Virtual Worlds

A.A. 2026/27

Dipartimento di Informatica
Università di Pisa

Marco { Di Benedetto }, Ph.D.

Senior Researcher @ CNR-ISTI-AIMH

Areas of Interest:

- Artificial Intelligence
- Computer Graphics
- Computer Vision
- Agentic Systems

Course Page:
https://aimh.isti.cnr.it/marcodibenedetto/virtual-worlds-2026-27/

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Fabio Carrara, Ph.D.

Senior Researcher @ CNR-ISTI-AIMH

Areas of Interest:

- Artificial Intelligence
- Computer Vision
- Multimedia Information Retrieval

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Our Research Laboratory

Artificial Intelligence for Media and Humanities - *AIMH* - https://aimh.isti.cnr.it/

Assessment Methods

Mini-Project …

Work in groups of 2-3 students to develop a Python or JavaScript application. You can choose from an assigned topic or propose your own project (subject to agreement).

… AND Oral Presentation

Present your project orally to demonstrate your work and understanding. This will include questions about your project and general course content

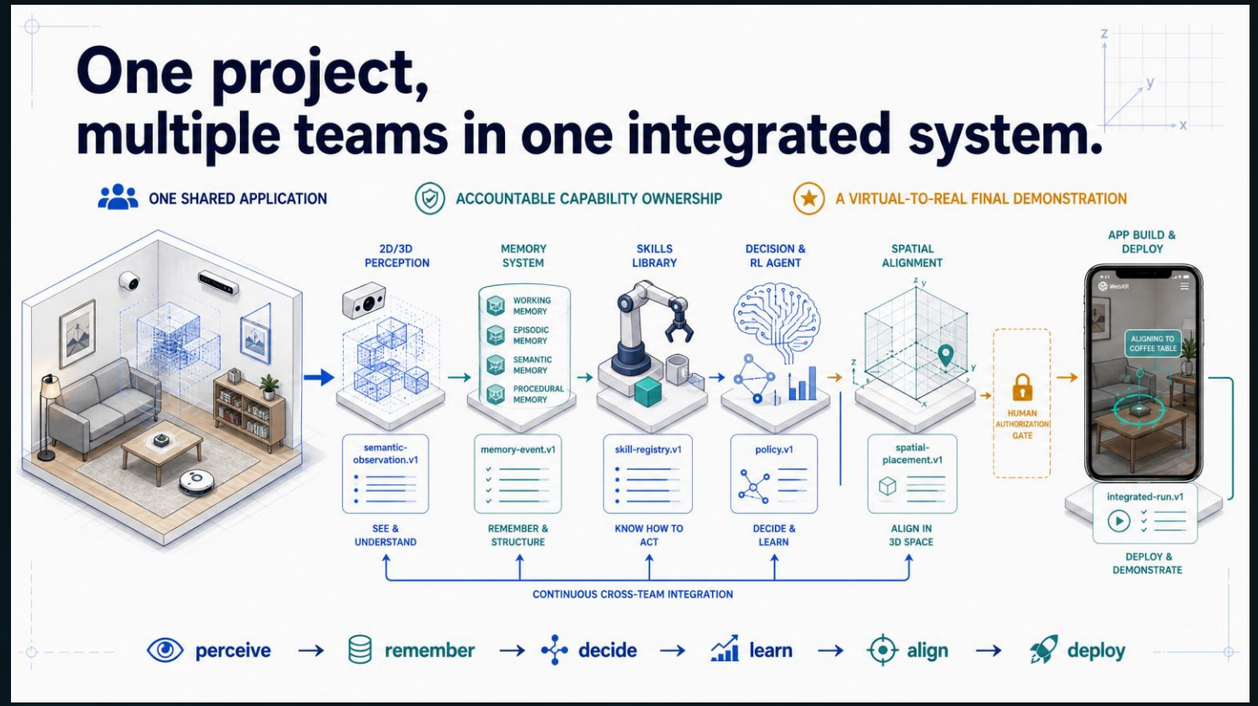
- Proactive commitment for *attending students*
- More detailed oral session for *working students*

Assessment Methods – Course Project

TO BE CONFIRMED

A shared, course-wide project that will partition students into teams, to which a single and independent part of the system will be assigned.

Topics will be related to agentic systems, reinforcement learning, virtual world training, 2d/3D computer vision, XR, app deployment.



Communications

Direct Communication

For quick questions and immediate feedback, reach us directly via **CNR-ISTI** email or after lessons.

Scheduled Reception

For in-depth discussions or specific inquiries, see us after lessons or schedule dedicated reception hours by agreeing on a time via email.

