

Embodied XR Systems for Neurodivergent Therapy & Sensorimotor Interaction

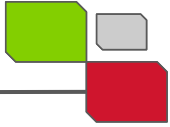
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RUTGERS

WINLAB | Wireless Information
Network Laboratory

Virtuix 
Aiyer Foundation

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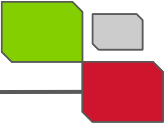


Dirk Catpo Risco

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Dr. Yingying Chen



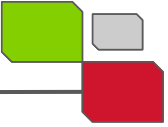
Real-World Behavior Is Embodied. Most VR Is Not.

Virtual Reality (VR) creates a safe, controlled environment for neurodivergent children to practise skills.

But what are we missing when the body stays still?

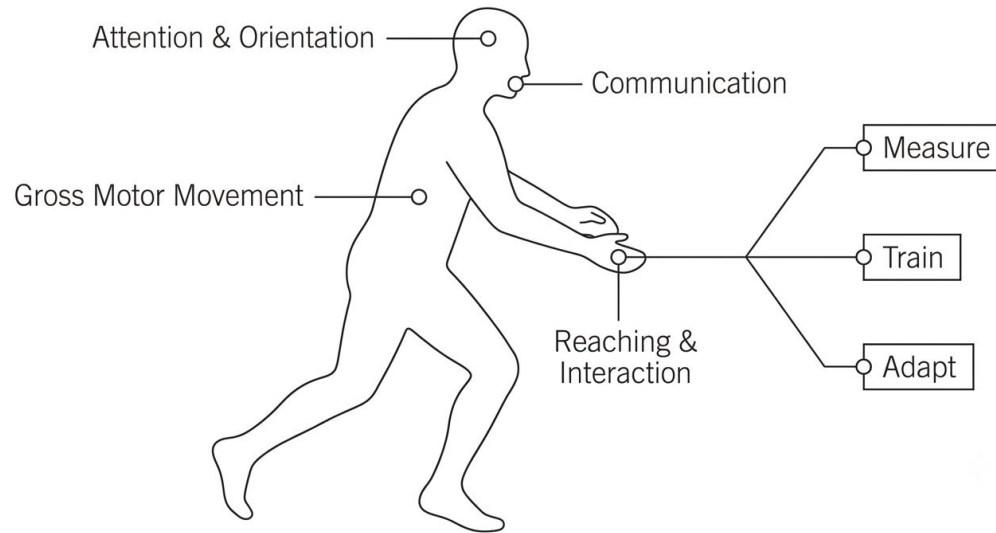


Knowing when to cross is only one part of crossing safely!



What Can Embodied XR Unlock?

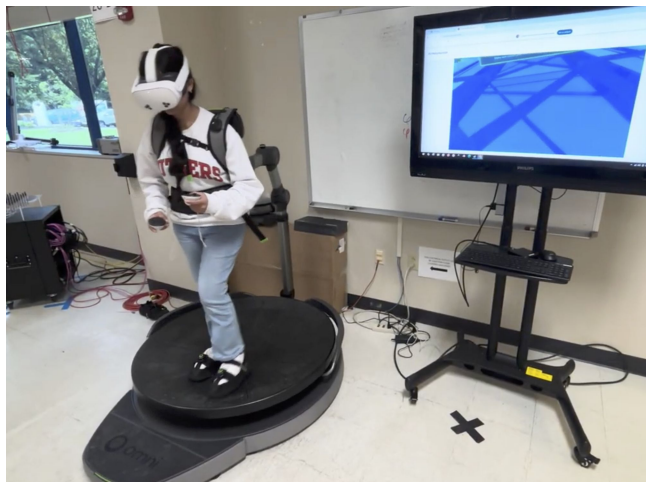
“Can embodied XR make functional **mind-body coordination** across **gross motor movement**, attention, cognition, and communication **measurable** & **trainable**?”



