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Mixed Reality HS2025

NeuroReach VR

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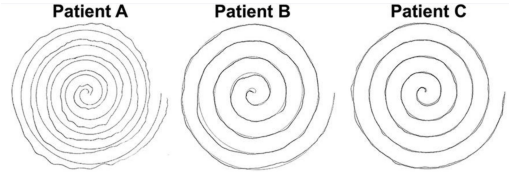
Project Framework

- **Goal** : To build NeuroReach VR, a proof-of-concept mixed-reality system that uses a gamified balloon-popping exercise and a path tracing task, with the aim of improving selective muscle activation in the arms for Parkinson's patients.
- **Tools used:** Meta Quest 3S and Logitech MX Ink , developed in Unity (C#) for Android
- **Key Deliverables:**
  - Develop a reach-and-grasp **balloon pop exercise**
    - Improves daily living movements through engaging goal-oriented practice
  - Design a **path (and spiral) tracing** task.
    - Enhances fine motor control by using real-time feedback to refine precision
  - Integrate **adaptive difficulty** with multimodal sensory feedback.
    - Optimizes learning with personalized challenges and enriched sensory cues
  - Create a tool to **log** and **analyze** performance data.
    - Enables objective tracking of user progress and disease progression over time



Current Progress

- **Strategy :**
  - Our initial development has focused on building and validating the project's technical foundation.
  - We have successfully implemented a vertical slice that
    - Integrates all core hardware and software
    - Creating a stable platform for the rapid development of our rehabilitation tasks

- **Validated Integrations:**
  - **Establish Pipeline:** Successfully setting up pipeline to deploy a Unity build on the Quest 3 ✓
  - **Passthrough Environment:** Successfully merged user real-world space with interactive virtual content ✓
  - **Spatial Anchors:** Pinning virtual objects to the real world ✓
  - **MX Ink Integration:** Real-time tracking of the stylus input ✓

Blockers & Solutions

- **Challenge 1:** Development is slowed by limited Windows access and Unity VCS user limits
  - **Solution:** We are migrating to GitHub with Git LFS to remove collaborator limits and have also requested a new machine from the supervisors. Currently we have divided the work into independent tasks integrated at regular intervals to minimize dependency on hardware.

- **Challenge 2:** Integrating haptic feedback is complex as the necessary API functions are extensively distributed across multiple documentation sources.
  - **Solution:** We are exploring the systematic mapping of API functions to specific haptic outputs through targeted technical experiment runs. We also plan to maintain a parallel build not fully dependent on haptics as a fallback to ensure the project execution is not delayed.

- **Challenge 3:** The user interface must be highly accessible for individuals with motor and cognitive impairments
  - **Solution:** We are prototyping with frequent testing to refine the user experience. This focuses on an intuitive menu along with clear controls and feedback, using high-contrast assets and consulting standard accessibility guidelines for maximum clarity.

Development Roadmap**

- **Work Package 2: VR Tasks and Multimodal Feedback (Weeks 1-3)**
  - **Focus:** Build core exercises with an integrated multimodal feedback system.
  - **Key Tasks:**
    - Implement a virtual reality balloon pop task with robust hand tracking.
    - Develop a high-precision stylus tracing task with real-time accuracy feedback.
- **Work Package 3: Adaptive Controller & Logging (Weeks 3-5)**
  - **Focus:** Implement an adaptive difficulty controller and well-detailed performance data logging.
  - **Key Tasks:**
    - Create a rule-based system to dynamically adjust task difficulty.
    - Implement a reliable logging system to capture kinematic and performance data.
- **Work Package 4: Pilot Study & Analysis (Weeks 5-8)**
  - **Focus:** Evaluate the system's usability and performance with a pilot study involving 5-10 participants.
  - **Key Tasks:**
    - Finalize the study protocol with guiding metrics and recruit participants for evaluation.
    - Analyze performance data and user feedback to validate the prototype as a proof-of-concept.

***This timeline represents our current estimate and is subject to change based on development progress and emerging priorities. Our strategy is to begin user studies as soon as a stable, testable prototype is ready, allowing us to dedicate the latter half of the project to iterative feedback and refinement.*

Strategic Outlook

- **End of Semester Goals:**
  - **Proof-of-Concept**: Deliver a functional prototype integrating the adaptive balloon pop and path tracing tasks.
  - **Pilot Study**: Complete a study with 5-10 participants to gather initial data on usability and performance.
  - **Analysis**: Provide a comprehensive report and final demonstration analyzing the study's findings.

- **Discussion Points:**
  - **Clinical Utility**: How can the results dashboard be designed to be most useful for both patients and therapists?
  - **Engagement**: What specific gamification elements will best maximize long-term user motivation and adherence?
  - **Project Feasibility**: Does the current roadmap seem effective, and are there any suggestions going ahead?

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Any Questions?

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THANK YOU!

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