DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY PATNA

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CSXX2012*:* **Augmented Reality/Virtual Reality** **L-T-P-Cr: 3-0-0-3**

Pre-requisites: Fundamental knowledge of Computer Graphics, Visual Perception from a Computer Graphics Perspective

Course Objectives.

1. Historical and modern overviews and perspectives on virtual reality and augmented reality.
2. Fundamentals of sensation, perception, and perceptual training.
3. The scientific, technical, and engineering aspects of virtual reality and augmented reality systems.
4. Evaluation of virtual reality and augmented reality from the lens of design.

Course Outcomes – After completing this course, students should be able to:

CO-1. *Recall* theories of geometric primitives drawing algorithms in the computer-graphics systems and implementing tools.

CO-2. *Express* elementary concepts of 2D transformation and 2D viewing and clipping approaches of the computer graphics, also explaining advanced concepts and related solutions to render complex images in the geometry of Virtual Reality systems.

CO-3. *Identify*, *examine*, and *develop* software that reflects fundamental techniques for the design and deployment of VR experiences and describe how VR/AR systems work.

CO-4. *Evaluate* the benefits of particular designs for VR/AR experiences and the drawbacks of specific VR/AR techniques on the human body.

CO-5. *Identify* and *examine* state-of-the-art VR/AR design problems and solutions from the industry and academic applications.

CO-6. *Design and determine* the simulated VR/AR environments for understanding the problems in the VR/AR projects.

Course Outcomes–Cognitive Levels–Program Outcomes Matrix –

[H: High relation (3); M: Moderate relation (2); L: Low relation (1)]

Course Outcomes	Program Outcomes											
	PO-1 (Engineering knowledge)	PO-2 (Problem analysis)	PO-3 Design/development of solutions)	PO-4 (Conduct investigations of complex problems)	PO-5 (Modern tool usage)	PO-6 (The engineer and society)	PO-7 (Environment and sustainability)	PO-8 (Ethics)	PO-9 Individual and team work)	PO-10 Communication)	PO-11 (Project management and finance)	PO-12 Life-long learning
CO-1	3	3	3	3	3	3			3	3	1	3
CO-2	3	3	3	3	3	3		1	3	3	1	3
CO-3	3	3	3	3	3	3			3	3	1	3
CO-4	3	3	3	3	3	2			3	3	1	3
CO-5	3	3	3	3	3	3	2	1	3	3	1	3
CO-6	3	3	3	3	3	1	1	1	3	3	2	2

Learning Outcomes.

Sl. No.	Outcome	Mapping to POs
1	Identify, examine, and develop software that reflects fundamental techniques for the design and deployment of VR experiences.	PO1, PO3
2	Describe how VR systems work.	PO1, PO3
3	Choose, develop, explain, and defend the use of particular designs for VR experiences.	PO1, PO4- PO7, PO12
4	Evaluate the benefits and drawbacks of specific VR techniques on the human body.	PO4, PO5
5	Identify and examine state-of-the-art VR design problems and solutions from the industry and academia.	PO3, PO4-PO7, PO12

Module I: Introduction- Course mechanics, Goals and VR definitions; Historical perspective; Birds-eye view (general); Birds-eye view (general); Birds-eye view (hardware); Birds-eye view (software); Birds-eye view (sensation and perception) **Lectures: 5**

Module II: Geometry of Virtual Worlds- Geometric modeling, Transforming models, Matrix algebra and 2D rotations, 3D rotations and yaw, pitch, and roll; 3D rotations and yaw, pitch, and roll; Axis-angle representations; Quaternions; Converting and multiplying rotations, Converting and multiplying rotations; Homogeneous transforms; The chain of viewing transforms; Eye transforms; Eye transforms; Canonical view transform; Viewport transform; Viewport transform **Lectures: 6**

Module III: Visual Physiology and Perception- Three interpretations of light; Refraction; Simple lenses; Diopters; Imaging properties of lenses; Lens aberrations; Optical system of eyes, Photoreceptors; Sufficient resolution for VR; Light intensity; Eye movements; Eye movements; Eye movement issues for VR; Neuroscience of vision, Perception, Depth perception; Depth perception; Motion perception; Frame rates and displays.
Lectures: 6

Module IV: Tracking Systems Overview; Orientation tracking; Tilt drift correction; Yaw drift correction; Tracking with a camera; Perspective n-point problem; Filtering; Lighthouse approach **Lectures: 5**

Module V: Visual Rendering Visual Rendering-Overview; Shading models; Rasterization; Pixel shading; VR-specific problems; Distortion shading; Post-rendering image warp **Lectures: 5**

Module VI: Audio Physics and physiology; Auditory perception; Auditory localization; Rendering; Spatialization and display; Combining other senses **Lectures: 4**

Module VII: Augmented Reality and Interfaces
Introduction to Augmented Reality (AR), Unity and unreal engine, Pose estimation, Pose tracking in AR, Marker-based Tracking and AR, Marker-less Tracking and AR, Computer Vision for AR - Object Detection and Tracking, Interaction, Modeling, Annotation and Navigation, VR/AR Interface, Social interaction; Evaluation of VR Systems

Lectures: 7

Module VIII: Human Factors & Applications
Human Factors in VR – Methodology and Terminology, VR Health and Safety Issues, VR and Society, Traditional and Emerging VR/AR applications – Education, Arts, Entertainment, Military, Manufacturing, Business, Health etc.

Lectures: 4

References

1. Steven M. LaValle, “Virtual Reality”, Cambridge University Press, 2019.
2. Grigore C. Burdea, and Philippe Coiffet, Virtual Reality Technology: Wiley Interscience publication; 2 edition, 2010.
3. George Mather, Foundations of Sensation and Perception: Psychology Press; 2 edition, 2009.
4. Jonathan Linowes, Augmented Reality with Unity AR Foundation: A practical guide to cross-platform AR development with Unity 2020.
5. Peter Shirley, Michael Ashikhmin, and Steve Marschner, Fundamentals of Computer Graphics, A K Peters/CRC Press; 3 edition, 2009.