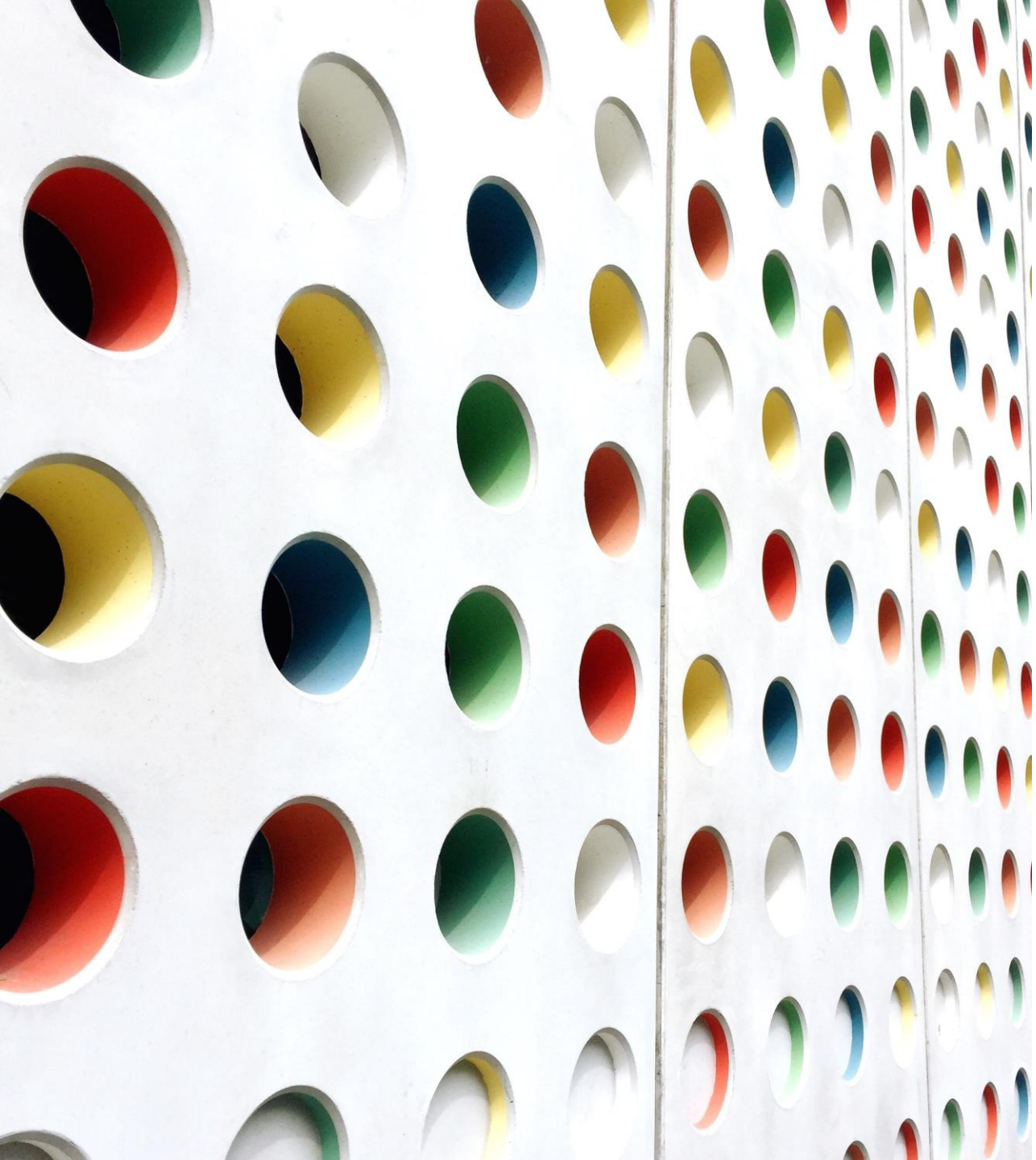


ANHIVR: An Adaptive Neuro-Haptic Interface for Virtual Reality

A PRESENTATION BY GOTAM SAI VARSHITH (22BCE1605)

The Challenge: Immersion vs. Precision

Immersion (Hand-Tracking):

- ✅ Highly natural and intuitive.
- ❌ Often imprecise, leading to errors and user frustration.

Precision (Controllers):

- ✅ Reliable, accurate, and provides haptic feedback.
- ❌ Breaks the sense of presence by introducing a physical tool.

A Window into the User's Mind 🧠

Key Finding:

- Research shows that user frustration, or cognitive conflict, can be objectively measured using a non-invasive EEG headset.

The Signal:

- This is detected via the Feedback-Related Negativity (FRN), a specific brainwave that appears milliseconds after we recognize an error.

The Opportunity:

- If we can detect when a user is struggling, we can build a system that intelligently steps in to help.

