VIRTUAL REALITY (VR)

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Course Name: Human Computer Interaction

Course Code: BCSE415L

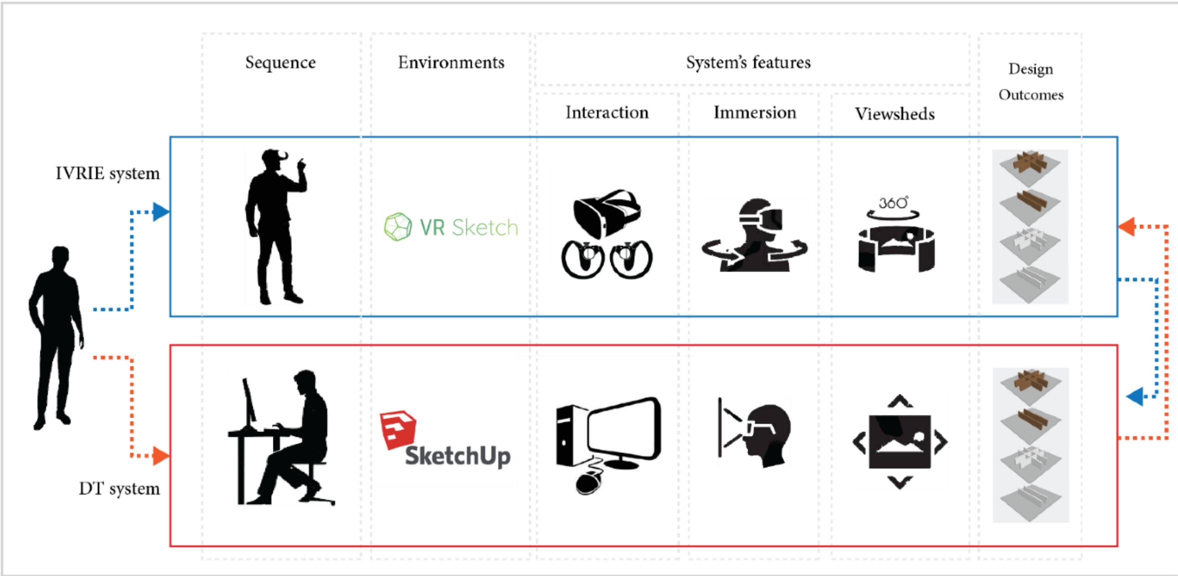
Slot: C1 + TC1

🔍 Topic: Literature Survey on Virtual Reality (VR)

📄 1. Immersion Metrics for Virtual Reality

Authors: Matias N. Selzer & Silvia M. Castro
Source: arXiv (2022)

- **Algorithms Used**:
  Multivariate regression modelling to compute immersion scores based on system hardware and software variables.
- **Methodology**:
  Experimental approach collecting data from diverse VR setups; regression analysis to find immersion predictors.
- **Performance Metrics**:
  Regression model accuracy (R^2), variable contribution weights, and validation error.



Abstract (10 lines):

- This paper proposes a set of immersion metrics grounded in both hardware (e.g., display resolution, FOV, tracking quality) and software (e.g., rendering frame rate, interactivity latency).
- The authors conducted controlled experiments across diverse VR configurations. Statistical regression identified relationships between system variables and immersion scores.
- Key predictors were high FOV, low latency, and natural input fidelity.
- The immersion model achieved high explanatory power ($R^2 > 0.8$).
- The methodology supports generalization to new VR setups.
- These metrics facilitate comparison across systems and help designers optimize immersion. From an HCI perspective, the work enables evaluation of interface changes on immersion.
- It aligns with proposed project goals of optimizing HCI design for enhanced user experience.

