literature

Examine AI-driven multimodal advancements and assess their potential for creating large-scale, AI-enhanced Method of Loci experiences.

Study AI

Experiment with AR tools and platforms to evaluate their ability to create immersive overlays that enhance the spatial and interactive aspects of the Method of Loci.

Study AR

Investigate integrating AI and AR to develop dynamic, context-aware memory augmentation systems that personalize retrieval based on user interactions and real-world environments.


Study AI + AR Integration

Develop speculative artifacts and prototypes to demonstrate how AI and AR can enhance memory experiences.

Develop Prototypes

Contributions

This research presents a design-led framework that integrates AI, AR, and mnemonic techniques to enhance human memory by aligning memory theories with emerging multimodal technologies. It demonstrates feasibility through proof-of-concept designs and an extensive literature review contextualizing AI and AR in memory augmentation, while a descriptive evaluation identifies where and how these integrated solutions are most effective.



Literature Synthesis

Integration
Framework

Proof of Concept
Prototypes

Evaluation Approach

Scope

This work focuses on the design and conceptual exploration of future digital mnemonic systems utilizing Artificial Intelligence (AI) and Augmented Reality (AR) technologies. Employing a speculative design and research-through-design methodology, the aim is to envision how classical mnemonic techniques, specifically the Method of Loci, can be transformed into innovative, technology-enhanced memory aids.

In Scope

Speculative
Prototypes

Research
Through
Design

Technical
Explorations

Out of Scope

Neuroscienc
e Validation

Artistic and
Aesthetic
Focus

Usability
Testing

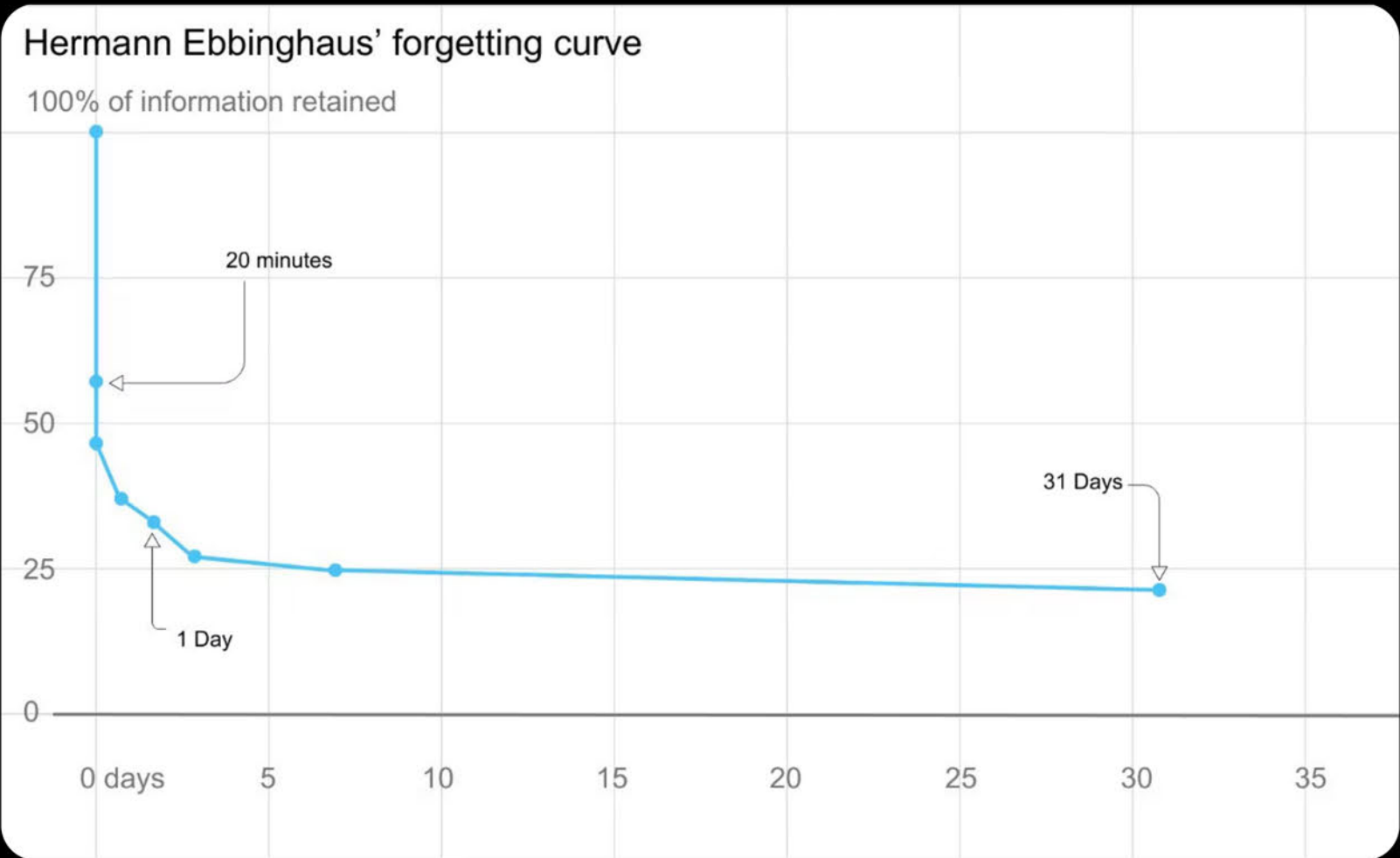
Market
Evaluation

Policies and
Ethical
Implications

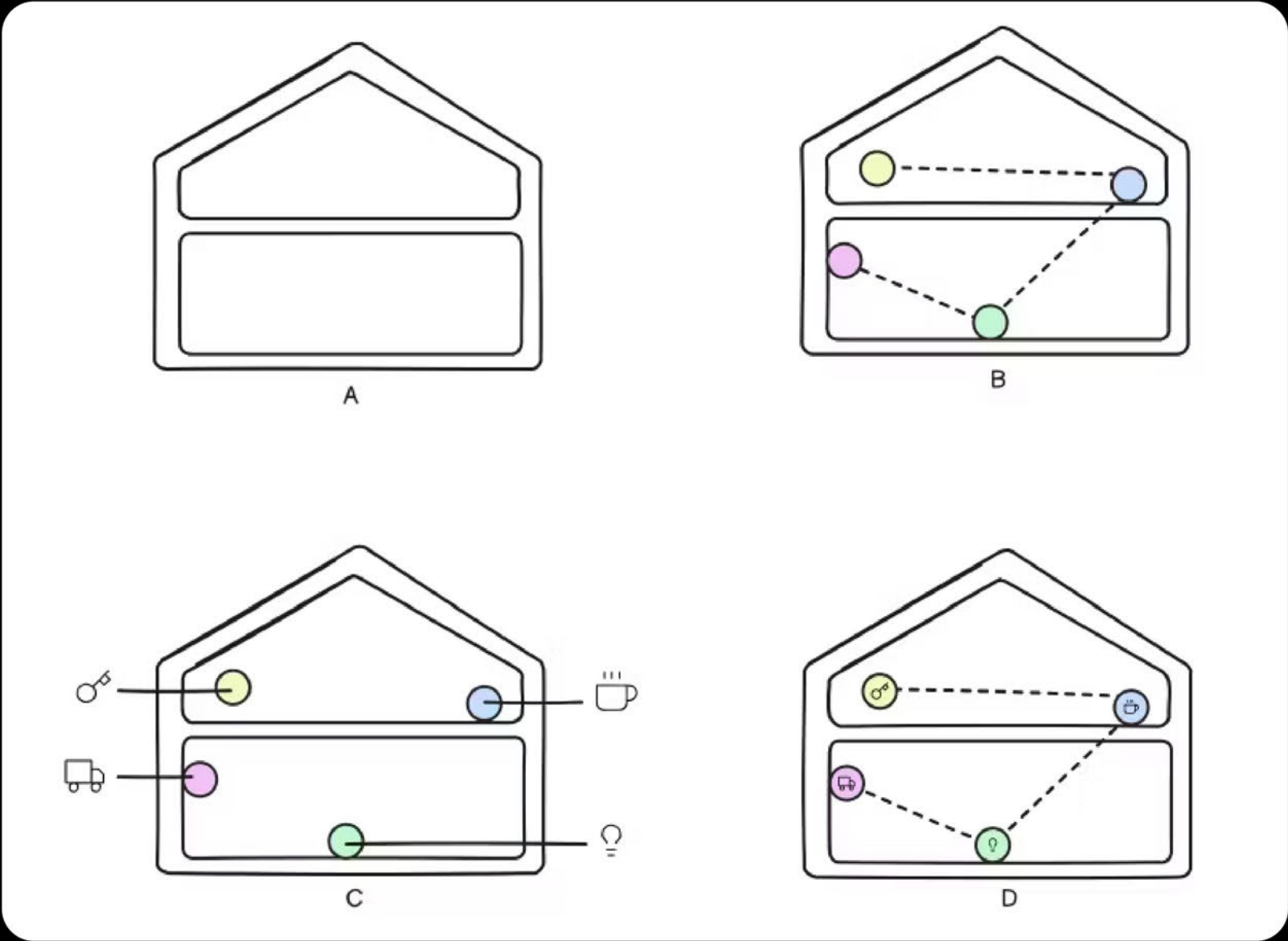
Inclusivity
and Safety

Background

Memory is a fundamental component of human cognition, crucial for learning, decision-making, and performing daily tasks. Human memory involves encoding, storage, and retrieval processes but is also susceptible to forgetting. Hermann Ebbinghaus's forgetting curve illustrates how information is lost over time without reinforcement, demonstrating a rapid decline in memory retention shortly after learning (Ebbinghaus, 1850-1909, as cited in Wittman, n.d.). This natural tendency to forget poses challenges in an era of information overload, where traditional memory techniques often prove inadequate for managing the vast amounts of data encountered daily.



Method of Loci



A: Choose a familiar place, like your home, as your memory palace.
B: Map out a fixed route with distinct stops for each item.
C: Assign vivid mental images to each stop in sequence.
D: Mentally walk through the route to recall the items.
(Adapted from Sousa et al., 2021)

Related Work

The following four case studies explore memory augmentation with advanced computational technologies. These studies have provided valuable insights for this thesis by highlighting different design and technical considerations. Each contributes unique perspectives on how technology can complement memory.

