MemLog

AI-Supported VR Research Platform
for Memory and Cognitive Support

MSC THESIS | STOCKHOLM UNIVERSITY & KAROLINSKA INSTITUTET
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THE GAP

Everyday AI tools shape how people remember and manage tasks, yet their cognitive impact remains poorly understood. Studying this requires controlled environments where AI behaviour, task state, and human actions can be precisely instrumented. No established platform combines ecological realism with research-grade instrumentation and programmatic access to AI–task state.

THE PLATFORM

MemLog is a modular, event-driven research platform for controlled studies of AI-assisted cognition. It provides structured behavioural instrumentation, a configurable task environment, and a state-aware AI integration architecture—all producing time-aligned, auditable datasets.

The first use case is a VR driving-and-errands study comparing a **baseline** against an **AI-assistant condition**.

MY ROLE

Sole architect and developer: platform design, Unity/C# implementation, XR interaction, event-driven task logic, structured data logging, experimental framing, and full system integration. Supervised at DSV (human–computer interaction) and KI (cognitive neuroscience).

CORE ARCHITECTURE

- **Engine & Runtime:** Unity 6, C#, OpenXR, Quest 3
- **Modular Environment:** Procedural city with configurable roads, intersections, and landmarks
- **Event-Driven Task Logic:** Errand hotspots, roadblocks, task-addition and removal controllers
- **State-Aware AI Layer:** Assistant with programmatic access to full task state
- **Instrumentation Pipeline:** Structured JSONL with dual timestamps and sequential ordering
- **Hardware Input:** Logitech G923 wheel/pedals; keyboard fallback

`Unity 6` `C#` `OpenXR` `Quest 3` `JSONL` `State-Aware AI` `Event-Driven` `Procedural Gen` `G923` `VR / XR`

CAPABILITIES DEMONSTRATED

- Unity/C# systems architecture
- Event-driven simulation logic
- Wheel and pedal hardware input
- Procedural environment design
- Behavioural instrumentation
- Experiment-oriented software
- Reusable platform architecture
- Experimental condition logic
- Quest 3 VR/XR interaction
- Human–AI interaction design
- Structured data pipelines
- Cross-discipline collaboration

DESIGN PRINCIPLES

Separation of concerns: Task logic, instrumentation, and AI coordination run as independent subsystems.

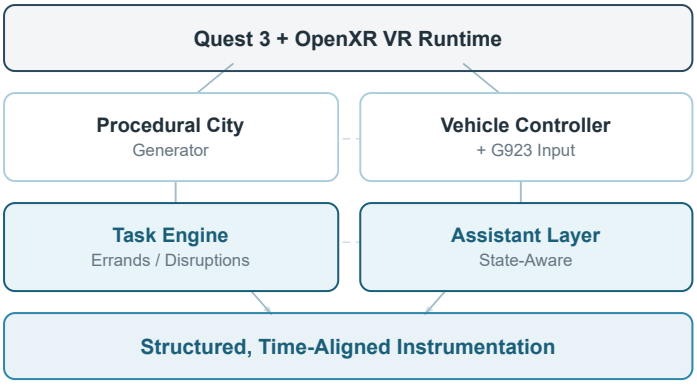
Auditability first: Every system event produces a structured, timestamped record.

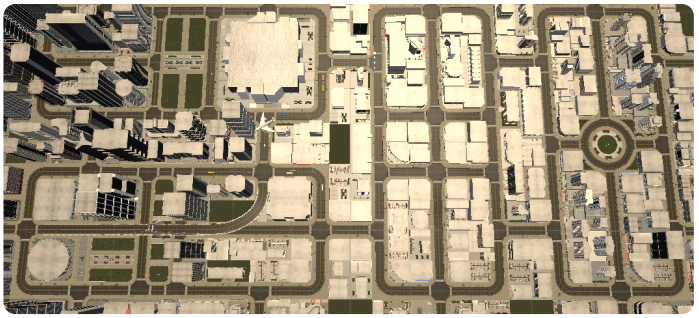
Ecological realism: VR scenarios replicate real-world multitasking under controlled conditions.

Reusable modules: Built for multiple studies and scenarios beyond one VR experiment.

PLATFORM ARCHITECTURE

MemLog runs as a state-aware Unity runtime where embodied input, task logic, instrumentation, and assistant coordination remain separable but time-aligned for analysis and reuse.





Procedurally generated virtual city. Layout frozen to a single configuration for the initial study; alternative environments can be authored for future use cases.

Environment Features

- Configurable road networks
- Dynamic intersection logic
- Errand hotspot placement
- Roadblock event triggers
- GPS and minimap overlays

INSTRUMENTATION SNAPSHOT

Structured JSONL records with ms-resolution dual timestamps linking task state, participant behaviour, and AI interactions.

Control state	→	Steering, throttle, brake input
Task stream	→	Errand lifecycle and task updates
Vehicle context	→	Position, speed, heading
AI context	→	Queries, responses, state refs

Data Characteristics

- Dual timestamps (wall-clock + session)
- Sequential ordering guarantees
- Structured JSONL format
- Auditable event chains

Foundation for richer multimodal pipelines including eye tracking, EEG, and physiological streams.

FIRST USE CASE

VR Driving & Errands

Baseline: Participants navigate the virtual city with GPS and minimap support.

Assistant: Same navigation, augmented by a state-aware GenAI assistant with full task-state access.

Event probes: Task additions, removals, and route disruptions test memory formation, updating, and maintenance.

- Between-subjects design
- Time-aligned data
- Controlled event probes
- AI–cognition comparison

Technical Integration

- Real-time AI state synchronization
- Configurable experimental conditions
- Automated event-probe scheduling
- Unified data export pipeline

Platform Direction

- Broader platform for memory and cognitive-support research
- Reusable study infrastructure beyond one VR scenario
- State-aware AI-guided task support architecture
- Event-driven logic adaptable to new experimental use cases
- Multimodal instrumentation: eye tracking and EEG integration
- Adaptive assistant workflows on the same runtime
- Reusable infrastructure for controlled experiments
- Platform vision centred on interactive memory support