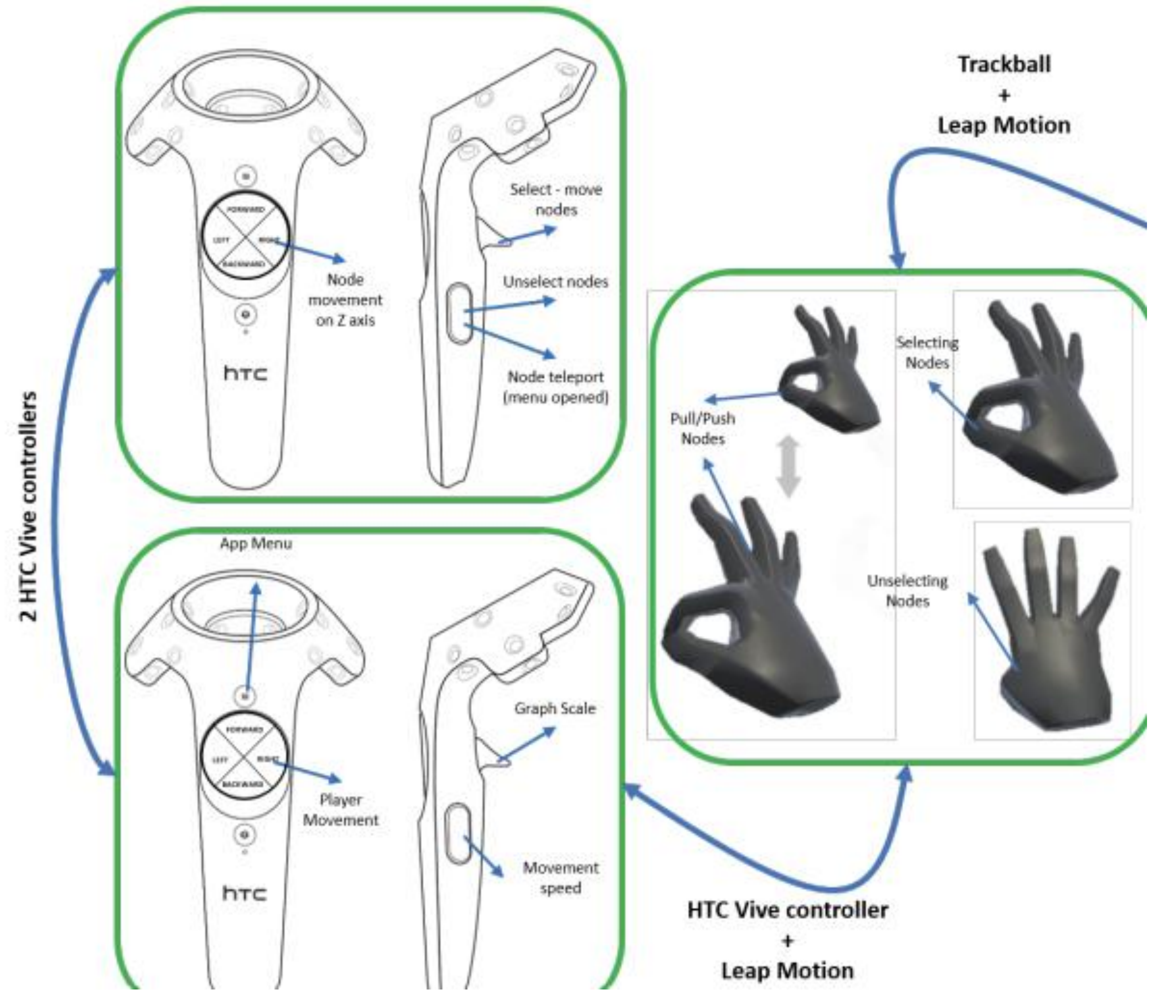
2. Evaluation of Virtual Reality Interaction Techniques: The Case of 3D Graph

Authors: Nicola Capece et al.
Source: arXiv (2023)

- **Algorithms Used**:
  Gesture recognition, 6-DOF controller processing.

- **Methodology**:
  Within-subject user study comparing hand gestures vs. controllers in HMD and spherical display setups.

- **Performance Metrics**:
  Immersion level, ease of use, usefulness, behavioral intention (via Likert scale).



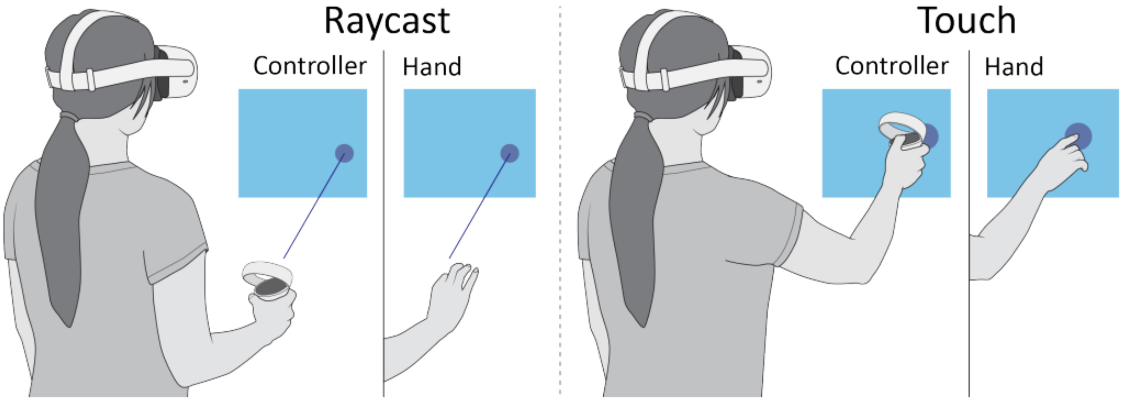
Abstract (10 lines):

- This study compares VR interaction modes—traditional controllers vs. hand-tracking gestures—across two display environments (HMD and spherical displays) using a 3D graph exploration task.
- Twenty users performed navigation and object manipulation tasks using each technique. Subjective measures were collected through questionnaires assessing immersion, ease, usefulness, and intention to use.
- The experiment revealed that hand-tracking offered higher realism and perceived naturalness, especially in spherical setups.
- Ease-of-use favoured controllers, although not significantly.
- Users indicated stronger behavioural intention with gestures.
- The findings highlight trade-offs between efficiency and immersive Ness.
- This comparison clarifies how interaction mode shapes HCI experience.
- The results inform design decisions in immersive VR interface development.

