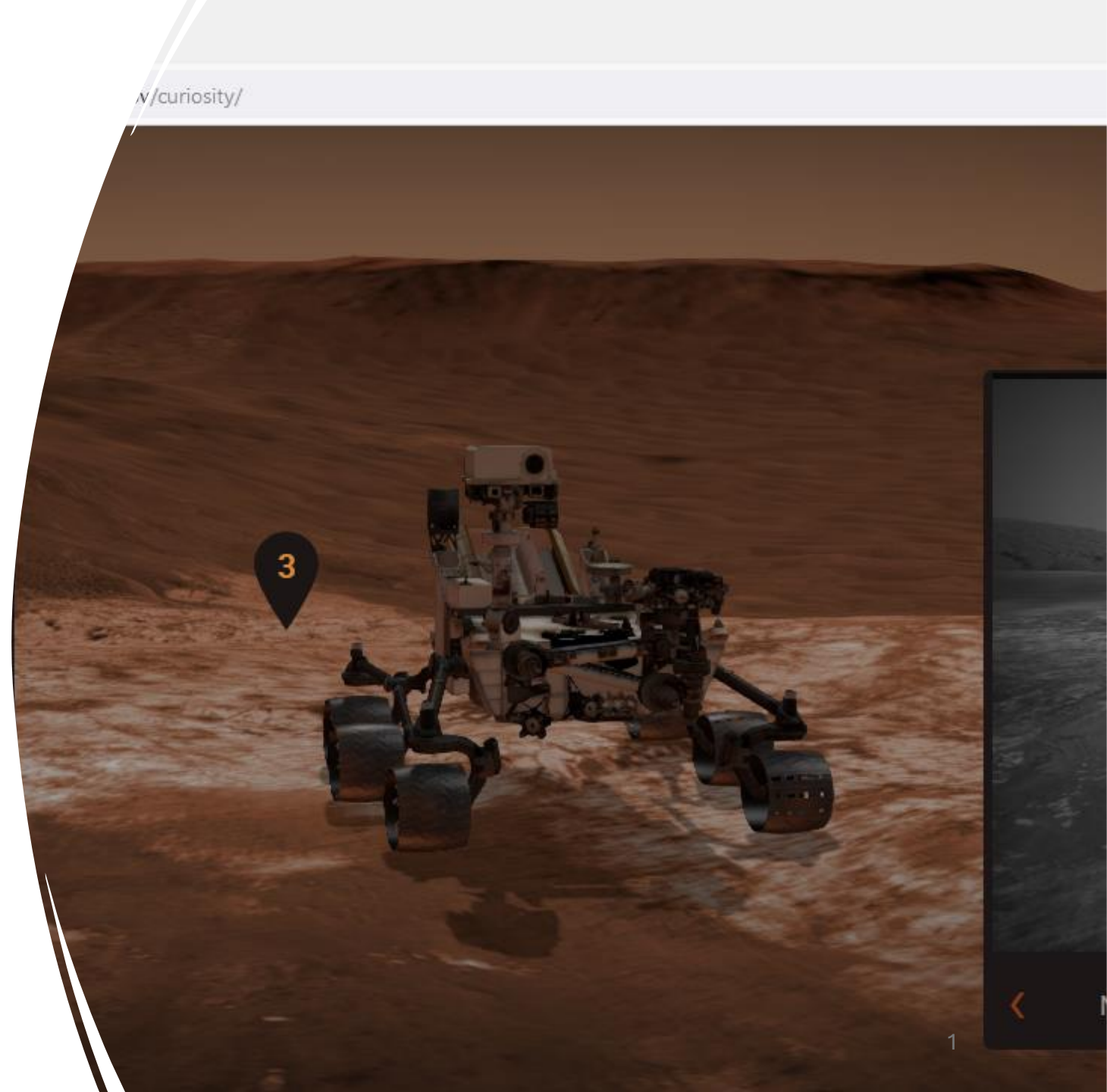# Introduction to WebGL

This short presentation delves into the application areas of computer graphics, highlighting the features and advantages of WebGL and showcases few live applications utilizing this library.