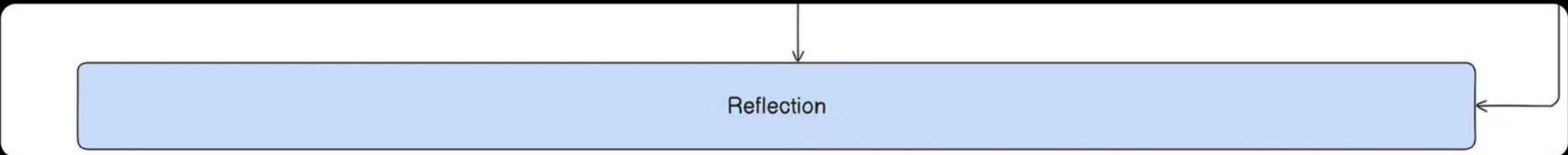
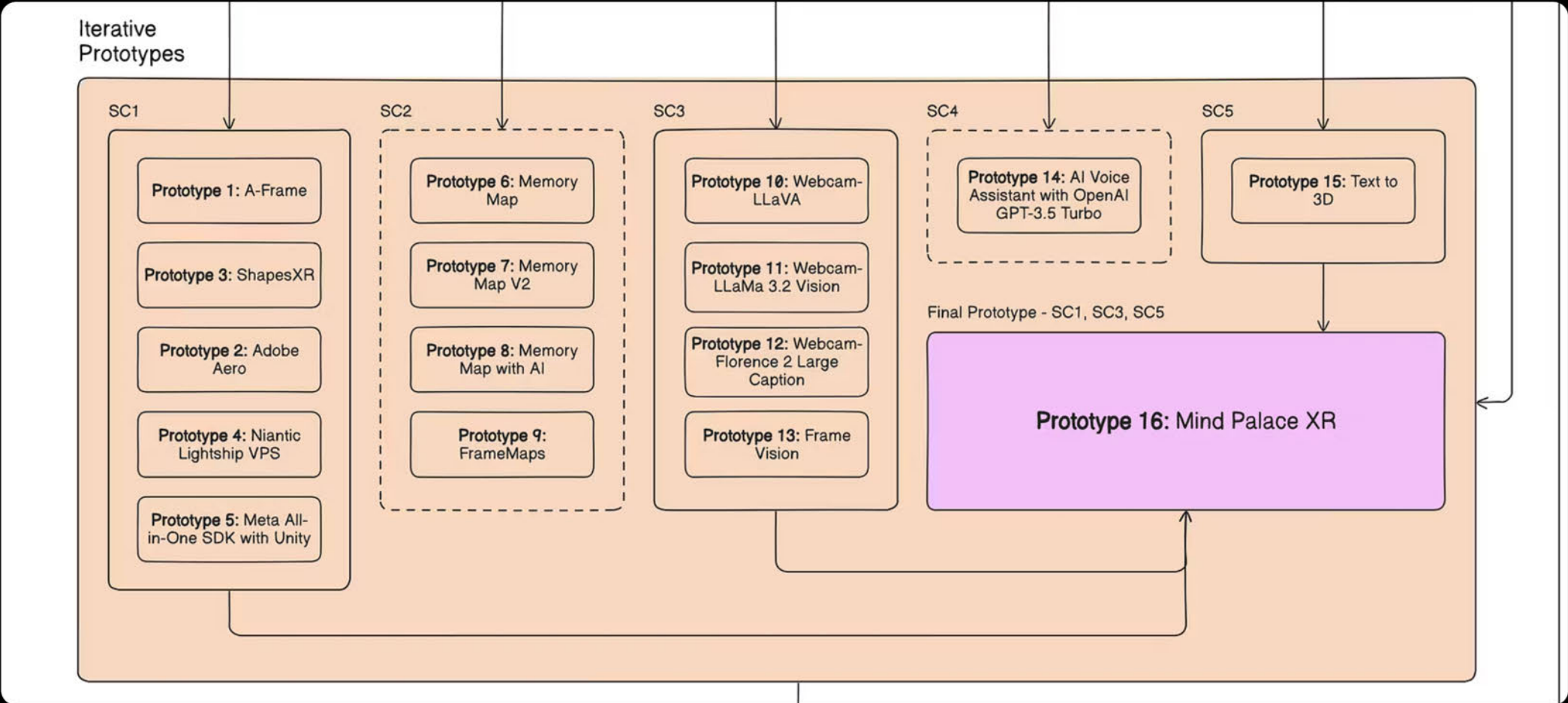
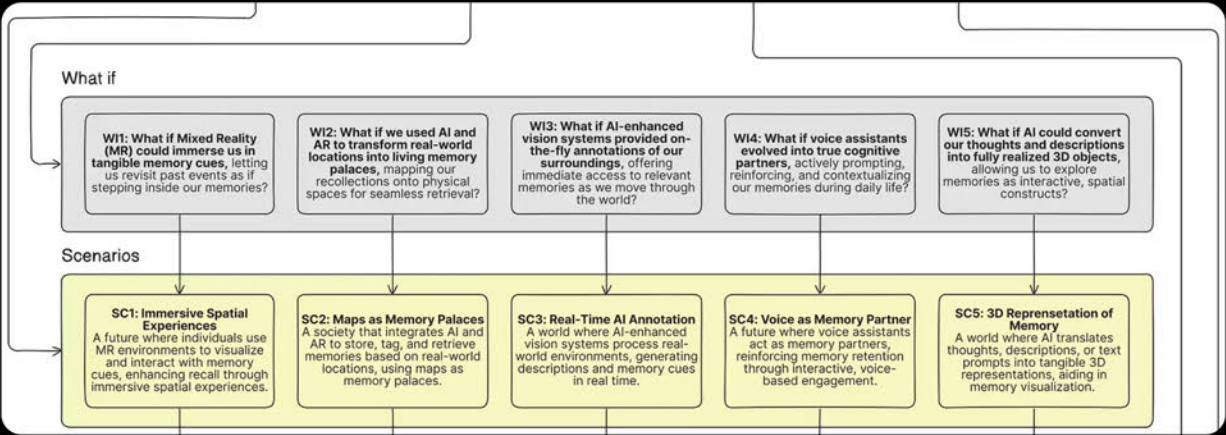
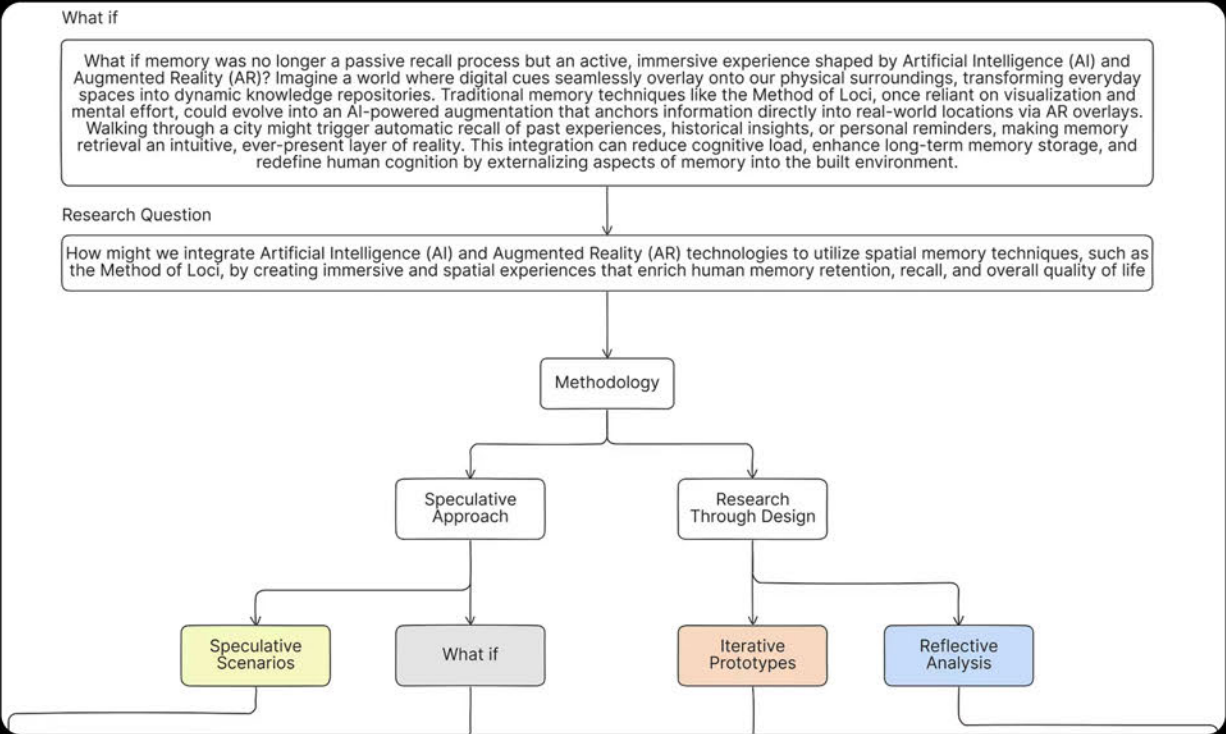
01	02	03	04
Memoro	ExoMem	NeverMind	Encode-Store-Retrieve
Using Large Language Models to Realize a Concise Interface for Real-Time Memory Augmentation	Augmented Reality-Based Human Memory Enhancement Using Artificial Intelligence	An Interface for Human Memory Augmentation	Augmenting Memory via Language-Encoded Egocentric Perception
Memory assistant, Large language models, Voice interfaces, Context aware agent, Minimal interfaces	Human memory augmentation, augmented reality (AR), computer vision (CV), artificial intelligence (AI), spatial cognition, object-location memory, navigation, cognitive load, performance, system usability.	Human memory augmentation, Augmented reality (AR) interface, Episodic memory, Spatial navigation, Memorization	HCI, Interaction paradigms: Mixed/Augmented Reality; Information Retrieval: Question Answering; AI, Computer Vision: Visual Content-Based Retrieval.