3. A Comparative Study of Interaction Time and Usability of Using Controllers and Hand Tracking in VR Training

Authors: Chaowanan Khundam et al.
Source: MDPI Informatics (2020)

- **Algorithms Used**:
  Hand-tracking gesture recognition vs. controller input mapping.
- **Methodology**:
  Quasi-experimental study involving 48 medical trainees using VR controllers and hand tracking for intubation training.
- **Performance Metrics**:
  Task time, System Usability Scale (SUS), USEQ (usefulness, ease of use, learning, satisfaction).



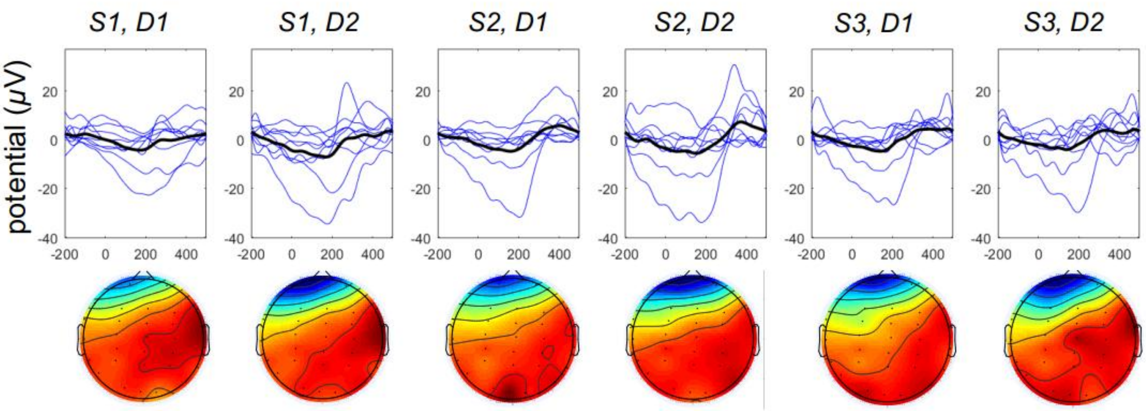
Abstract (10 lines):

- Focusing on VR medical training, participants completed tasks using either handheld controllers or bare-hand gestures.
- Objective interaction times were logged for each task procedure.
- Subjective questionnaires—SUS and USEQ—captured usability, satisfaction, and intuitive use.
- Statistical tests showed no significant difference in task completion time or usability scores between input modes.
- Many users preferred controllers for reliability, but hand-tracking scored higher on perceived realism.
- Interviews revealed gestures made the experience more authentic but sometimes suffered from tracking errors.
- Authors recommend hand input for skill-based training, pending hardware refinement.
- This informs HCI research around balancing realism and performance in VR training interfaces.

4. Measuring Cognitive Conflict in VR with Feedback-Related Negativity (FRN)

Authors: Avinash Kumar Singh et al.
Source: arXiv / HCI Conference (2017)

- **Algorithms Used**:
  EEG signal processing; Feedback-Related Negativity (FRN) extraction.
- **Methodology**:
  Two-phase study with EEG sensors and tracked-hand object selection, using variable selection radii to trigger conflict.
- **Performance Metrics**:
  FRN amplitude, error rate, user response time, subjective user comfort.



