LAKIREDDY BALI REDDY COLLEGE OF ENGINEERING

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DEPARTMENT OF MECHANICAL ENGINEERING

Colloquium meeting : 01	**Venue of meeting** : Online
Date : 07.08.2026	**Time** : 12.05 PM
Name of the speaker : Dr.A.Nageswara Rao	**Research Group** : Materials and Manufacturing
Topic selected from : Conference paper	**Title of the topic**: Development of a VR Based Digital Twins for a Drown treat simulation counter UAV Response training

1. Introduction and Motivation

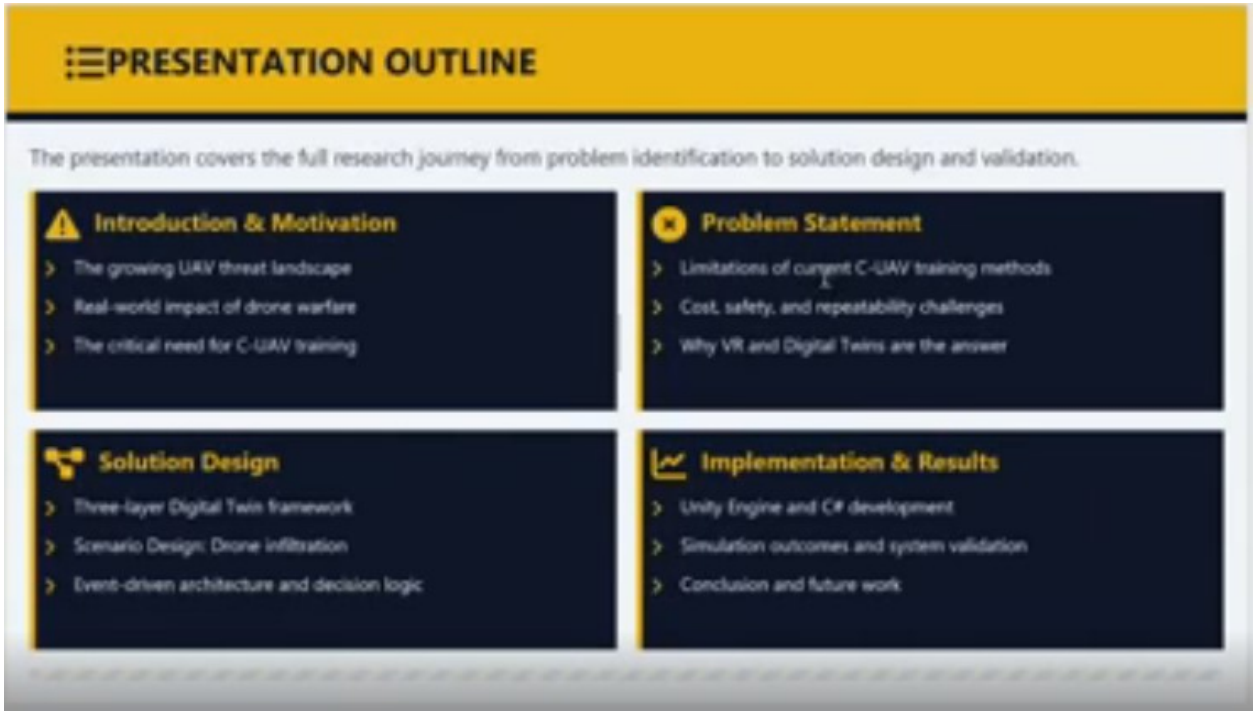
1. INTRODUCTION

Unmanned Aerial Vehicles have developed rapidly from specialized platforms into widely used systems for photography, inspection, agriculture, mapping, logistics, surveillance and emergency response. The accessibility and flexibility of small UAVs also mean that unauthorized drone activity can occur in sensitive or restricted areas. Consequently, organizations responsible for protecting people, facilities and airspace require personnel who can recognize and appropriately respond to simulated UAV threats.

Training for such situations is challenging because realistic live exercises can involve cost, safety constraints, equipment availability, environmental restrictions and limited repeatability. A training environment should allow instructors to create controlled scenarios, repeat them under

comparable conditions and measure trainee performance. Digital Twins and Virtual Reality provide complementary technologies for achieving these goals.

