

VIRTUAL REALITY: THEORY AND PRACTICE

SYLLABUS - 2024 WINTER - GIUSEPPE TURINI

INSTRUCTOR INFORMATION

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COURSE INFORMATION

Title: CS-420: “*Virtual Reality: Theory and Practice*”.¹

Desc.: Ph.D. course on the theory and practice of virtual reality applications, focused on the design of VR systems and on the software development of VR apps. These are some of the topics that will be discussed: history of VR, VR technology, game engines, HMDs and CAVEs, stereographics, motion tracking, VR interactions and haptics, VR locomotion, VR comfort and safety. Each course session will be a mix of theory (VR principles) and practice (VR coding examples).¹

Hours: 20 hours in total (split in 5 sessions of 4 hours each).¹

Credits: 5 credits.¹

Room: Aula Riunioni del Dipartimento di Ingegneria dell’Informazione (DII).
Via G. Caruso 16, Pisa - Ground Floor.¹

Web: Online repository on GitHub (github.com/turinig/vrphd).

TEACHING METHOD

This course is organized in 5 lessons of 4 hours each, and 20 hours in total. Each lesson includes 2 parts: part 1 focuses on VR theory, and part 2 focuses on VR development in Unity and C#.

The last lesson will not follow this pattern and instead will include an overview of history and future of VR, followed by a 1-hour exam (on the theoretical material covered in the previous 4 lessons).

All course material (slides, code, assets, etc.) is available on the course repository.

¹ See: phd.dii.unipi.it/en/courses.

COURSE SCHEDULE

These are the lessons included in this course and the details on the topics that will be discussed in class (the actual coverage may vary).

Lesson 1: Intro to VR and VR System Design (Fri 2 Feb 2024, 9:00-13:00).

Part 1: VR terminology, VR fundamentals, modern VR ecosystem, main interface devices, VR system design, real user workspace vs. virtual avatar environment, locomotion/interactions/UI, VR application fields, the 3 illusions, immersion and presence, embodiment, visual/tactile/motor synchrony, effects on attitudes/behaviors/cognition, HMDs, CAVEs, controllers, tracking systems, IMUs, haptic interfaces, and other interface devices.

Part 2: the Unity game engine, the Unity Editor, gameobjects and components and assets, practice with main windows and components.

Lesson 2: Stereo Visualization and HMDs (Thu 8 Feb 2024, 9:00-13:00).

Part 1: stereographics, stereo pairs, depth cues, parallaxes, stereo perspective viewing frustum, and anaglyphs.

Part 2: Unity scripting, script components, the Inspector, event functions, gameobject-component interactions, split-screen stereographics example.

Lesson 3: Virtual Interactions and UIs in VR (Fri 16 Feb 2024, 9:00-13:00).

Part 1: tracking, controllers, gestures, speech, gaze, active/passive interactions, and UI design for VR.

Part 2: UIs in Unity, the Canvas and Rect Transform components, scripting UIs, gaze-based interaction example.

Lesson 4: VR Locomotion, and Evaluation (Fri 23 Feb 2024, 9:00-13:00).

Part 1: locomotion and navigation, real user workspace versus virtual avatar environment, VR interfaces, locomotion, teleportation, presence, navigation, and comfort quantitative/objective vs qualitative/subjective, perceptual training, best practices, comfort, experiments on human subjects.

Part 2: character controllers, first-person controller, controller collisions, teleporting platform example.

Lesson 5: VR History and Future (Fri 1 Mar 2024, 9:00-13:00).

Part 1: augmented reality, mixed reality, AR interfaces, optical-see-through vs video-see-through, computer vision, SLAM, and gestures, smell and taste, brain-machine interfaces, fully-controlled avatars, novel application fields, novel HW interfaces.

Part 2: character controllers, first-person controller, controller collisions, teleporting platform example.

REFERENCES AND SW TOOLS

References.

- S.M. LaValle. “*Virtual Reality.*” Cambridge University Press, 2019. lavalle.pl/vr/.
- R. Doerner et al. “*Virtual and Augmented Reality (VR/AR): Foundations and Methods of Extended Realities (XR).*” Springer, 2022. [ISBN: 3030790622](#).
- J. Linowes. “*Unity Virtual Reality Projects.*” Packt, 2015. [ISBN: 1785286803](#).
- W. Sherman et al. “*Understanding Virtual Reality: Interface, Application, and Design.*” Morgan Kaufmann, 2003. [ISBN: 1558603530](#).
- D. Bowman et al. “*3D User Interfaces: Theory and Practice.*” Addison-Wesley, 2004. [ISBN: 013339056X](#).
- D. Schmalstieg et al. “*Augmented Reality: Principles and Practice.*” Addison-Wesley Professional, 2016. [ISBN: 0133153207](#).
- G. Mather. “*Foundations of Sensation and Perception (2nd Edition).*” Psychology Press, 2009. [ISBN: 1841696986](#).

Software Tools.

- Online course repository on GitHub (github.com/turing/vrphd).
- Unity online manual (docs.unity3d.com/Manual).
- Unity online scripting API (docs.unity3d.com/ScriptReference).
- C# online documentation (learn.microsoft.com/en-us/dotnet/csharp).

STUDENT ASSESSMENT

Attendance.

In-person attendance of at least 80% of the lessons is required (4 lessons out of 5).

Final Exam.

This course ends with a 1-hour in-class exam. The exam covers only the theoretical material discussed in part 1 of the first 4 lessons (from lesson 1 to lesson 4).