Course Context

The course is divided into two parts, each focusing on different aspects of Virtual Worlds and AI (12 + 12 == 24 lessons of about 2 hours each)

Part 1: Marco Di Benedetto

Virtual Worlds & Reality Fusion

- Digital Content
- Computer Graphics / XR
- Reinforcement Learning
- Agentic Systems

Part 2: Fabio Carrara

AI & Sensing

- 3D Deep Learning
- Human Pose Estimation
- Open-Vocabulary Perception
- Edge AI

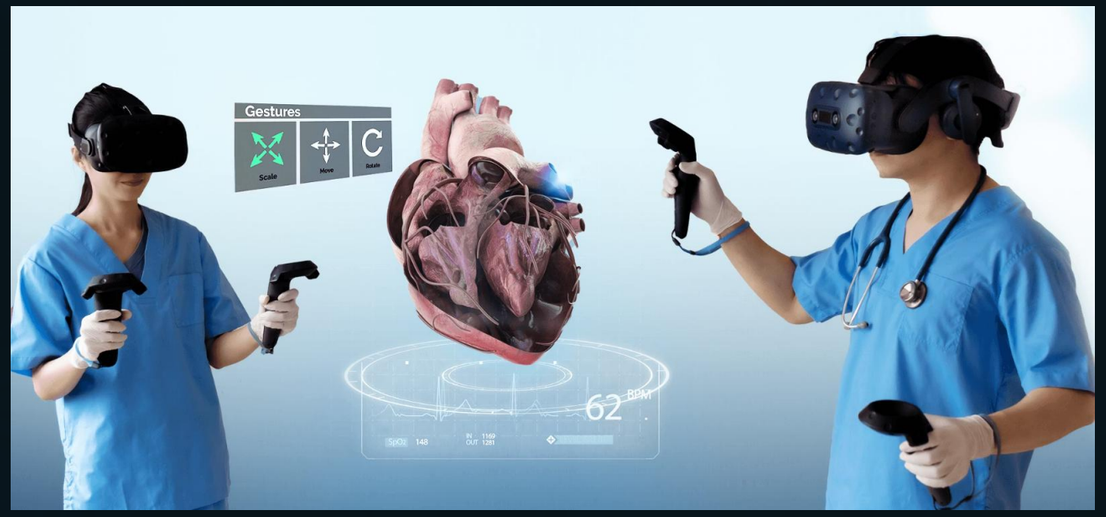
Course Context – Part 1

Virtual Worlds & Reality Fusion

Explore the intersection of virtual worlds and artificial intelligence.

As future leaders in IT and digital health, understanding these technologies is crucial for advancing medical education, training, and patient care.

We'll examine both theoretical foundations and practical implementations.



Learning Objectives - Part 1

1. **Define virtual worlds and their foundational concepts**

   Establishes core virtual world architectures, digital twin theory with 3D digitalization techniques, and synthetic data generation

2. **Computer Graphics fundamentals**

   Covers 3D geometry representations, materials/texturing/rendering principles, and hands-on programming

3. **Extended Reality Technologies**

   Explores the AR/VR/MR continuum for immersive applications, including tracking systems, SLAM algorithms, and registration techniques

4. **Advanced AI Integration**

   Introduces reinforcement learning for virtual modeling

5. **Practical Focus**

   Apply concepts to real scenarios including training, digital twins, PPE detection

6. **Comprehensive Assessment**

   Combines weekly implementation tasks with a final team project integrating digital twins, synthetic data generation, and interactive visualization

Course Context - Part 2

AI & Sensing

Examine how artificial intelligence leverages virtual worlds as both environments and tools.

We will study how AI systems perceive, learn, and act within 3D spaces, and how virtual worlds provide a unique setting for training, evaluating, and deploying these systems.

The focus is on bridging theory and practice to understand the role of AI in shaping the future of interactive and intelligent virtual environments.

Learning Objectives – Part 2

1. Explain the role of AI in understanding and navigating virtual worlds: Connect perception methods to the challenges of complex 3D spaces
2. Compare representations and models for AI in virtual environments: Evaluate how different approaches enable recognition and interaction in synthetic worlds
3. Analyze virtual worlds as platforms for AI development: Examine their use for data generation, training, and simulation
4. Assess deployment challenges at the boundary of real and virtual: Explore domain gaps, adaptation, and efficiency in practical applications

What we expect from you

01
10

Basic-Mid programming skills

In theory and practice (Python, JavaScript, Java, C, C#, C++, ...)

AI/ML foundations

Supervised / Unsupervised, Neural Networks, Clustering, ...

... and a lot of computer scientist curiosity

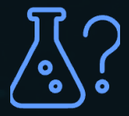
Advices

Seek Clarification

If something is unclear, please ask! We encourage you to reach out for support during your learning process.

Engage with Exercises

Almost every lesson will include small questions or exercises. These are not additional burdens, but integral parts of your active studying.



Integrate Theory and Practice

Do not separate theoretical study from practical application. Trying to do the project without integrating theory will lead to a **bloodbath**!

Questions?