Research Gaps

01	02	03	04
Lack of Design-Led Speculative Research	Insufficient Real-World Integration	Scalability Issues on technology	Controlled Environment Bias
Few studies explore how AI and AR could imaginatively transform everyday memory practices or spaces.	Limited understanding of how AI & AR technologies function in dynamic, immersive, everyday environments.	Insufficient work into how well these technologies scale across different settings. (Fischer, 2023)	Most studies are conducted in artificial, lab-based settings, limiting real-world applicability. (Fassbender & Helden, 2006; Huttner et al., 2018)
Lack of Longitudinal Studies	Limited Participant Diversity	Risk of Over-Reliance	
Limited research on the long-term effects of AI and AR on memory in real-world settings. (Fassbender & Helden, 2006; Huttner et al., 2018).	Existing research often uses small, homogeneous samples (e.g., university students), reducing generalizability. (Fischer, 2023)	Underexplored potential for users to become dependent on AI/AR tools, possibly weakening natural memory functions. (Fischer, 2023)	

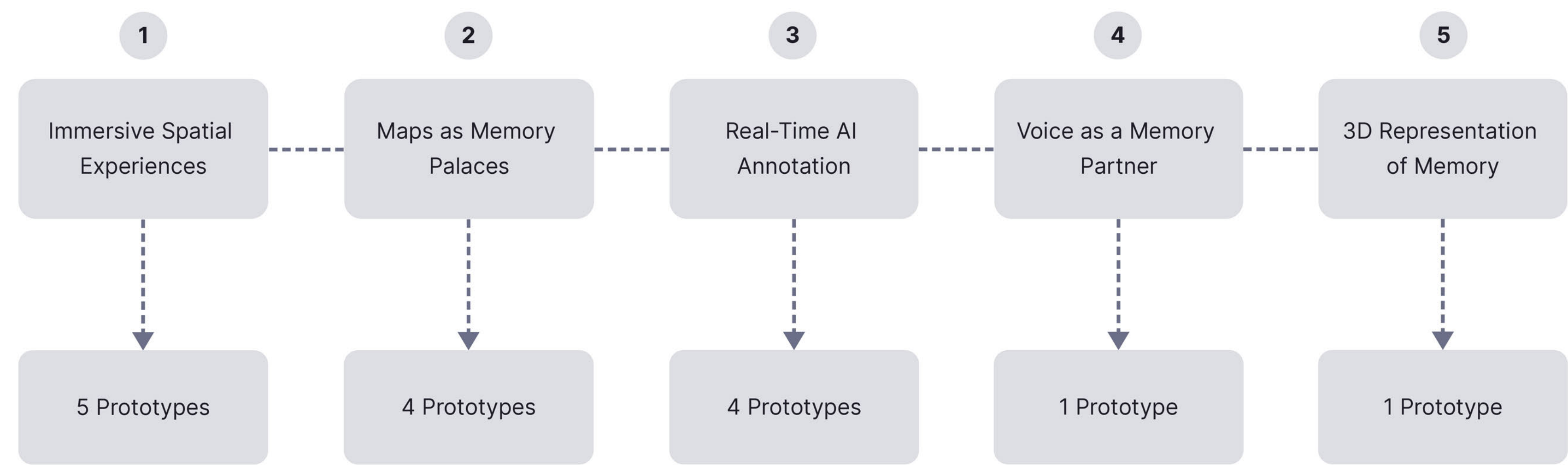
Methodology

This research utilizes Speculative Design combined with Research Through Design (RtD) methodologies to explore how Artificial Intelligence (AI) and Augmented Reality (AR) technologies might support and enhance human memory through immersive experiences



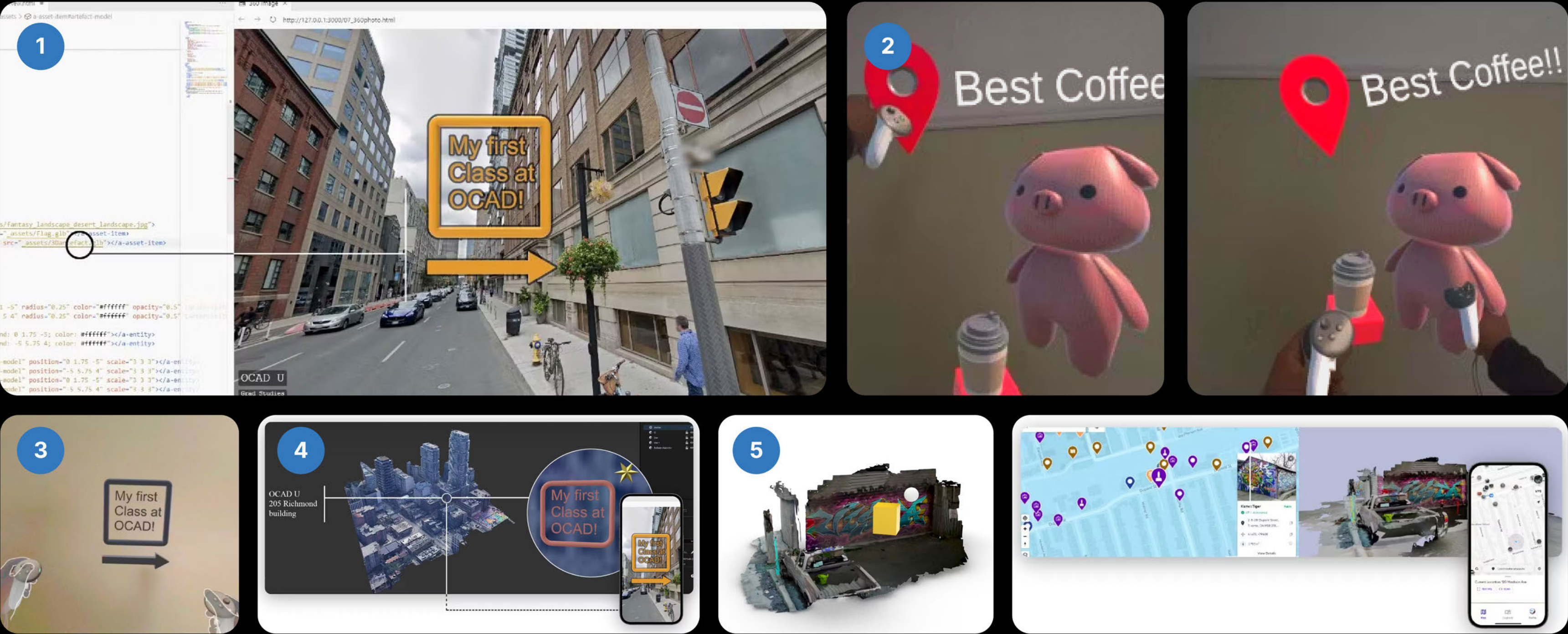
Prototyping Process

Iterative Prototypes in speculative design transform “what if” questions into tangible scenarios that provoke reflection and critique (Dunne & Raby, 2013; Kiialainen, 2022). They bridge imagination and practice, revealing insights through hands-on exploration and iterative refinement (Gaver, 2012).



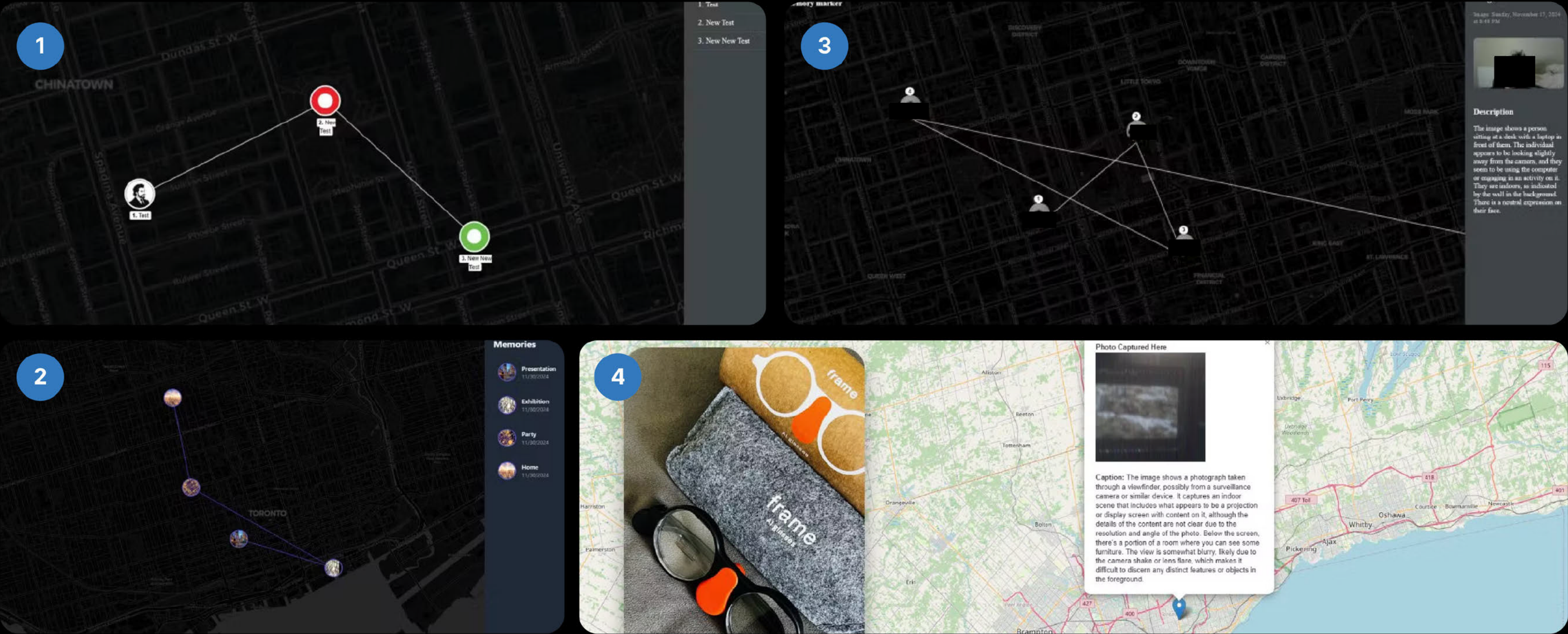
Immersive Spatial Experiences (5 Prototypes)

What if Mixed Reality (MR) could immerse us in tangible memory cues, letting us revisit past events as if stepping inside our memories?