Explore: https://eyes.nasa.gov/curiosity/
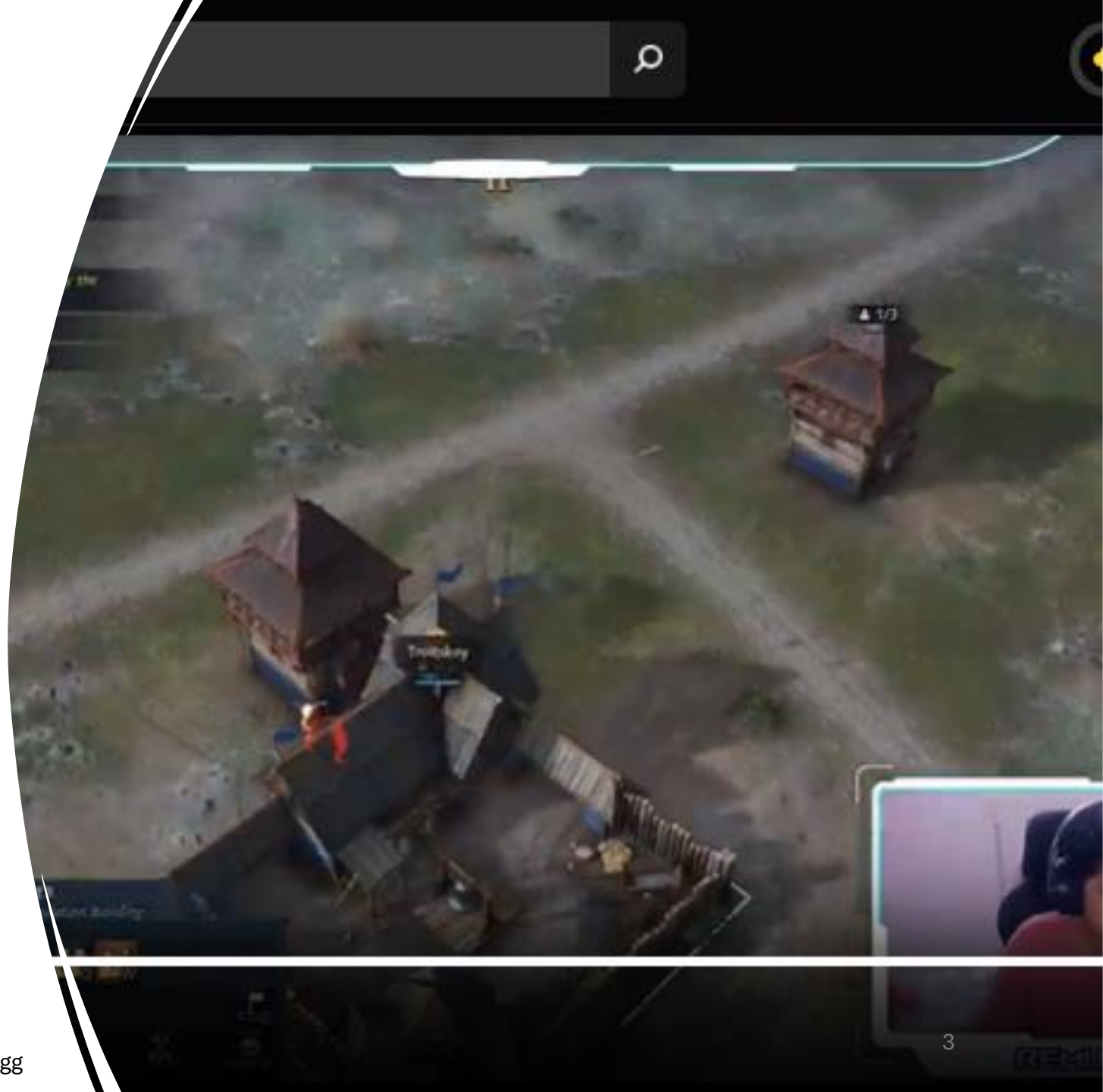Image Source:. nasa.gov

Application areas of Computer Graphics (CG)

Video Game Industry

- The industry is one of the major driving force behind modern CG.

- It earned even larger revenue than the combined earnings of the movie and music industries in 2020.

Image Source:. loco.gg

Animation Industry

- CG helps animation movies create realistic characters and stunning visual effects.