The Adaptive Neuro-Haptic Interface for VR

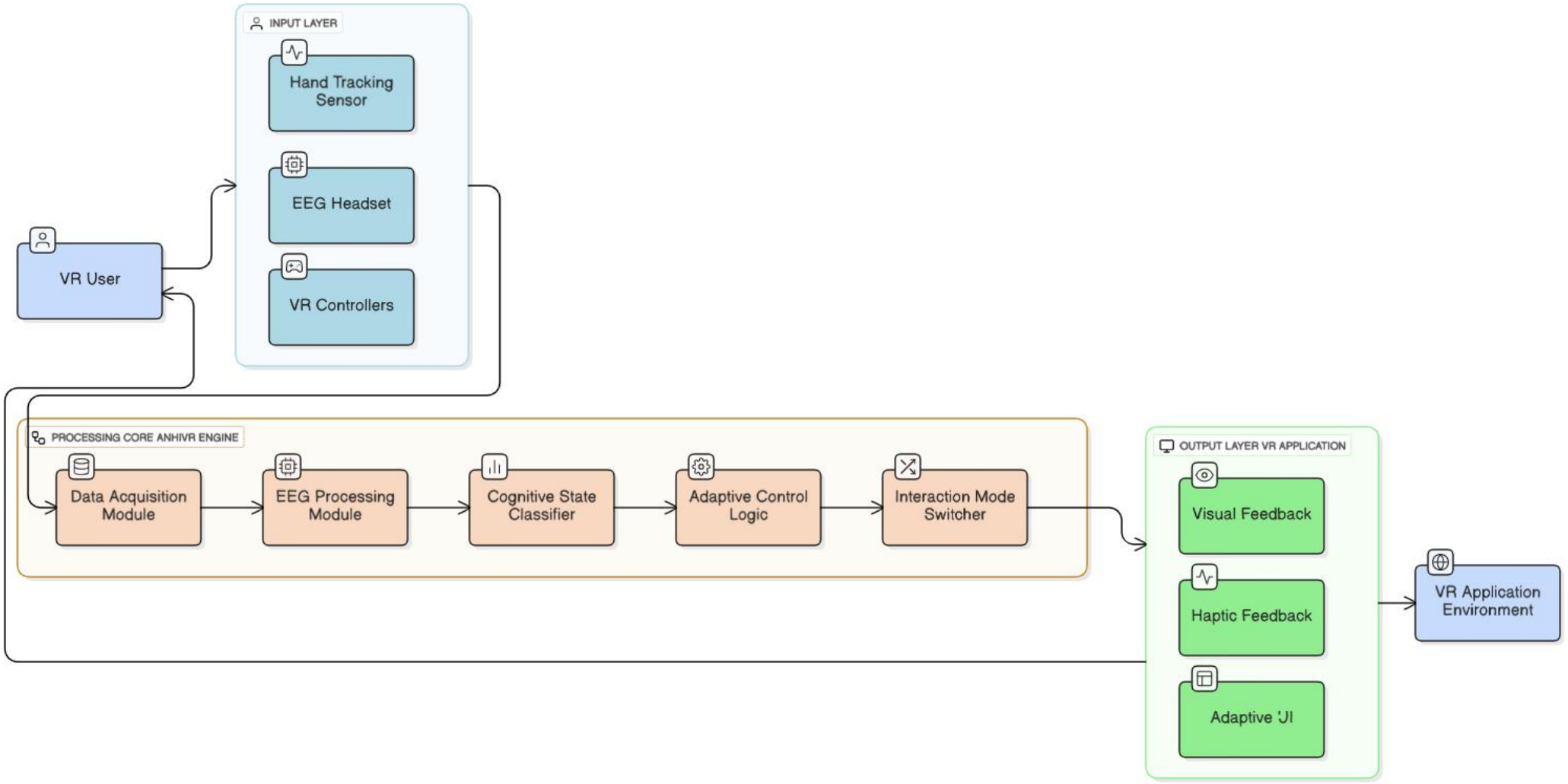
Core Idea:

- A smart, closed-loop system that monitors the user's cognitive state and adapts the interaction mode to match their needs.

How it Works:

- **Default Mode:** User interacts naturally with hand-tracking for maximum immersion.
- **Struggle Detected:** The system's EEG sensors detect FRN signals, indicating frustration.
- **Adaptive Switch:** The interface seamlessly transitions to a controller-assisted mode, providing the precision needed to overcome the challenge.
- **Revert:** Once the task is done and frustration subsides, it switches back to hand-tracking.

How the ANHIVR System Works



How the ANHIVR System Works

Simple Flow:

- **Input:** Sensors (Hand Tracker, EEG, Controllers) gather data.
- **Processing:** The ANHIVR Engine processes the EEG data, classifies the user's cognitive state, and decides whether to switch modes.
- **Output:** The VR application's UI and interaction mode are updated.

How Will We Know If It Works? 🧪

Methodology: A within-subject user study where participants perform a complex task (e.g., virtual engine assembly) under three different conditions.

The Three Conditions:

- Controller-Only (Baseline for Precision)
- Hand-Tracking-Only (Baseline for Immersion)
- Adaptive ANHIVR (The Proposed System)

Metrics for Success:

- **Objective:** Task completion time, number of errors.
- **Subjective:** User-rated usability (SUS), cognitive load (NASA-TLX), and immersion.

The Best of Both Worlds

Hypothesis: The ANHIVR system will outperform the baseline conditions by combining their strengths.

Condition	Error Rate (Lower is Better)	Immersion Score (Higher is Better)	Usability Score (Higher is Better)
Controller-Only	🟦 Low	🟧 Medium	🟩 Medium
Hand-Tracking-Only	🟦 High	🟧 High	🟩 Low
Adaptive (ANHIVR)	🟦 Low	🟧 High	🟩 High

Error Rate: ANHIVR should be low, similar to Controllers.

Usability Score: ANHIVR should be high.

Immersion Score: ANHIVR should be high, similar to Hand-Tracking.

Conclusion and Next Steps

Contribution:

ANHIVR presents a novel, bio-adaptive approach to HCI in VR, creating interfaces that respond to a user's internal cognitive state.

Future Work:

- Integrate other biosensors (e.g., heart rate, eye-tracking) for a more robust picture of user state.
- Use machine learning to create personalized profiles that adapt to individual user's brain patterns.
- Apply this adaptive concept to other areas like training, accessibility, and rehabilitation.


Thank You