Maps as Memory Palaces (4 Prototypes)

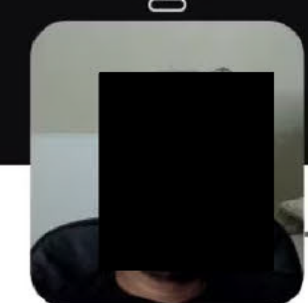

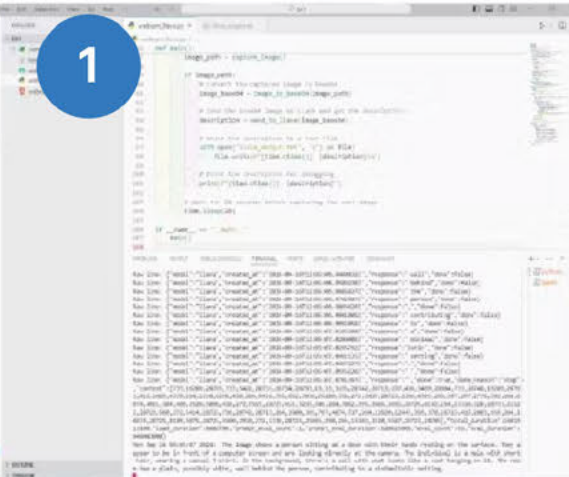
What if we used AI and AR to transform real-world locations into living memory palaces, mapping our recollections onto physical spaces for seamless retrieval?





Real-Time AI Annotation (4 Prototypes)

What if AI-enhanced vision systems provided on-the-fly annotations of our surroundings, offering immediate access to relevant memories as we move through the world?

1



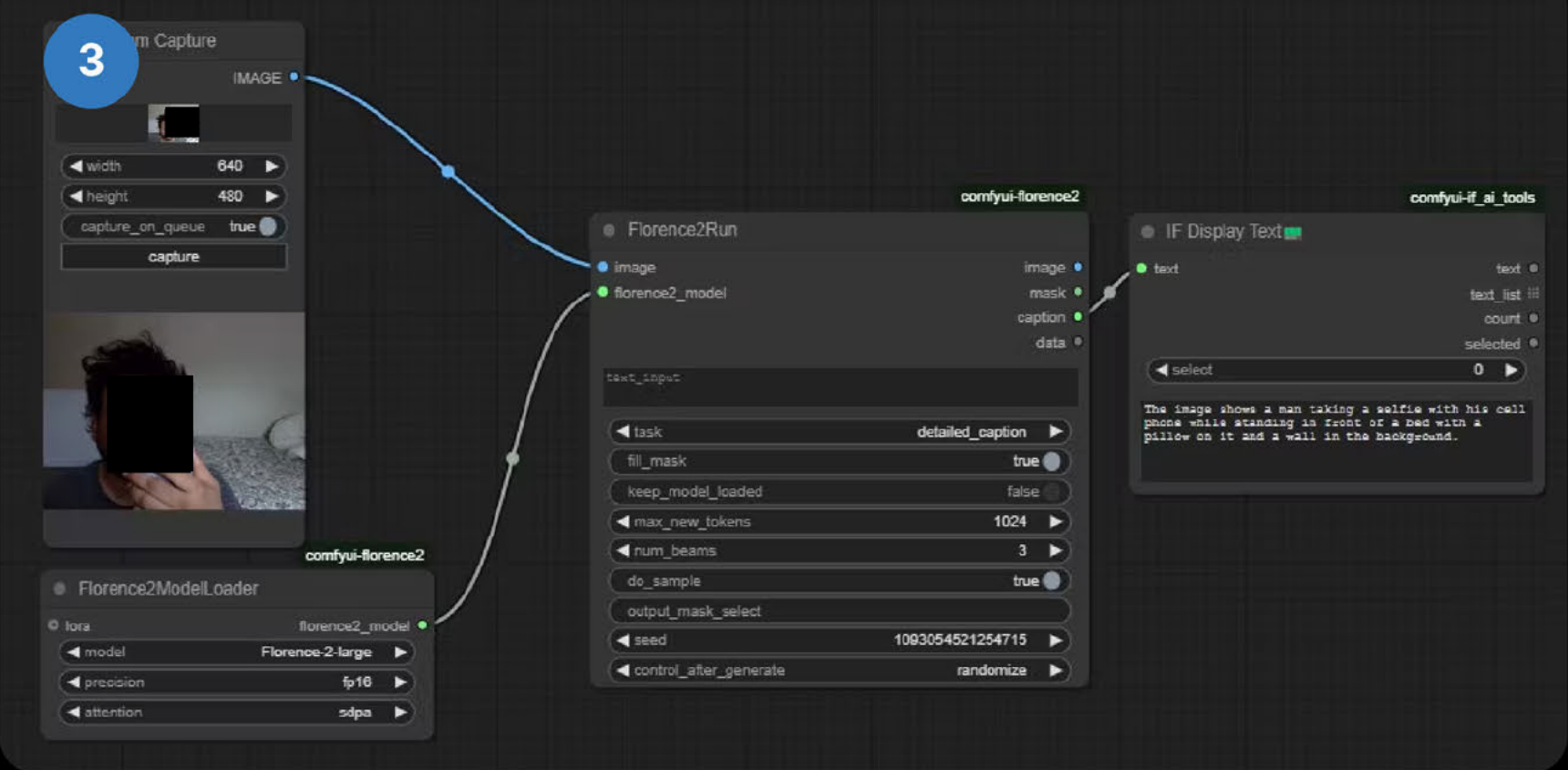
The image shows a person sitting at a desk, looking directly at the camera. The person appears to be using a computer and has messy hair. There is a wall with a plain, light color behind them. The environment suggests a personal workspace or home office.



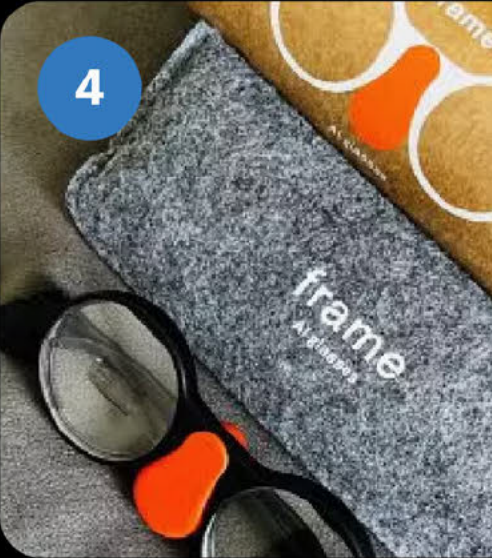
Webcam to LLaVA | Python
Camera, Visual reasoning, captioning

Lama - Large Language Model Meta AI
LLaVA - Large Language and Vision Assistant

3



4



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try:
    response = requests.post(url, json=payload, headers=headers, stream=True)
    if response.status_code != 200:
        print(f"Error: Status code {response.status_code}, Response: {response.text}")
        return "Error: LLaVA API request failed"
    full_response = ""
    # Log and parse response line by line
    for line in response.iter_lines():
        if line:
            decoded_line = line.decode('utf-8')
            print(f"Raw response line: {decoded_line}")
            try:
                json_line = json.loads(decoded_line)
                full_response += json_line.get("response", "")
                if json_line.get("done", False):
                    break
            except json.JSONDecodeError as e:
                print(f"Error decoding JSON: {e}, line: {decoded_line}")
                return "Error: Invalid JSON response"
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Voice as a Memory Partner (1 Prototype)

What if voice assistants evolved into true cognitive partners, actively prompting, reinforcing, and contextualizing our memories during daily life?

1

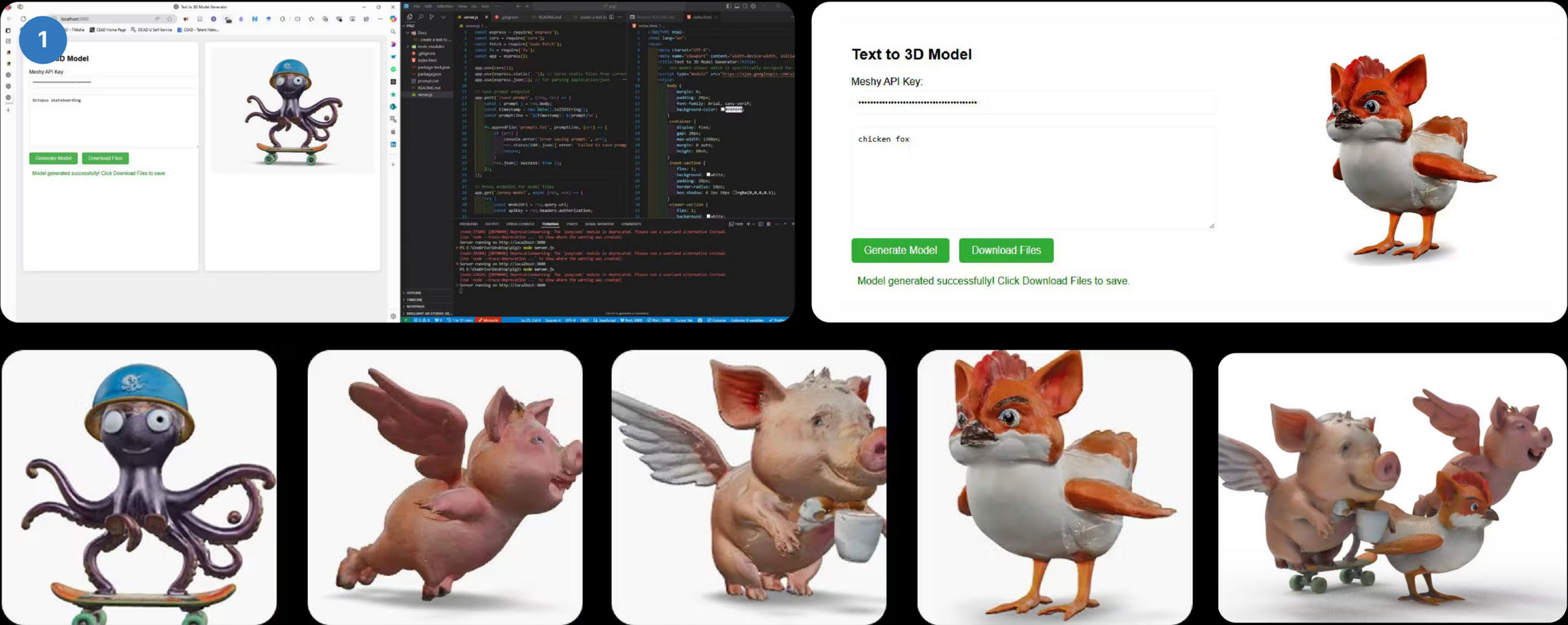
```
conversation.py X
conversation.py ...
1 import openai
2 import speech_recognition as sr
3 import pyttsx3
4 import os
5
6 # Set your OpenAI API key
7 openai.api_key = (
8
9 # Initialize the text-to-speech engine
10 engine = pyttsx3.init()
11
12 # Conversation log file
13 conversation_file = 'conversation.txt'
14
15 # Initialize recognizer
16 r = sr.Recognizer()
17
18 # Function to get audio input from the user and convert it to text
19 def get_audio():
20     with sr.Microphone() as source:
21         print("Listening...")
22         r.adjust_for_ambient_noise(source) # Adjust for ambient noise
23         audio = r.listen(source)
24
25     try:
26         print("Recognizing...")
27         text = r.recognize_google(audio)
28         print(f"You: {text}")
29         return text
30     except sr.UnknownValueError:
31         print("Sorry, I did not get that.")
32         return None
33     except sr.RequestError as e:
34         print(f"Could not request results: {e}")
35         return None
36
37 # Function to get response from OpenAI
38 def get_response(prompt):
39     response = openai.ChatCompletion.create(
40         model="gpt-3.5-turbo", # or 'gpt-4' if you have access
41         messages=[
42             {"role": "system", "content": "You are a helpful assistant."},
43             {"role": "user", "content": prompt}
44         ],
45         temperature=0.9,
46         max_tokens=150,
47         n=1,
48         stop=None
49     )
50     return response.choices[0].message.content
```