Anatomy of an Embodied XR Experience

Physical Hardware

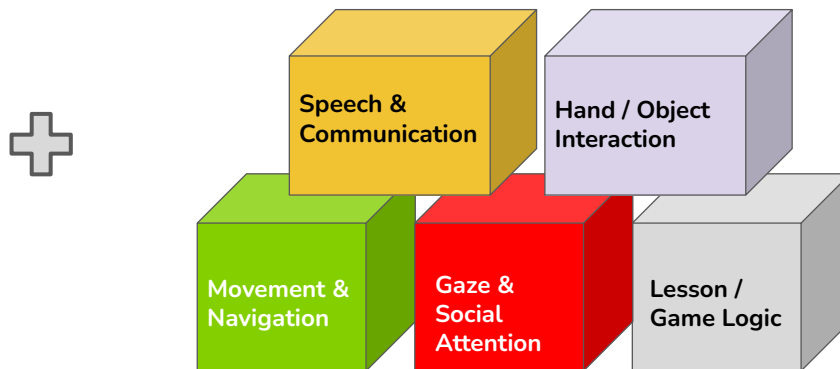
Virtuix Omni One Treadmill + Meta Quest



- Full-body walking & running
- Natural 360° turning
- Head & hand tracking

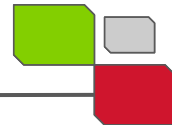
Our Embodied XR Framework

Core Reusable Unity Modules

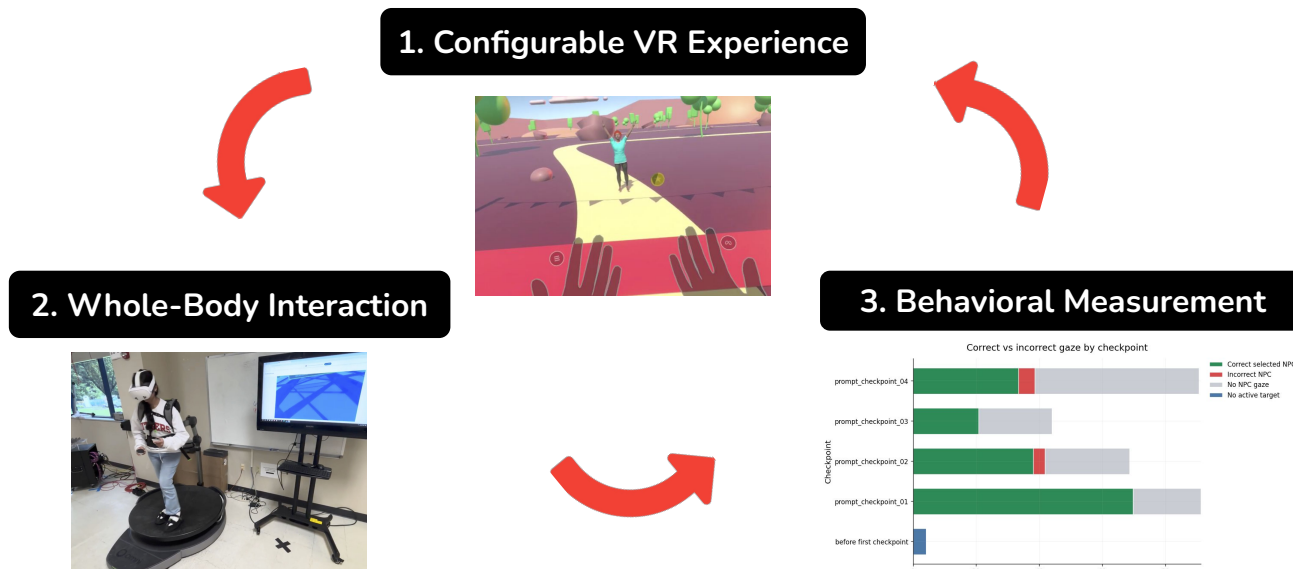


- Capable of real-time behavioural data capture
- AI-powered interaction
- Adaptive NPC behavior