A Digital Twin is a virtual representation of a physical system, process or environment that can maintain information about its state and behaviour. In a training application, the Digital Twin does not need to control a real-world system; instead, it can represent the relevant operational environment and simulate events. VR can then provide an immersive three-dimensional interface through which a trainee observes and interacts with that virtual environment.



2.1 Unmanned Aerial Vehicles

UAVs are aircraft that operate without a human pilot physically onboard. They may be remotely controlled, partially autonomous or capable of following programmed missions. Their characteristics vary substantially in size, endurance, speed, payload and control architecture. For training purposes, a simulation can represent these characteristics at an appropriate level of abstraction without requiring a physical UAV.

2.2 Counter-UAV Systems

Counter-UAV systems are intended to support the detection, identification, tracking and management of unauthorized or potentially hazardous UAV activity. A complete operational system may include sensing, command-and-control, assessment and response functions. In the

proposed seminar framework, these functions are represented at a high level for training and evaluation rather than as a guide for real-world engagement.

2.3 Virtual Reality

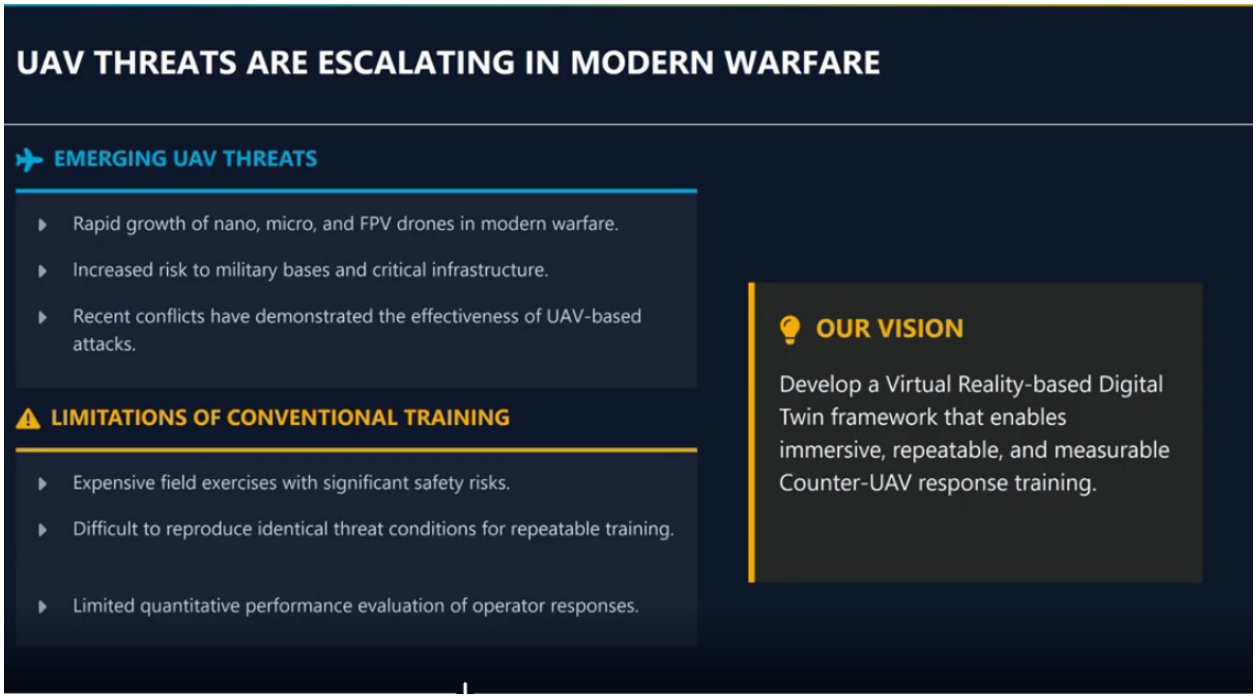
Virtual Reality creates an interactive computer-generated environment that can provide a strong sense of presence. In a training system, VR can reproduce a facility, restricted zone or other representative environment and allow the trainee to observe simulated events from a first-person perspective. This can improve engagement and support experiential learning.

