Development

Developing Immersive Applications

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Learning Objectives:

- describe common tools for developing immersive applications
- differentiate WebXR and OpenXR standards
- setup programming environment for building WebXR applications
- implement a minimal WebXR scene with Babylon.js

Key APIs

API	Type	Platform	XR-Specific
WebXR	Open Standard	Web	Yes
OpenXR	Open Standard	Native	Yes
Vulkan	Open Standard	Native	No
WebGL	Open Standard	Web	No
OpenGL	Open Standard	Native	No
DirectX	Proprietary	Native (Windows)	No
Metal	Proprietary	Native (Apple)	No

Key Points:

- **WebXR** — web standard for VR/AR, browser-based, no install
- **OpenXR** — cross-platform native standard for VR/AR
- **WebGL** — foundational web graphics API, WebXR builds on it
- Use WebXR for accessibility; OpenXR for native features

Development Frameworks

Framework	Type	WebXR	Key Features
Unity	Native Engine	Partial	Industry standard, C#, asset store
Unreal Engine	Native Engine	Partial	High-fidelity graphics, Blueprint
Babylon.js	Web Framework	Full	TypeScript, WebXR helpers (this module)
Three.js	Web Framework	Manual	Most popular, flexible, manual setup
A-Frame	Web Framework	Full	HTML-based, beginner-friendly
PlayCanvas	Web Framework	Full	Web editor, collaborative

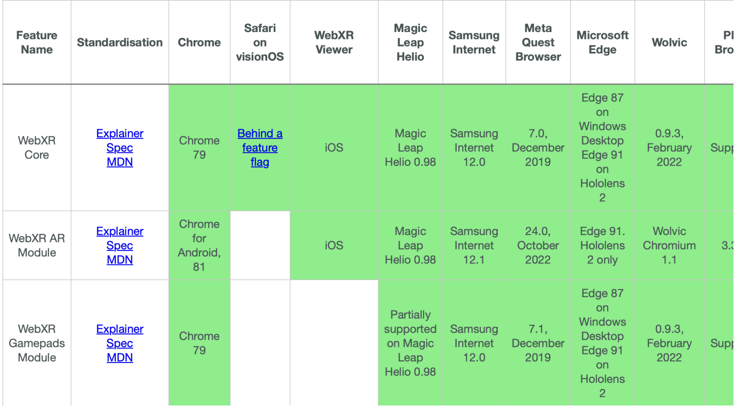
Development Frameworks

Framework	Type	WebXR	Key Features
CoSpaces	No-Code Tool	N/A	Educational, drag-and-drop
Spatial	No-Code Tool	N/A	AR/VR creation without coding

Choosing a Framework:

- **Maximum accessibility?** WebXR (Babylon.js, Three.js, A-Frame)
- **Novel hardware interaction?** OpenXR SDK in C++
- **High visual fidelity?** Unity or Unreal Engine
- **No coding experience?** CoSpaces or Spatial

WebXR Support Across Browsers



Feature Name	Standardisation	Chrome	Safari on visionOS	WebXR Viewer	Magic Leap Helio	Samsung Internet	Meta Quest Browser	Microsoft Edge	Wolvic	Pl Bro
WebXR Core	Explainer Spec MDN	Chrome 79	Behind a feature flag	iOS	Magic Leap Helio 0.98	Samsung Internet 12.0	7.0, December 2019	Edge 87 on Windows Desktop Edge 91 on Hololens 2	0.9.3, February 2022	Supp
WebXR AR Module	Explainer Spec MDN	Chrome for Android, 81		iOS	Magic Leap Helio 0.98	Samsung Internet 12.1	24.0, October 2022	Edge 91. Hololens 2 only	Wolvic Chromium 1.1	3.3
WebXR Gamepads Module	Explainer Spec MDN	Chrome 79			Partially supported on Magic Leap Helio 0.98	Samsung Internet 12.0	7.1, December 2019	Edge 87 on Windows Desktop Edge 91 on Hololens 2	0.9.3, February 2022	Supp

https://immersiveweb.dev

Babylon.js vs Three.js

Quick comparison:

- Babylon.js: built-in WebXR helpers, TypeScript-first, feature-rich
- Three.js: manual WebXR setup, lighter core, more DIY flexibility
- Babylon trades size for convenience; Three trades boilerplate for control

Babylon.js vs Three.js

Both frameworks:

- Can be used to build WebXR applications
- Support VR controllers, hand tracking, and AR passthrough
- Can run on Meta Quest 2 using Quest controllers

Project Setup Basics

Development Environment:

- **Node.js + npm** — JavaScript runtime and package manager
- **TypeScript** — Typed superset of JavaScript
- **Vite** — Fast build tool and dev server
- **package.json** — Project dependencies and scripts
- **tsconfig.json** — TypeScript compiler configuration

Basic Workflow:

`npm install` — Install dependencies

`npm run dev` — Start development server

`npm run build` — Build for deployment

Babylon.js App Boilerplate

Engine + render loop setup:

```
import { Engine } from "@babylonjs/core";
import { App } from "./app";

const canvas = document.getElementById("renderCanvas");
const engine = new Engine(canvas, true);

const app = new App(engine);
app.createScene().then(scene => {
engine.runRenderLoop(() => { scene.render(); });
});

window.addEventListener("resize", () => engine.resize());
```

Babylon.js createScene Snippets

IPA1 basics:

Key steps:

- instantiate a new `Scene` with the engine
- add a quick console log for debugging
- create default camera and light helpers
- replace with specific cameras later (e.g., `ArcRotateCamera`)

WebXR Setup in Babylon.js

Adding WebXR to your scene:

```
const ground = MeshBuilder.CreateGround("ground", { ... });
const xr = await scene.createDefaultXRExperienceAsync({
floorMeshes: [ground] // Enable teleportation
});
```

What you get automatically:

- VR/AR mode button in the UI
- Controller input handling (grip, trigger, buttons)
- Teleportation system (if floorMeshes provided)
- Hand tracking support (if device supports it)

WebXR Setup: Babylon.js vs Three.js

Compare with manual WebXR setup in Three.js:

```
// Three.js requires manual WebXR setup
const session = await navigator.xr.requestSession("immersive-vr", {
requiredFeatures: ["local-floor"]
});
const gl = canvas.getContext("webgl", { xrCompatible: true });
await gl.makeXRCompatible();

const glBinding = new XRWebGLBinding(session, gl);
const layer = new XRWebGLLayer(session, gl);
session.updateRenderState({ baseLayer: layer });

const referenceSpace = await session.requestReferenceSpace("local-floor");
```

WebXR Setup: Babylon.js vs Three.js

(continued) Manual WebXR setup in Three.js:

```
// Manual render loop with XR frame handling
function onXRFrame(time, frame) {
    const pose = frame.getViewerPose(referenceSpace);
    // Update camera matrices, render to each eye's viewport
    // Manual rendering code here...
    session.requestAnimationFrame(onXRFrame);
  }
session.requestAnimationFrame(onXRFrame);
// No built-in controllers, teleportation, or hand tracking!
```

WebXR Setup: Babylon.js vs Three.js

(continued) Manual WebXR setup in Three.js:

```
// Manual render loop with XR frame handling
function onXRFrame(time, frame) {
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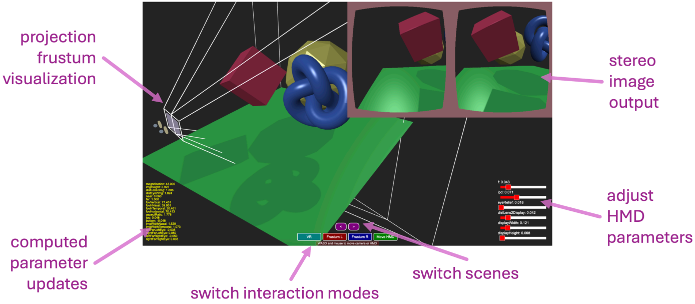
HMD Simulator

Purpose: Understanding Hardware-Software Connection

- Visualize how HMD hardware parameters affect rendering
- Experiment with lens properties, IPD, FOV, eye relief
- See real-time impact on the rendered view