How Embodied XR Works

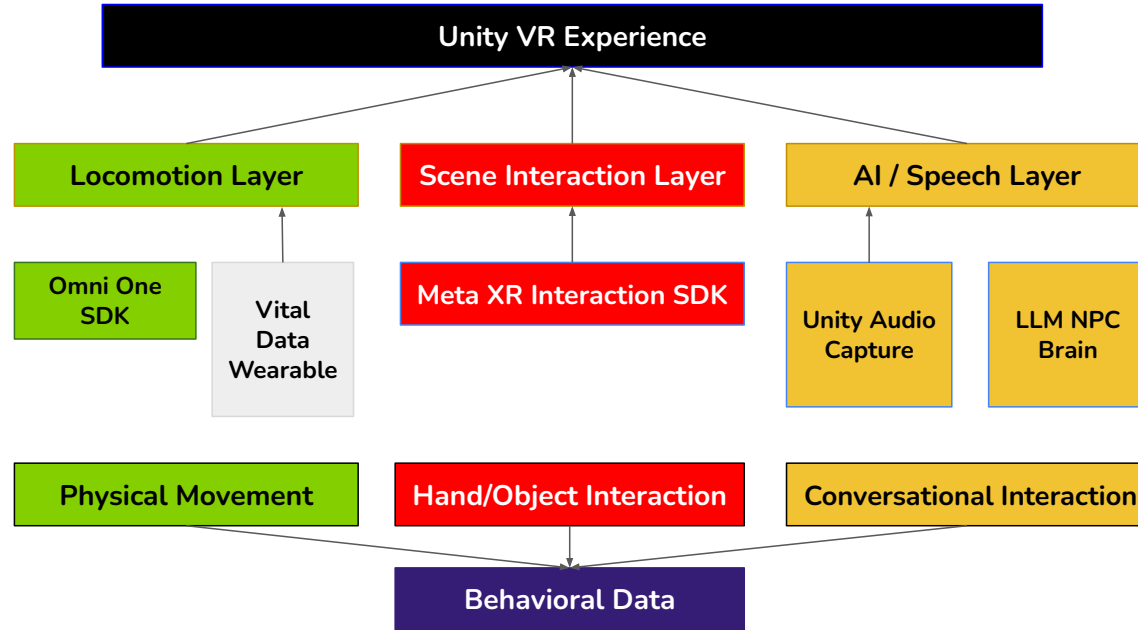
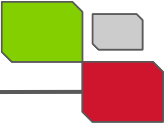


We design a skill-targeted experience, the participant acts within it, and the system captures how that behaviour unfolds.



Goal: Turn a skill into a scenario, a scenario into controlled variations, and every interaction into data.

A Modular Embodied XR Framework



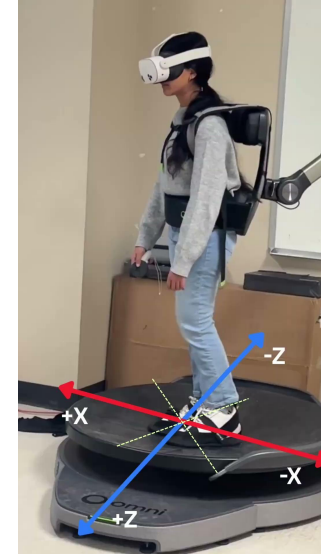
Technical Implementation of the Core Modules

Full-body locomotion

Omni input vector

- Headset-relative direction mapping
- Movement scaling

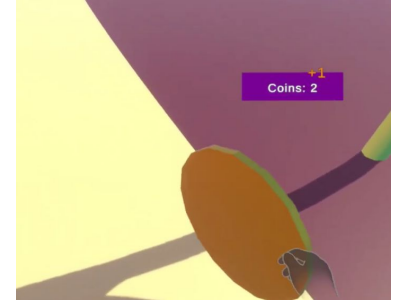
Maps physical walking & turning to stable movement of the Meta XR rig!