2.4 Digital Twin

A Digital Twin connects a real or conceptual system with a digital representation of its components, states, relationships and behaviours. For simulation-based training, the twin can contain virtual models of the environment, UAVs, sensors, alarms, operators and other relevant entities. The twin can update state variables as the simulation progresses and can generate information for analysis.

3. Objectives

- To study the concepts and applications of VR and Digital Twin technologies in simulation-based training.
- To design a conceptual Digital Twin of a representative environment for drone-threat simulation.
- To develop configurable UAV infiltration and monitoring scenarios for training purposes.
- To provide an immersive VR interface for trainee observation and interaction.
- To implement event-driven simulation and decision-state modelling.
- To establish performance indicators and a validation methodology for the training environment.
- To identify future opportunities for hardware integration, intelligent behaviour modelling and multi-user training.



5. Implementation Approach

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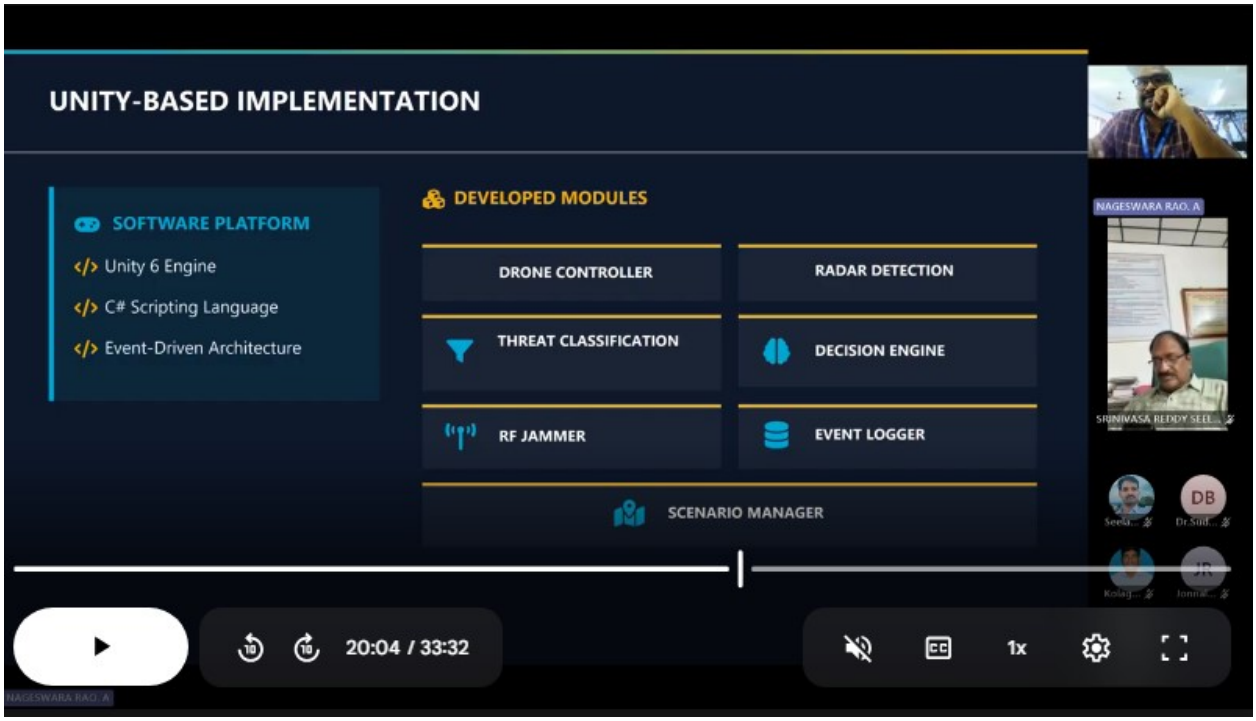