conversation.txt X
conversation.txt
1 Conversation Log
2
3
4 You: hello
5 You: hello
6 You: hello
7 You: hello
8 You: hello
9 AI: Hello! How can I assist you today?
10
11 You: tell me some joke
12 AI: Sure! Here's a joke for you:
13
14 Why did the scarecrow win an award?
15 Because he was outstanding in his field!
16
17 You: tell me some news
18 AI: I'm glad you're interested in staying informed! Could you please specify the topic or category you'd like to hear news about?
19
20 You: sports news
21 AI: I'm not able to provide real-time news updates. Would you like me to provide you with some general sports news or information instead?
22
23 You: yes
24 AI: How can I assist you today?
25
26 You: what is 45 + 64
27 AI: 45 + 64 equals 109.
28
29 You: okay
30 AI: How can I assist you today?
31
32 You: hello
33 You: hello
34 AI: Hello! How can I assist you today?
35
36 You: show me the story of
37 AI: I'm sorry, it seems like your message got cut off. Could you please provide more context or let me know the story you would like me to share?
38
39 You: tell me a story of Naruto
40 AI: "Once upon a time, in the hidden leaf village of Konoha, there lived a spirited young ninja named Naruto Uzumaki. Despite facing many challenges and hardships, Naruto was determined to become a great ninja and protect his village. Born with the powerful Nine-Tails fox demon sealed inside him, Naruto was often shunned and misunderstood by his fellow villagers. But with his unwavering determination and the guidance of his mentor, he grew into a powerful ninja. Throughout his journey, Naruto made many friends and allies, including Sasuke Uchiha, Sakura Haruno, and Kakashi Hatake. Together, they faced

Python, OpenAI GPT 3.5 Turbo, Speech to Text, Text to Speech

3D Representation of Memory (1 Prototype)

What if AI could convert our thoughts and descriptions into fully realized 3D objects, allowing us to explore memories as interactive, spatial constructs?



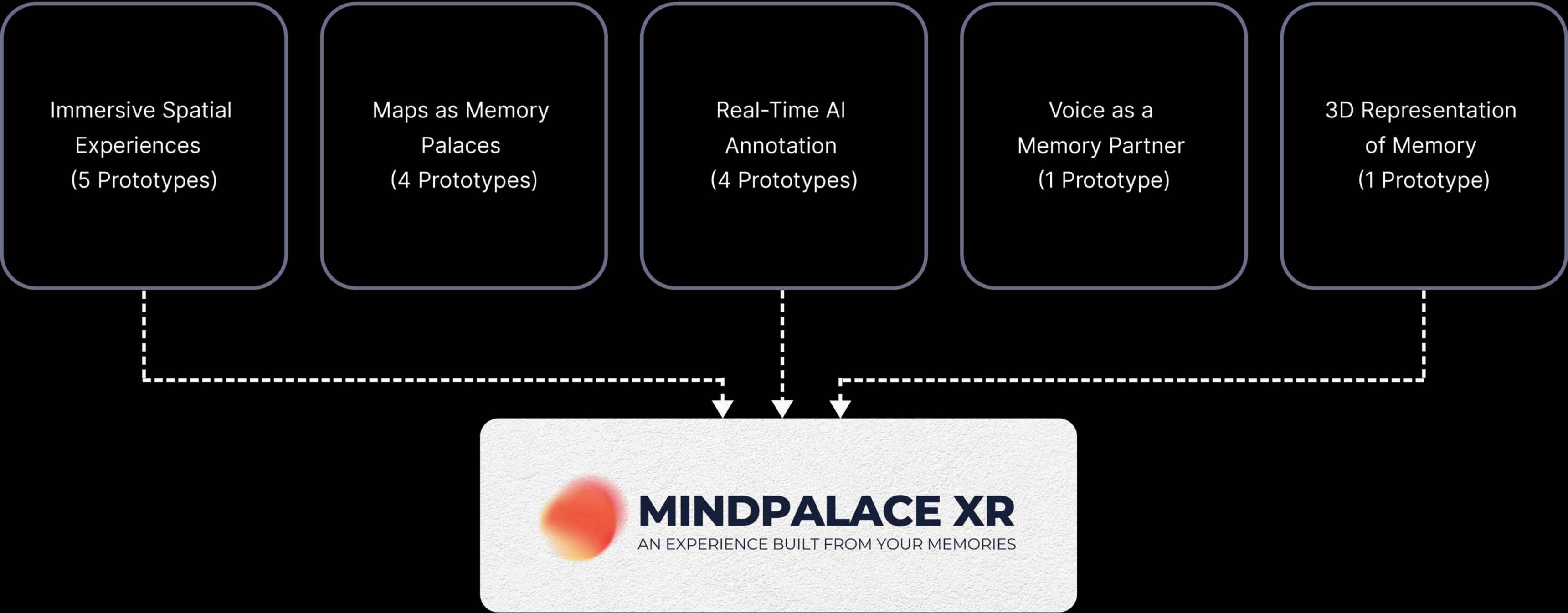
Mind Palace XR

Mind Palace XR showcases the integration of multiple AI services, converting live real-world views into interactive 3D memory cues. It uses advanced vision, language, and 3D model generation technologies to create a dynamic, world-scale memory palace in real time.



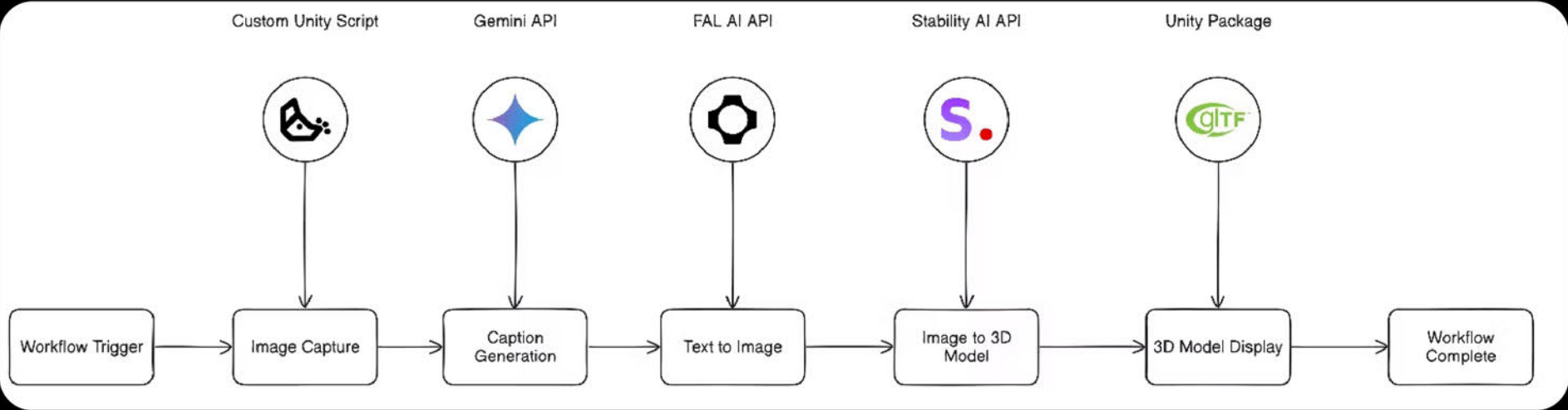
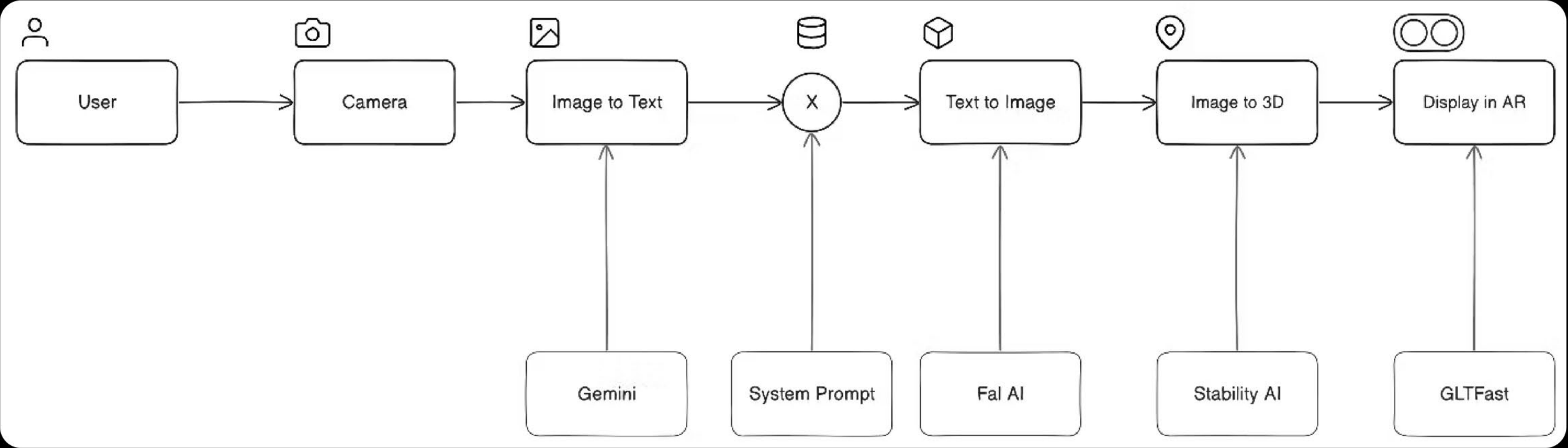
Mind Palace XR

From scenarios 1, 3, and 5, the final prototype takes shape as **Mind Palace XR**, synthesizing key speculative elements into an immersive experience.



