BI/D/TY

Reg. No:

Final Assessment Test – April 2025

VIT
Vellore Institute of Technology

Course: CSI4005 - Augmented Reality and Virtual Reality

Class NBR(s): 2145/2149/2154 Slot: D1+TD1

Time: Three Hours Max. Marks: 100

- ➢ KEEPING MOBILE PHONE/ANY ELECTRONIC GADGETS, EVEN IN 'OFF' POSITION IS TREATED AS EXAM MALPRACTICE
- ➢ DON'T WRITE ANYTHING ON THE QUESTION PAPER

Answer ALL Questions

(10 X 10 = 100 Marks)

1.a) Explain underlying principles of computer vision, artificial intelligence, and spatial computing converge to enable real-time augmented reality experiences, and what are the key technological advancements driving the evolution of AR systems?

OR

1.b) Describe varying levels of immersion in virtual reality—ranging from non-immersive to fully immersive systems—affect user interaction, perception, and engagement across diverse industries, and what are the key technological and experiential factors driving their adoption in fields such as healthcare, education, and entertainment?

2. Analyze the fundamental principles of augmented reality, including spatial computing, real-time sensor fusion, and computer vision, facilitate seamless interaction between digital overlays and physical environments, and what technological advancements are driving the evolution of this dynamic integration?

3. Compare Simultaneous Localization and Mapping (SLAM) integrated real-time spatial tracking, depth sensing, and environmental reconstruction to enhance the accuracy and stability of AR experiences, and what are the key challenges in optimizing SLAM for dynamic, large-scale, and occlusion-heavy environments?

4. Illustrate the process human brain and interpret virtual environments, and what are the underlying neurological, psychological, and physiological mechanisms that contribute to immersion, presence, and potential cognitive or sensory distortions in VR experiences?

5. Support the relation between the QR code, distance from camera, and the image formed in the camera using pinhole camera model, consider 'f' and 'ps' as focal length, and pixel size, respectively. Furthermore, using the same principle, solve the following problem. The marker has a known side length of 10cm. When the marker is detected, the system calculates the position of the marker in the camera's field of view.

The camera has the following properties:

i. The focal length is 90 pixels.
ii. The pixel size is 0.02 cm per pixel.

When the marker is detected, its image on the camera sensor has a side length of 150 pixels. Calculate the distance D from the camera to the marker.

*In both cases, for simplicity, consider the image does not undergo any perspective distortion.

6. Solve the following problems:

i. Problem 1: A 3D point P(4, 5, -6) needs to be clipped against a viewing frustum defined by the following perspective projection volume:

$$-3 \le x \le 3,\ -3 \le y \le 3,\ -5 \le z \le -1$$

Determine whether the point P(4,5,-6) is inside or outside the clipping boundaries and explain the decision process.

ii. Problem 2: A 3D line segment is defined by endpoints A(4, 2, -3) and B(-2, 5, -6). Given the same viewing frustum as before, determine whether the line segment is visible, partially visible, or completely clipped.

7. Apply 3D transformations on the given points as instructed below:

i. A point P(2, 3, 5) is translated by Tx = 4, Ty = -2, Tz = 3. Find the new coordinates of the transformed point.

ii. A point P(1, 2, 3) is scaled by Sx = 2, Sy = 3, Sz = 0.5. Find the new coordinates after scaling.

iii. A point P(4, 4, 2) is rotated 90° counterclockwise about the Z-axis. Find the new coordinates.

iv. A point P(3, -2, 4) is reflected in the XY-plane. Find the new coordinates.

v. A point P(2, 3, 4) is transformed using the shear parameters Shx = 1.5, Shy = 2 in the Z-direction. Find the new coordinates.

8. Evaluate how modern real time systems (such as autonomous vehicles, robotic motion planning, and game physics engines) implement the following:-

i. Advance collision detection techniques like Continuous Collision Detection (CCD).

ii. Spatial partitioning (like BVH, KD-Trees).

iii. And impulse based physics.

To ensure accurate and efficient object interactions.

9. Examine how skeletal animation in VR leverage inverse kinematics (IK), physics-based motion blending, and real-time motion capture to achieve realistic character movement and interaction? Additionally, how do modern VR systems address challenges such as motion retargeting, self-intersection avoidance, and dynamic adaptation to user-driven inputs while maintaining computational efficiency and immersion?

10.a) Justify do augmented reality (AR) systems navigate the ethical and privacy challenges associated with real-time data collection, biometric tracking, and persistent real-world surveillance? Additionally, what measures can be implemented to mitigate risks related to unauthorized data harvesting, user consent, and algorithmic biases, while ensuring transparency, security, and ethical compliance in AR applications?

OR

10.b) Criticise how will virtual reality (VR) shape the future of the metaverse and digital presence by enabling immersive social interactions, decentralized economies, and AI-driven virtual environments? Furthermore, what technological advancements in haptic feedback, brain-computer interfaces (BCIs), and real-time photorealistic rendering are necessary to overcome current limitations, ensuring a seamless integration of VR into the broader metaverse ecosystem while addressing concerns related to identity, accessibility, and digital ethics?

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