Hand & Attention Tracking

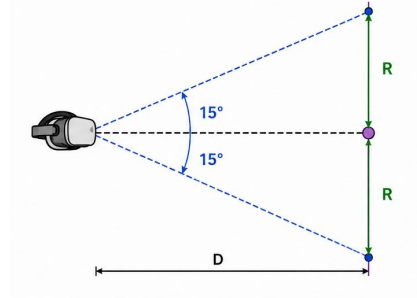
Meta XR hand tracking

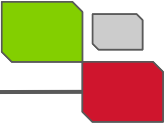
- Grabbable / HandGrabInteractable
- Custom selection & tag events



CenterEyeAnchor

- Raycast + angle / distance checks
- Head-directed attention events

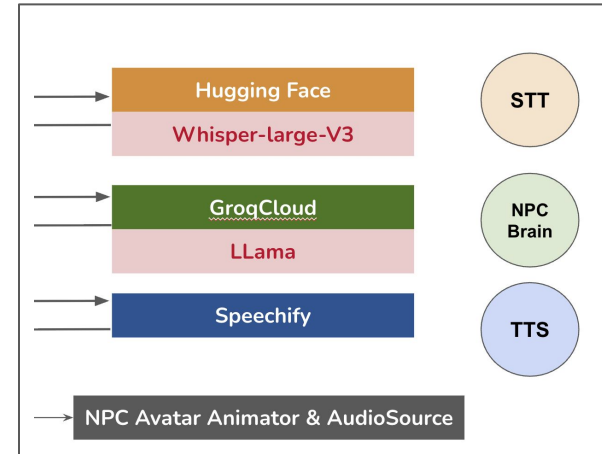


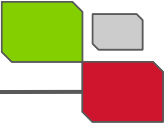


AI NPC Speech & Conversation

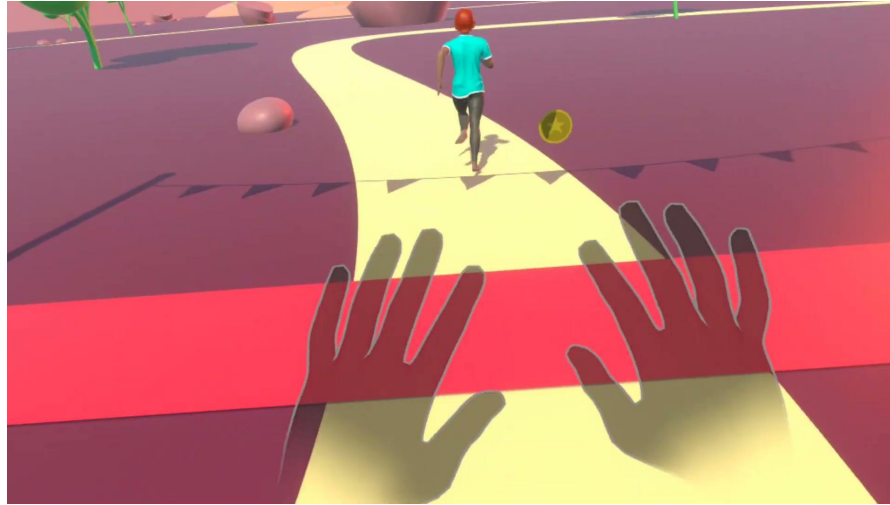
Real-Time Conversational AI Avatars

- VAD-Gated Audio Capture
- **Asynchronous REST Inference**
- LLM Dialogue Generation