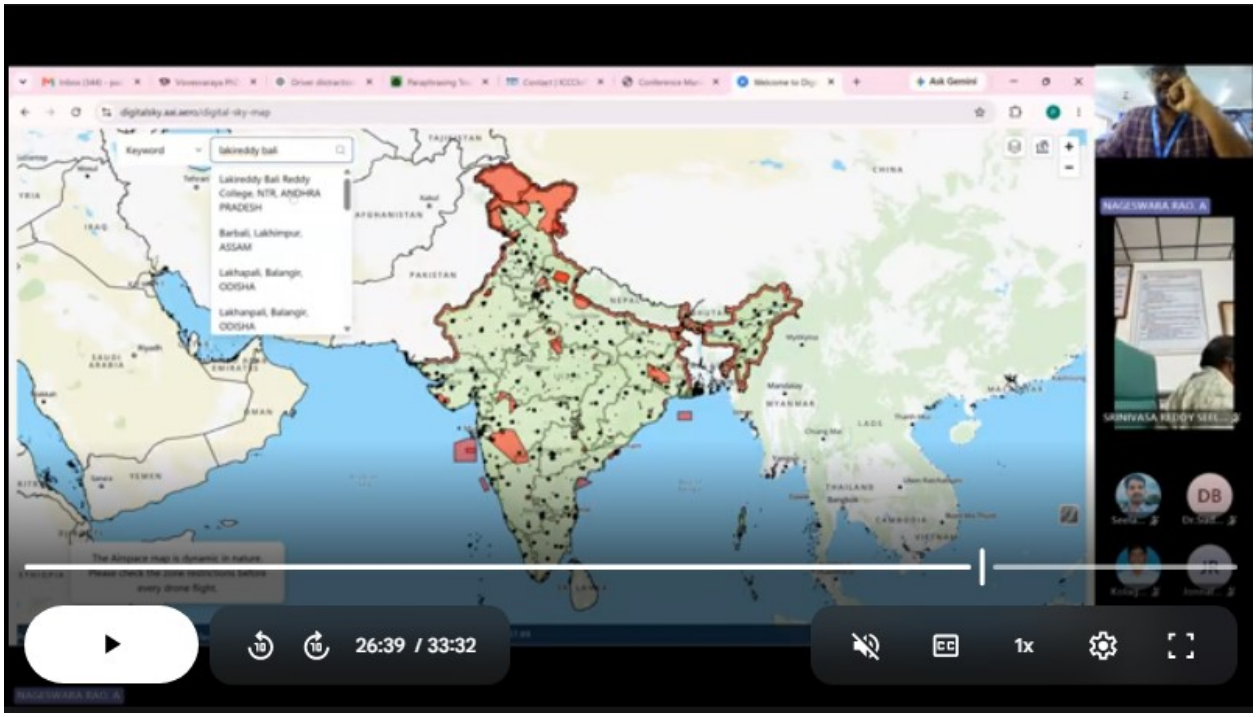

6. PROPOSED VR-BASED DIGITAL TWIN FRAMEWORK

The proposed framework consists of three conceptual layers: the environment and system layer, the Digital Twin and simulation layer, and the VR training and analytics layer. This separation allows physical concepts to be represented independently from the visualization and training interface.

6.1 Environment and System Layer

This layer represents the virtual facility, protected zone, terrain, buildings, UAVs, observation points and other relevant objects. Each object is assigned attributes such as position, status, movement and relationships with other objects. The level of detail is selected according to the training objective.

6.2 Digital Twin and Simulation Layer

The Digital Twin layer maintains virtual states and simulation rules. It controls scenario progression, UAV behaviour, event generation, state transitions and data logging. An event-driven approach is useful because training scenarios are naturally organized around events such as entry into a zone, detection, tracking changes, alerts and completion conditions.

6.3 VR Training and Analytics Layer

The VR layer presents the simulated environment to the trainee. Interaction can include movement, observation, selection of virtual objects and interaction with training interfaces. An analytics module records timestamps, scenario states, user actions and selected performance indicators. The purpose is to support training evaluation rather than to provide instructions for real-world counter-UAV engagement.

Signature of the (Faculty member)	Signature of (Colloquium Coordinator)	Signature of (HOD – ME)