Mind Palace XR - Development

The application uses a head-mounted display to capture the environment, processes it via Gemini Vision for scene description, stylizes it with FalAI, converts it to 3D using StabilityAI, and integrates it into AR with GLTFast, operating in real time.



Unity, Meta Quest 3 (HMD camera), Google Gemini Vision (scene description), FalAI (stylized 2D images), StabilityAI (text/2D-to-3D), GLTFast (3D importing)

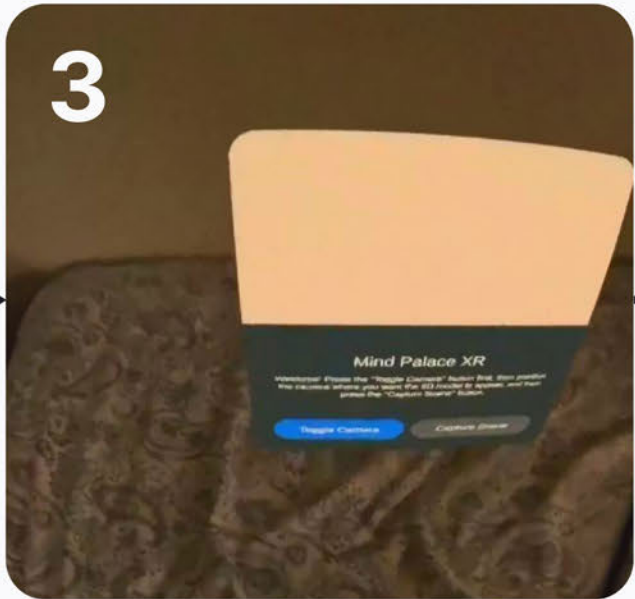
Mind Palace XR - How it works (Steps)



Launch the app



Splash screen appears



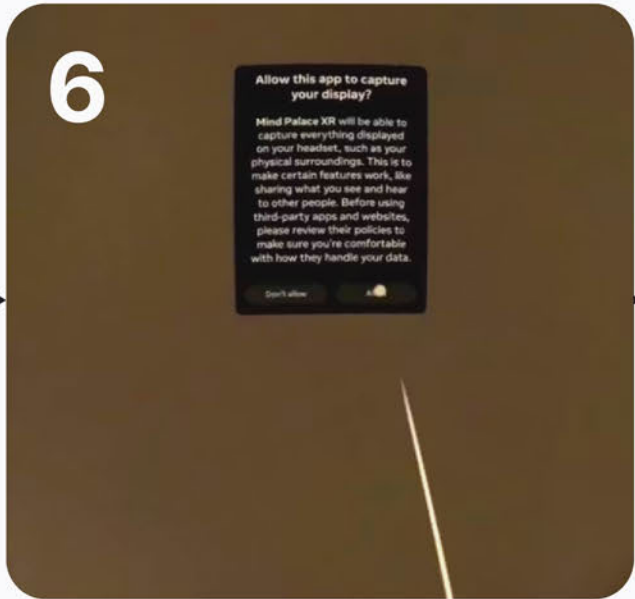
Camera Toggle and capture panel appears



Clear view of the Camera toggle and capture panel



Click Toggle camera



Allow permission to access camera



Look at a object/ place/ event etc and press capture



3D model appears based on a system prompt

Mind Palace XR - How it works (Video)



[Demo Indoor Video](#)

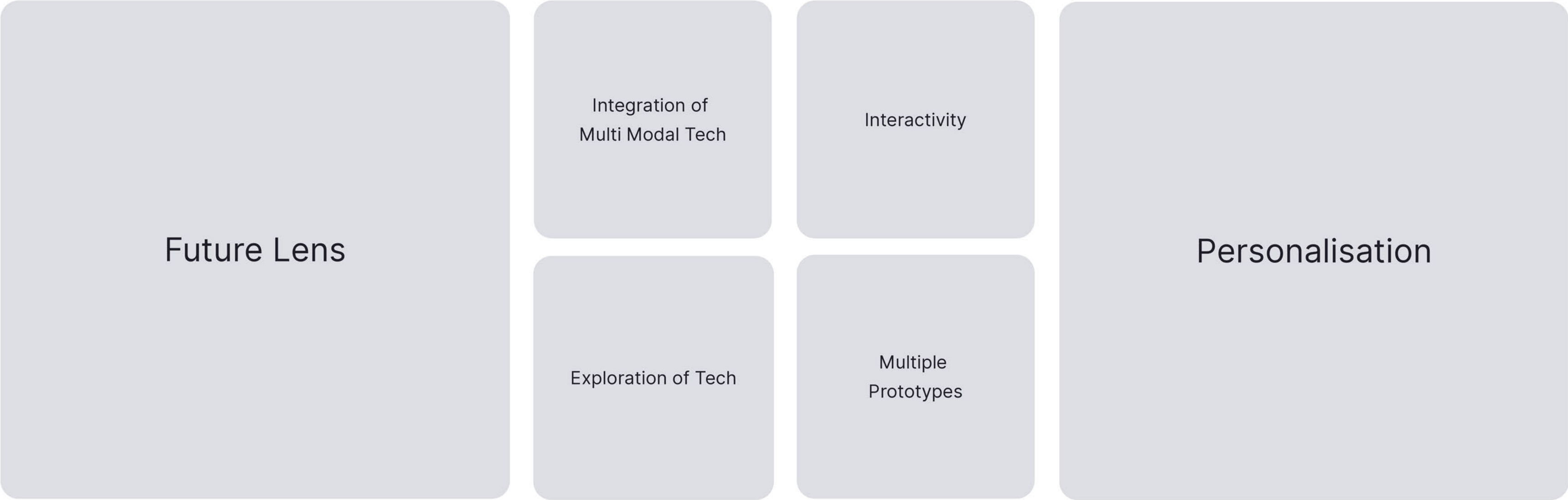


[Demo Indoor Video](#)



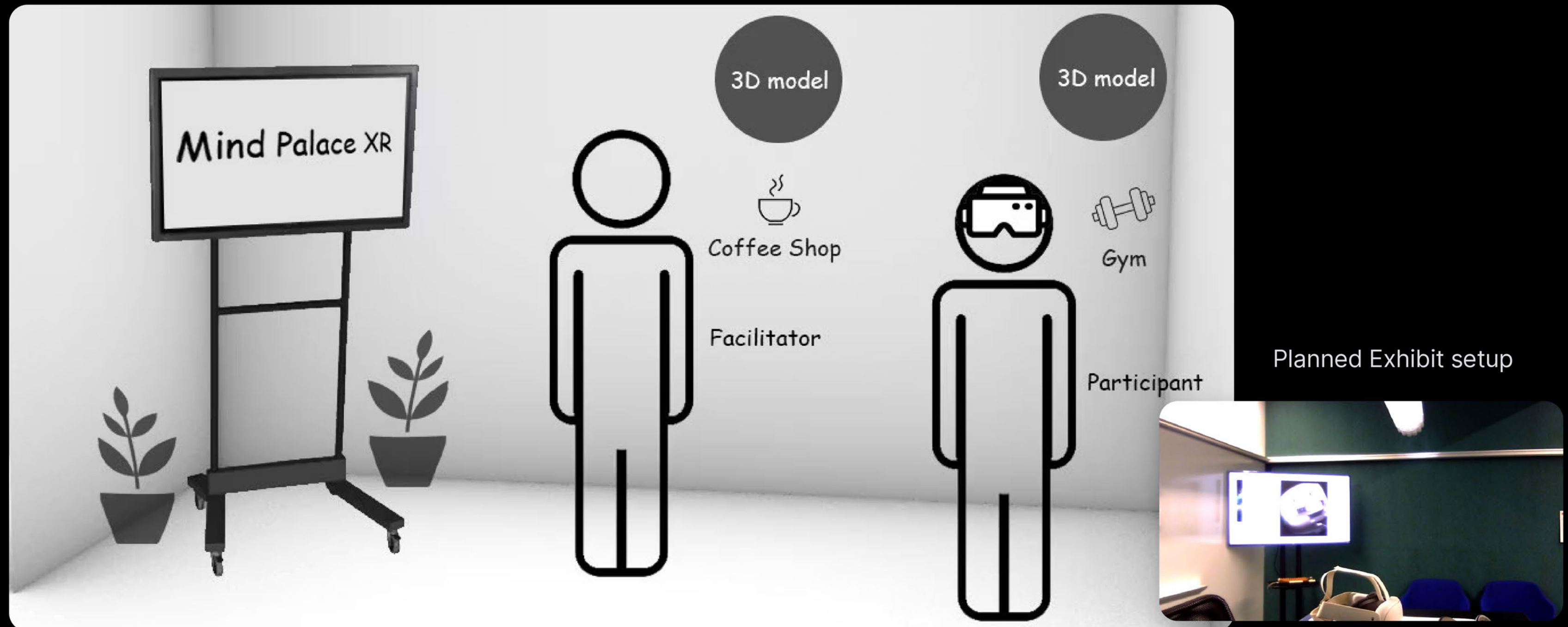
[Demo Outdoor Video](#)

Key Takeaways



Public Exhibition

The final prototype was showcased at DFX 2025, held from March 27 to April 2 at OCAD U's Waterfront Campus, featuring graduate work from MDes, MFA, and MA students. Visitors experienced the guided Mind Palace XR demo via Meta Quest 3, exploring AI-augmented memory techniques through spatially anchored 3D objects.