1) Single-NPC VR Tag



Run

Look

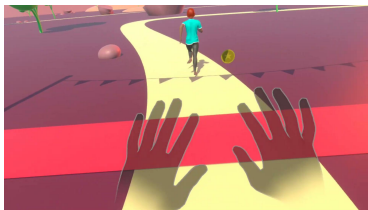
Grasp

Speak

Choose

Skills Addressed: Spatial navigation, Hand-eye coordination & Speech Initiation

Framework in Action: Prototype Experiences

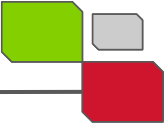


Behavioral Data

Tag-to-Reward Sequence Timeline

Timing between each NPC tag and subsequent reward collection



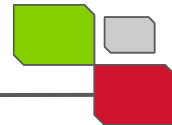


2) Multi-NPC VR Tag

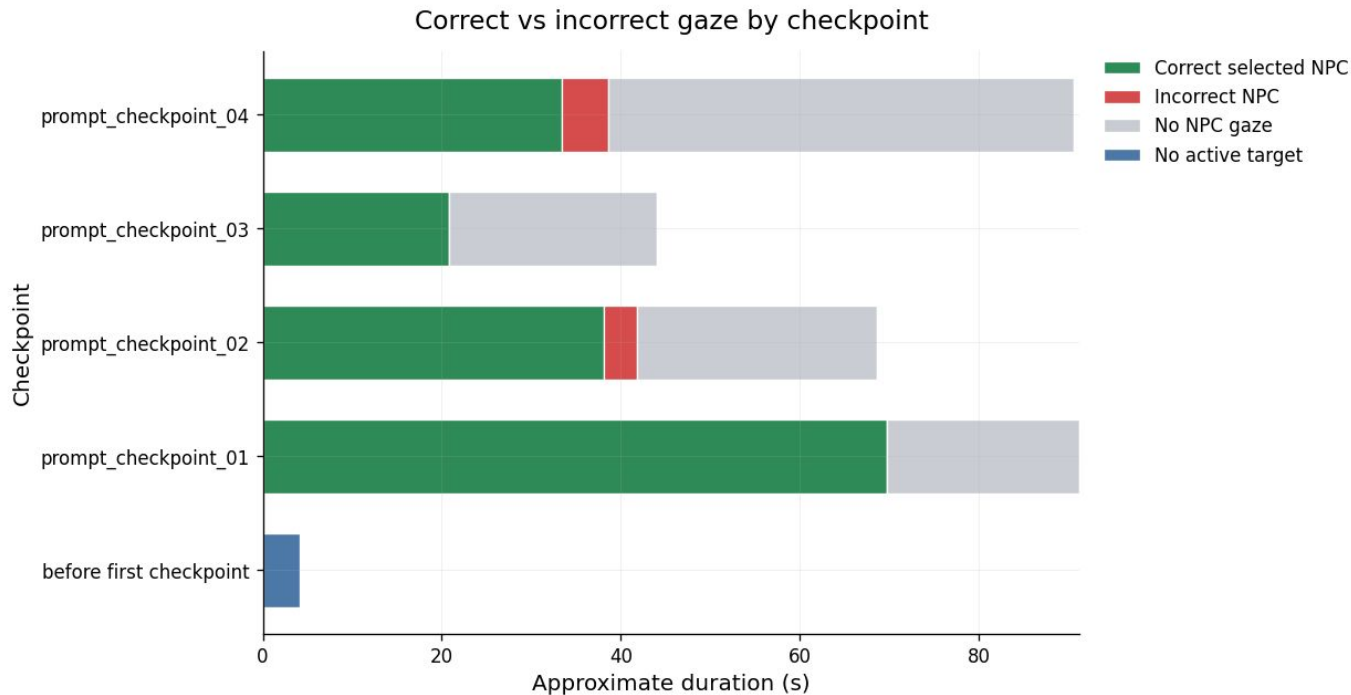


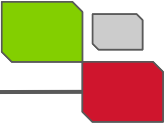
Skills Addressed: Selective & Social Attention, Instruction
Following, Spatial navigation