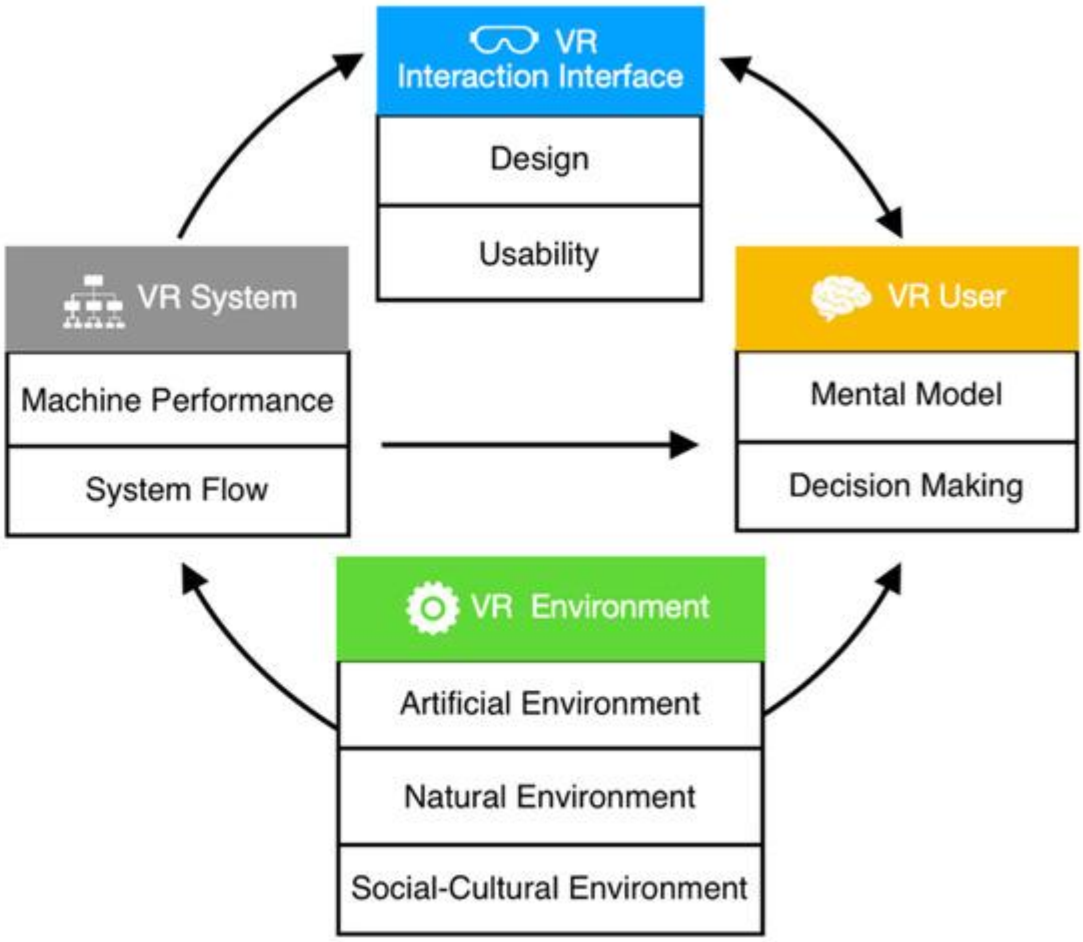
Abstract (10 lines):

- This paper introduces an EEG-based framework to quantify cognitive conflict during VR tasks by measuring feedback-related negativity.
- Participants performed 3D object selection using hand tracking in VR; the selection radius was varied to induce mis-selections.
- Behavioural data (error rates, reaction times) were collected alongside EEG recordings.
- The analysis showed that FRN amplitude increased with selection difficulty and errors, confirming sensitivity to cognitive conflict.
- Virtual hand realism also modulated FRN responses, linking to the uncanny valley.
- The framework supports designers in evaluating interface-induced cognitive load.
- From an HCI standpoint, it highlights the value of neurophysiological metrics in assessing immersive interaction techniques.

5. A Survey on the Design of Virtual Reality Interaction Interfaces

Authors: Meng-Xi Chen et al.
Source: MDPI Sensors (2024)

- **Algorithms Used**:
  Not applicable (systematic literature review using qualitative analysis).
- **Methodology**:
  Review of 438 papers from 2011–2023, categorized into interaction types and evaluation methods.
- **Performance Metrics**:
  Task completion time, usability scores, error rates, subjective experience scores.



Abstract (10 lines):

- This comprehensive review examines interaction interface design in VR from 2011 to 2023.
- It categorizes interaction tasks such as navigation, pathfinding, and system control, and analyses empirical studies across these domains.
- Objective and subjective performance measures—including task time, errors, SUS, user satisfaction, and immersion—are synthesized.
- The survey highlights that menu-based UI, overview maps, and tactile gestures improve usability for navigation and control tasks.
- Major gaps include lack of multi-sensory interface research and limited participant diversity. The review identifies the absence of unified evaluation standards.
- It provides design guidelines and future research directions.
- The findings anchor your project's literature foundation and help justify chosen methodology.

📚 References

- Selzer, M. N., & Castro, S. M. (2022). *Immersion Metrics for Virtual Reality*. arXiv:2206.07748.

- Capece, N., et al. (2023). *Evaluation of VR Interaction Techniques: The Case of 3D Graph*. arXiv:2302.05660.

- Khundam, C., et al. (2020). *A Comparative Study of Interaction Time and Usability...*. Informatics, 8(60), MDPI.

- Singh, A. K., et al. (2017). *Measuring Cognitive Conflict in VR with FRN*. arXiv:1703.05462.

- Chen, M.-X., et al. (2024). *A Survey on the Design of VR Interaction Interfaces*. Sensors, 24(6204).