Exhibition Key Takeaways

Overall

Novel & engaging

Strengths

Efficient AI

Memorable Visuals

Intuitive UX

Core Concept

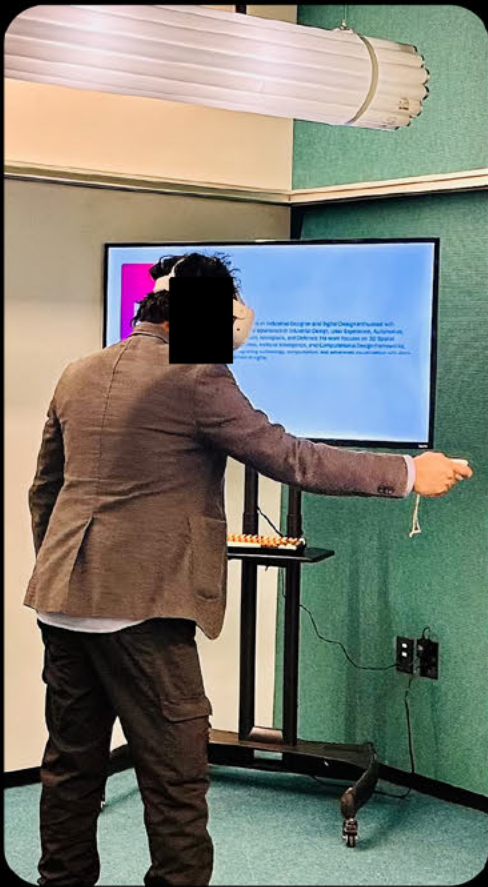
Potential Uses and Suggestions

Elderly memory support

Shopping reminders

Audio interface

Offline AI

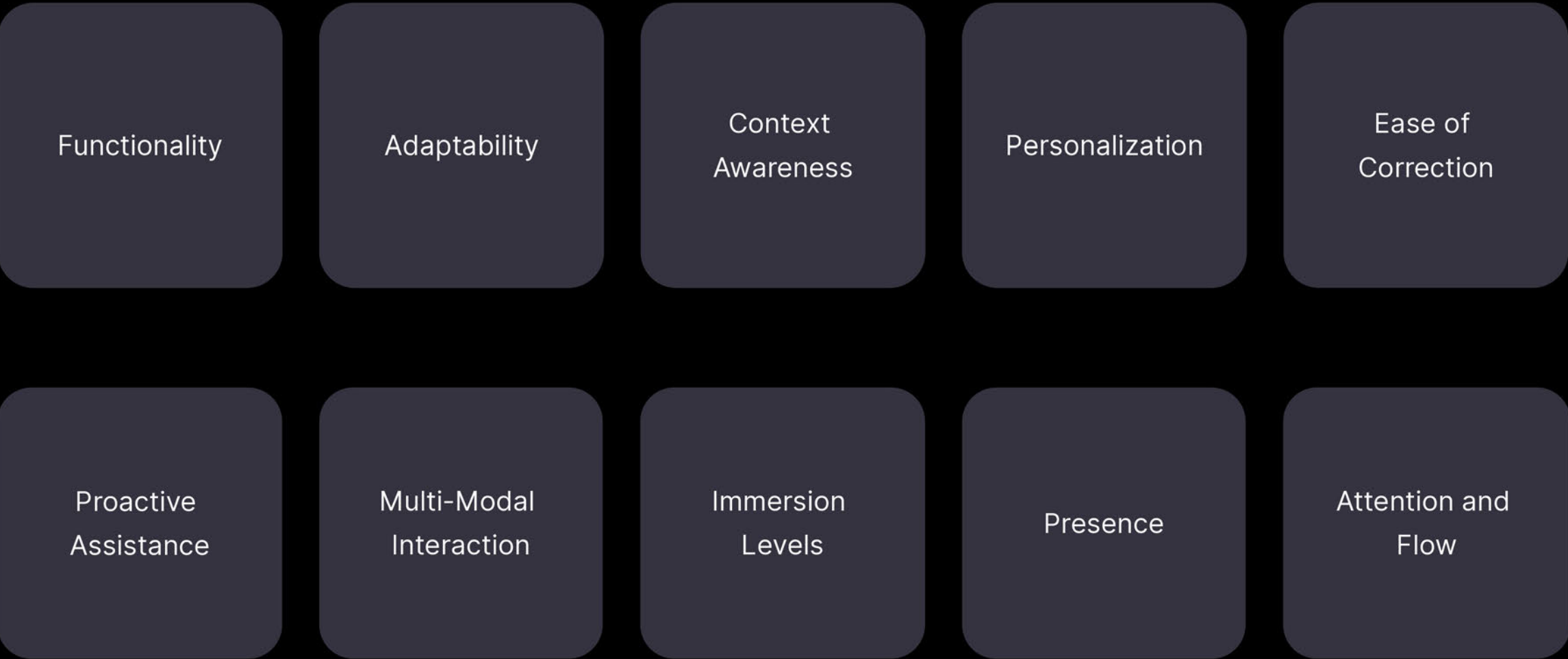


Evaluation

This work is evaluated through both descriptive and subjective methods. The descriptive analysis, guided by literature-based criteria, highlights strengths and gaps in functionality, context awareness, and personalization. The subjective evaluation traces the evolution of prototypes from early AR concepts to AI-driven features, emphasizing immersion, proactive support, and hands-free logging. Together, these approaches provide a comprehensive view of how XR and AI enhance memory support and user engagement, revealing both opportunities and areas for refinement.

No.	Prototype	Functionality	Adaptability	Context Awareness	Personalization	Ease of Correction	Proactive Assistance	Multi-Modal Interaction	Immersion Levels	Presence	Attention and Flow
1	WI1, SC1: A-Frame	2	1	1	1	1	1	1	3	3	2
2	WI1, SC1: Adobe Aero	3	1	1	1	2	1	2	3	2	2
3	WI1, SC1: ShapesXR	1	1	1	1	2	1	2	3	3	3
4	WI1, SC1: Niantic Lightship	2	3	3	2	2	1	2	3	3	3
5	WI1, SC1: Meta All in one SDK	2	2	3	2	2	1	3	3	3	3
6	WI2, SC2: Memory Map	2	2	2	2	3	1	1	1	1	2
7	WI2, SC2: Memory Map V2	3	3	2	3	3	1	1	1	1	2
8	WI2, SC2: Memory Map with AI	4	3	3	3	3	2	2	1	1	2
9	WI2, SC2: Frame Maps	4	3	3	3	3	2	2	1	1	2
10	WI3, SC3: Webcam LLaVA	2	3	3	3	3	2	2	1	1	2
11	WI3, SC3: Webcam LLaMa 3.2 Vision	2	2	2	1	2	1	2	1	1	1
12	WI3, SC3: Webcam Florence 2 Large Caption	2	2	2	1	2	1	2	1	1	1
13	WI3, SC3: Frame Vision	4	4	3	3	3	2	2	2	2	2
14	WI4, SC4: AI Voice Assistant (GPT 3.5 turbo)	2	3	2	3	3	2	2	1	1	2
15	WI5, SC5: Text to 3D	2	3	1	3	2	1	2	2	2	2
16	Final Prototype: Mind Palace XR	5	3	4	4	3	3	4	5	4	4

Criteria based on literature



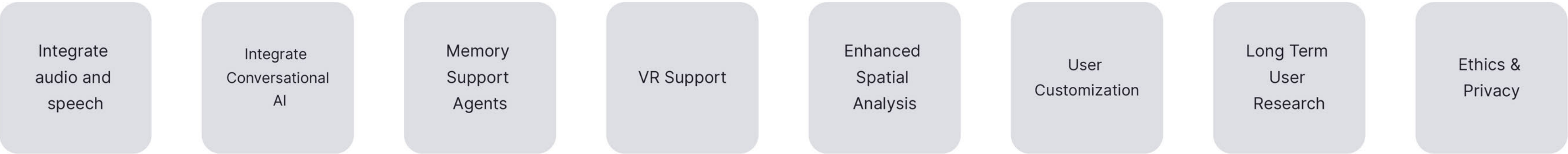
Conclusion

This thesis is shaped by my journey through industrial design, aerospace, defense, and higher education. Early on, I saw how algorithmic and generative tools could improve design and inspire new ideas. Over time, I noticed how both industry and academia often lose valuable knowledge. As a design educator, I saw students struggle to remember key concepts, echoing Ebbinghaus’ forgetting curve. These experiences led me to explore how technologies like Artificial Intelligence (AI) and Augmented Reality (AR), combined with traditional memory techniques, can help bridge these gaps. This work has strengthened my belief that blending human creativity with smart technology may enrich memory.

This research acknowledges several limitations. The absence of real-user testing and reliance on personal reflection introduce subjectivity, as evaluations were not supported by empirical validation. The focus remained primarily on technical development, limiting in-depth exploration of dimensions such as emotional resonance and artistic style. As a result, the outcomes should be viewed as explorative and speculative, rather than conclusive findings. Broader user studies are needed to assess the effectiveness and applicability in real-world contexts.

Background, Promising technologies - AI & AR, Absence of User study - Speculative approach, Descriptive evaluations

Directions for Future Work



Thank You

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Appendix

Scenario 1



What if Mixed Reality (MR) could immerse us in tangible memory cues, letting us revisit past events as if stepping inside our memories?

Aisha slips on her lightweight MR headset, immediately seeing a glowing café symbol that sparks recognition. Instead of scrolling through messages, she follows luminous orbs shaped like coffee beans floating along the sidewalk, guiding her effortlessly. Approaching the entrance, a translucent 3D model of two coffee cups appears, vividly recalling their last visit. Nearby, a floating photo of her friend's smiling face triggers a replay of their laughter, mingling with the sensory cue of fresh espresso aroma. Passersby glance curiously at her joyful expression, unaware she's immersed in these rich visual memory cues. Stepping inside, a final image from their past meeting gently fades, anchoring her back into reality. In this new age, memories are vividly woven into daily life through symbolic visuals and immersive cues.

Scenario 2



What if we used AI and AR to transform real-world locations into living memory palaces, mapping our recollections onto physical spaces for seamless retrieval?