Framework in Action: Prototype Experiences



Behavioral Data

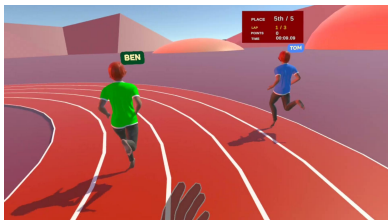




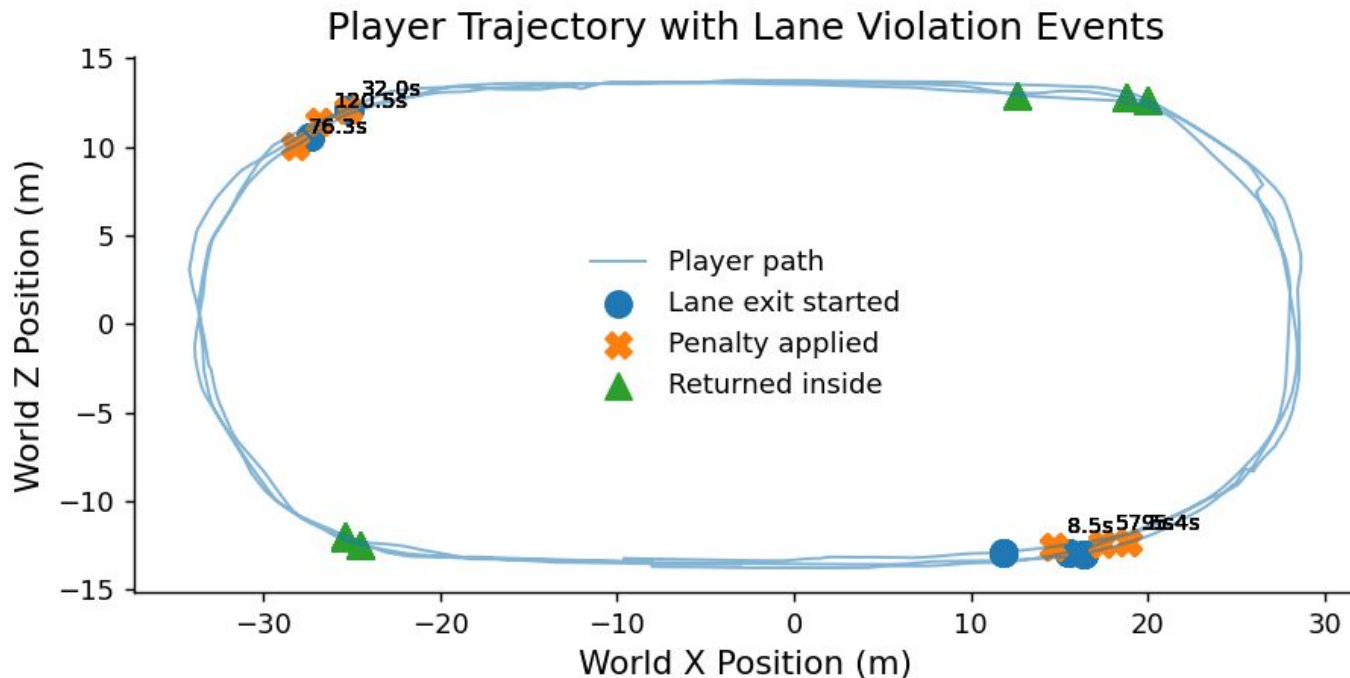
3) Adaptive Running VR Track



Skills Addressed: Sustained attention, Pacing & Motor Regulation, Movement Precision



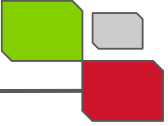
Behavioral Data



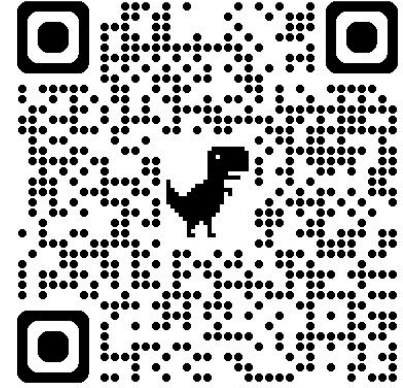
From Measurable Behavior to Personalized Support

Future Directions

- **Expand the library** of skill-targeted embodied XR experiences
- Introduce controlled difficulty and adaptive task variations
- Collect **longitudinal** movement, attention, speech, and **performance data**
- Evaluate individual behavioral patterns across repeated sessions
- Develop **clinically grounded, context-aware AI**-powered NPCs with fine-tuning



Any Questions?



Scan for more details
about the Embodied
XR project!