```
magnification: 43.000
imgHeight: 2.925
distLens2Img: 1.806
distEye2Img: 1.824
near: 0.060
far: 1.060
fovVertical: 77.451
fovHNasal: 39.951
fovHTemporal: 30.461
fovHorizontal: 70.413
aspectRatio: 1.778
top: 0.048
bottom: -0.048
imgWidthNasal: 1.528
imgWidthTemporal: 1.073
leftForLeftEye: -0.035
rightForLeftEye: 0.050
leftForRightEye: -0.050
rightForRightEye: 0.035
```

```
f: 0.043
ipd: 0.071
eyeRelief: 0.018
distLens2Display: 0.042
displayWidth: 0.121
displayHeight: 0.068
```

WASD and mouse to move camera or HMD

projection frustum visualization

stereo image output

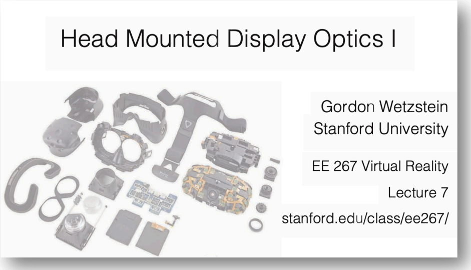
adjust HMD parameters

computed parameter updates

switch interaction modes

switch scenes

Hardware & Software Connection



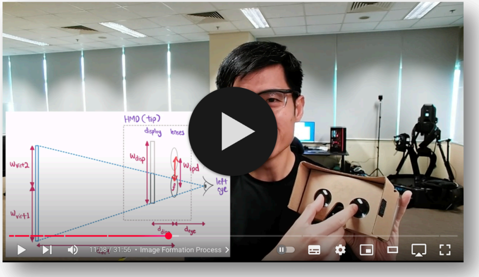
Head Mounted Display Optics I

Gordon Wetzstein
Stanford University

EE 267 Virtual Reality

Lecture 7

stanford.edu/class/ee267/

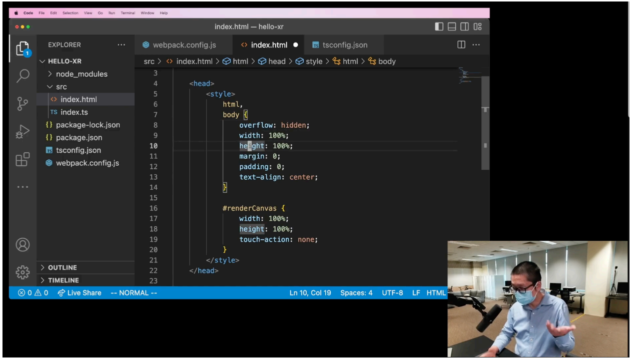


Stanford EE267 | `https://stanford.edu/class/ee267/lectures/lecture7.pdf`

Immersification Video | `https://youtu.be/0KD4jrnn4WE`

Video Tutorial

Live Coding Basics:



```

    <head>
        <style>
            html,
            body {
                overflow: hidden;
                width: 100%;
                height: 100%;
                margin: 0;
                padding: 0;
                text-align: center;
            }

            #renderCanvas {
                width: 100%;
                height: 100%;
                touch-action: none;
            }
        </style>
    </head>

```

https://youtu.be/iDCnmggNIy8

Summary

Today we covered:

- Key graphics/XR APIs: WebXR, OpenXR, Vulkan, WebGL, DirectX, Metal
- Development frameworks: Unity, Unreal, Babylon.js, Three.js, A-Frame
- Project setup with Node.js, TypeScript, Vite
- HMD Simulator for hardware-software connection

Next Steps:

- Review project setup video tutorial
- Experiment with HMD Simulator
- Browse Stanford EE267 lecture notes on HMD optics

Further Reading

WebXR & OpenXR Standards:

- WebXR's Immersive Web Working Group
- WebXR Resources (immersiveweb.dev)
- OpenXR API (Khronos Group)
- Mozilla's Hello WebXR demo

Development Frameworks:

- A-Frame website
- BabylonJS Documentation
- BabylonJS GitHub repository
- BabylonJS Playground and Inspector demo