While strolling through her bustling neighborhood, Mari uses an app that turns each street corner into part of her personalized memory palace. At the bakery, a small holographic bookshelf hovers, reminding her of the cookbook she borrowed from a neighbor. Near the florist, virtual petals swirl around her, prompting her to recall the time she bought flowers for her sister's graduation. The app ensures these cues feel natural, placed in exact spots where those memories first took shape. Neighbors start swapping their own memory markers, creating a shared map of personal highlights that sparks conversation among passersby. Families introduce their children to stories rooted in these everyday locations, embedding bits of their lives in the very pavement they traverse. Over time, a simple trip to pick up groceries transforms into a gentle journey through collective recollection.

Scenario 3



What if AI-enhanced vision systems provided on-the-fly annotations of our surroundings, offering immediate access to relevant memories as we move through the world?

Jake steps out in the morning wearing smart glasses equipped with AI-assisted vision. As he gazes at the bookstore ahead, a subtle overlay flickers, reminding him he once met an old friend there to discuss a must-read novel. When he moves along, a translucent note appears near a lamp post, nudging him to recall the errands he intended to run, he had promised to buy sugar for his grandmother. The system analyzes his surroundings in real time, highlighting spots tied to previous plans or sentimental memories. Privacy concerns arise, of course, and some folks prefer turning the feature off. Yet for individuals like Jake, the relief of not forgetting small tasks or cherished moments is a welcome change. Where typical reminders might fade in a phone's cluttered notifications, these direct overlays keep important bits of life front and center.

Scenario 4



What if voice assistants evolved into true cognitive partners, actively prompting, reinforcing, and contextualizing our memories during daily life?

Tanya's morning begins with a gentle voice in her ear, her AI partner that has grown more interactive over the past year. While making coffee, the assistant softly references a recent chat Tanya had with her cousin, prompting her not to forget the call she'd promised. On her commute, the assistant recalls a past musical performance Tanya attended, suggesting a playlist that might spark fresh ideas for an upcoming project. The conversations flow freely, almost like banter with a close friend who remembers every key moment. At work, it chimes in again when she's stuck on a problem, recalling an old brainstorming technique she used once with success. Though some worry about depending too heavily on these continuous prompts, many find that these voice-based nudges enrich day-to-day decision-making. In this new setting, the subtle guidance of a digital companion feels more personal than ever.

Scenario 5



What if AI could convert our thoughts and descriptions into fully realized 3D objects, allowing us to explore memories as interactive, spatial constructs?

On a quiet evening, Rosa takes a seat in her favorite park and focuses on a childhood memory: her father teaching her to tie shoelaces. Seconds later, a 3D hologram appears at the foot of a bench, illustrating the exact steps. The system allows her to rotate and enlarge the scene, even pausing it to savor details she forgot. Artists embrace this invention to shape conceptual models, creating tangible shapes out of their roughest sketches. Teachers discover its value in crafting detailed lessons out of a student's imagination, turning abstract thoughts into visual aids on the fly. Critics wonder if these creations might blur the line between recollection and fantasy, but folks like Rosa see them as a heartfelt way to hold treasured stories in plain sight. In just a few years, the act of remembering can bring entire scenes to life with a single request.

Mind Palace XR – Association

With MindPalace XR on Meta Quest 3, you can create memory artifacts by placing 3D models in real-life locations as you go about your day. These models, created by AI, work together with the place to help you remember just like the method of loci. The AI helps with imagining, but the remembering happens through your own associations, so the agency of remembering stays with you. (Pedersen, 2016)



Location, Event, Object etc



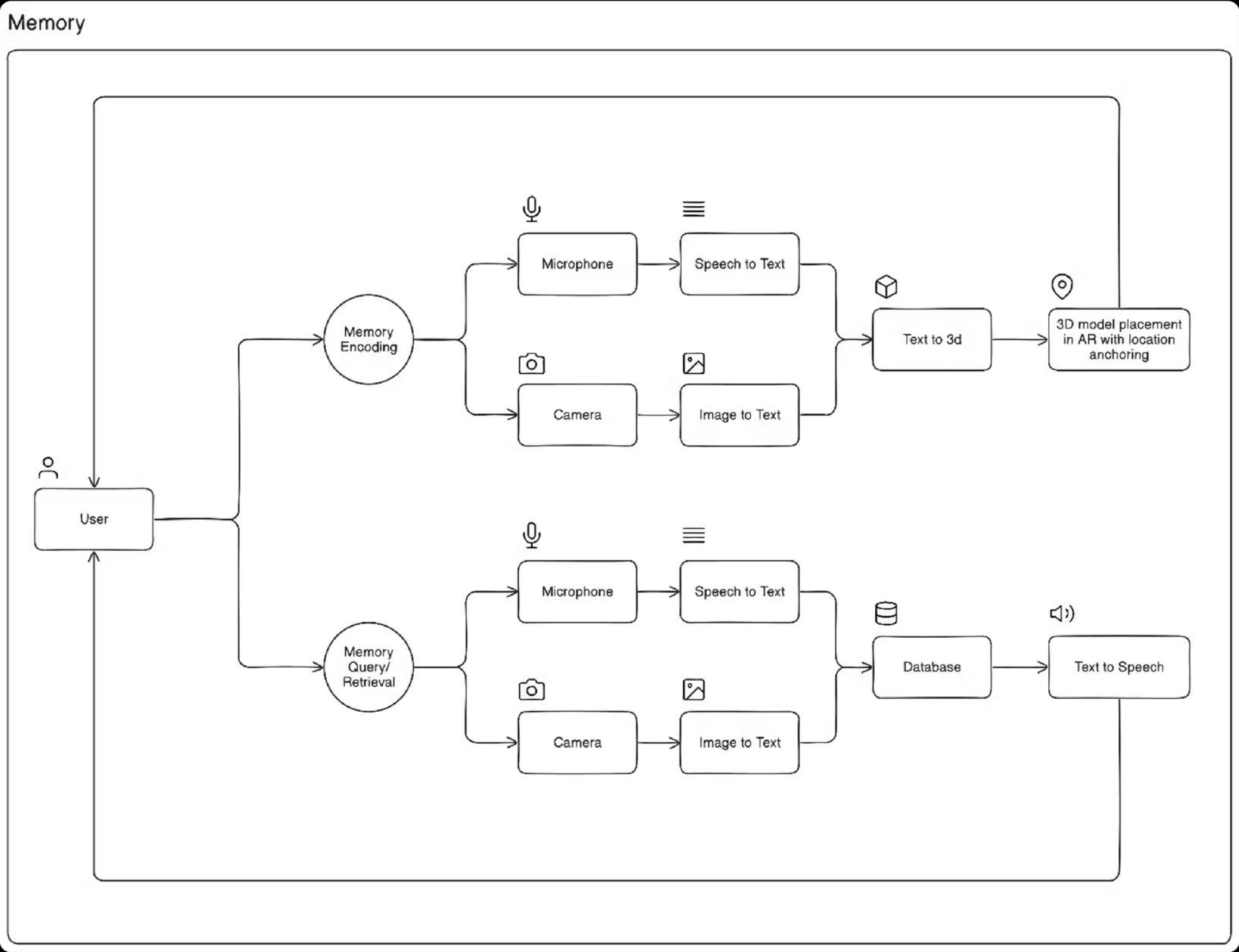
3D Artifact



Memory Record
Location, Time, Context,
Personal involvement

Ideal System

The ideal system envisions a multimodal AI that seamlessly integrates memory encoding and retrieval through both visual and speech-based interactions. As AI models advance to better handle the physical world, this system ensures balanced support for both audio/speech and visual interfaces, creating a more intuitive and immersive memory augmentation experience.



Mind Palace XR - System Prompt

"Your task is to create a prompt for an AI image generator. The prompt will generate a 2D image of a 3D model to help the user remember the object at the center of the image. This is for the memory palace technique."

Tech Stack

- Concept 1 - A-Frame, Adobe Aero, Shapes XR, Niantic Lightship ARDK, Unity
- Concept 2 - HTML/Js/Leaflet, React, TypeScript, Python, Open CV, LLaVA, Ollama, Brilliant Labs Frame SDK
- Concept 3 - Python, OpenCV, LLaVA, Ollama, LLaMa 3.2, Comfy UI, Florence 2, Brilliant Labs Frame SDK
- Concept 4 - Python, OpenAI GPT 3.5 Turbo, Speech to Text, Text to Speech
- Concept 5 - Meshy.ai API, Node.js, Js, Google model viewer
- Final Prototype - Unity, Meta Quest 3 (HMD camera), Google Gemini Vision (scene description), FalAI (stylized 2D images), StabilityAI (text/2D-to-3D), GLTFast (3D importing)

Github Repositories



[calluxpore/DF_Thesis_Prototype_Feb10](https://github.com/calluxpore/DF_Thesis_Prototype_Feb10)



[calluxpore/Webcam-Florence-2-Large-Caption](https://github.com/calluxpore/Webcam-Florence-2-Large-Caption)



[calluxpore/Text-to-3D-Model-Generator](https://github.com/calluxpore/Text-to-3D-Model-Generator)



[calluxpore/FrameMap-Photo-Capture-Description-and-Location-Visualization](https://github.com/calluxpore/FrameMap-Photo-Capture-Description-and-Location-Visualization)



[calluxpore/FrameVision-Smart-Image-Capture-Description-with-Location](https://github.com/calluxpore/FrameVision-Smart-Image-Capture-Description-with-Location)



[calluxpore/Webcam---LLaMa-3.2-Vision](https://github.com/calluxpore/Webcam---LLaMa-3.2-Vision)



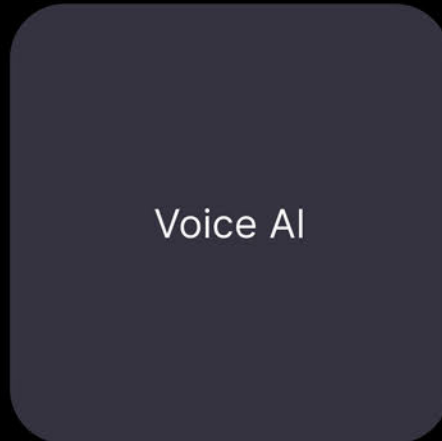
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[calluxpore/Webcam-LLaVA](https://github.com/calluxpore/Webcam-LLaVA)



<https://github.com/calluxpore/VoiceAI>