- One of the animation video "Johnny Johnny Yes Papa", a nursery rhyme, earned second most-views of all time in 2021.
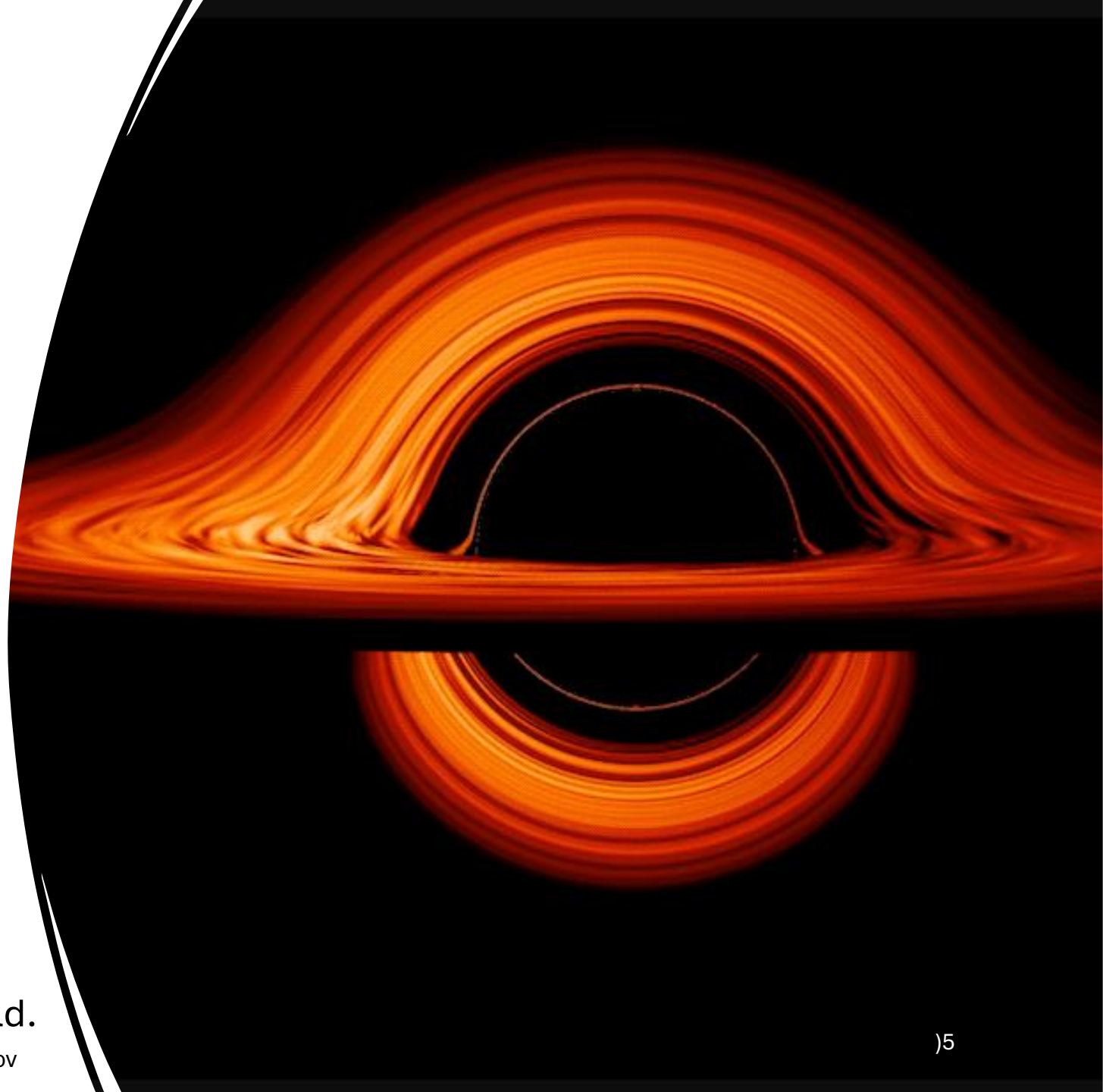
Image Source: LooLoo Kids

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Scientific Visualization

- Scientists utilizes CG to illustrate complex physical phenomenon's for better understanding, analysis, interpretation and communication.

Visualization of Black Hole's Warped World.

Image Source: nasa.gov

Virtual Reality

Virtual Reality or VR is a CG generated Immersive experience with Virtual Worlds and interacting them with hand gestures.

NOW PLAYING
GORN

Image from the demo of HTC Vive VR Headset

Augmented Reality

- Augmented Reality or AR overlays CG information over the real world environments, enhancing user's perception.

Image from the demo. of google AR glasses

Web vs Desktop Applications

- **High end graphics applications are primarily written for desktop-based applications. However, there are numerous benefits writing them for web. Some of them are listed below.**

- **Pervasiveness:** Web-based applications are inherently pervasive, meaning they can run on any machine, regardless of whether it's a Mac, Windows, Linux, or Android device.

- **UI Development:** The user interface and experience for web-based applications are primarily facilitated through HTML and CSS.

- **JS libraries:** WebGL is accessible through JavaScript-based method calls, making it a versatile tool for developing game and graphics applications. The open-source Node.js environment further expands the possibilities by providing server-side programming capabilities using JavaScript. This combination allows developers to harness the power of freely available JavaScript libraries to create full-fledged games and graphics applications.

Web vs Desktop Applications

- **AR/VR development:**

- The WebXR API provides access to device sensors and input mechanisms, allowing developers to create experiences that respond to user movements and interactions.

- **T**he WebXR API eliminates the need for users to install dedicated VR/AR applications, making it more accessible and user-friendly.
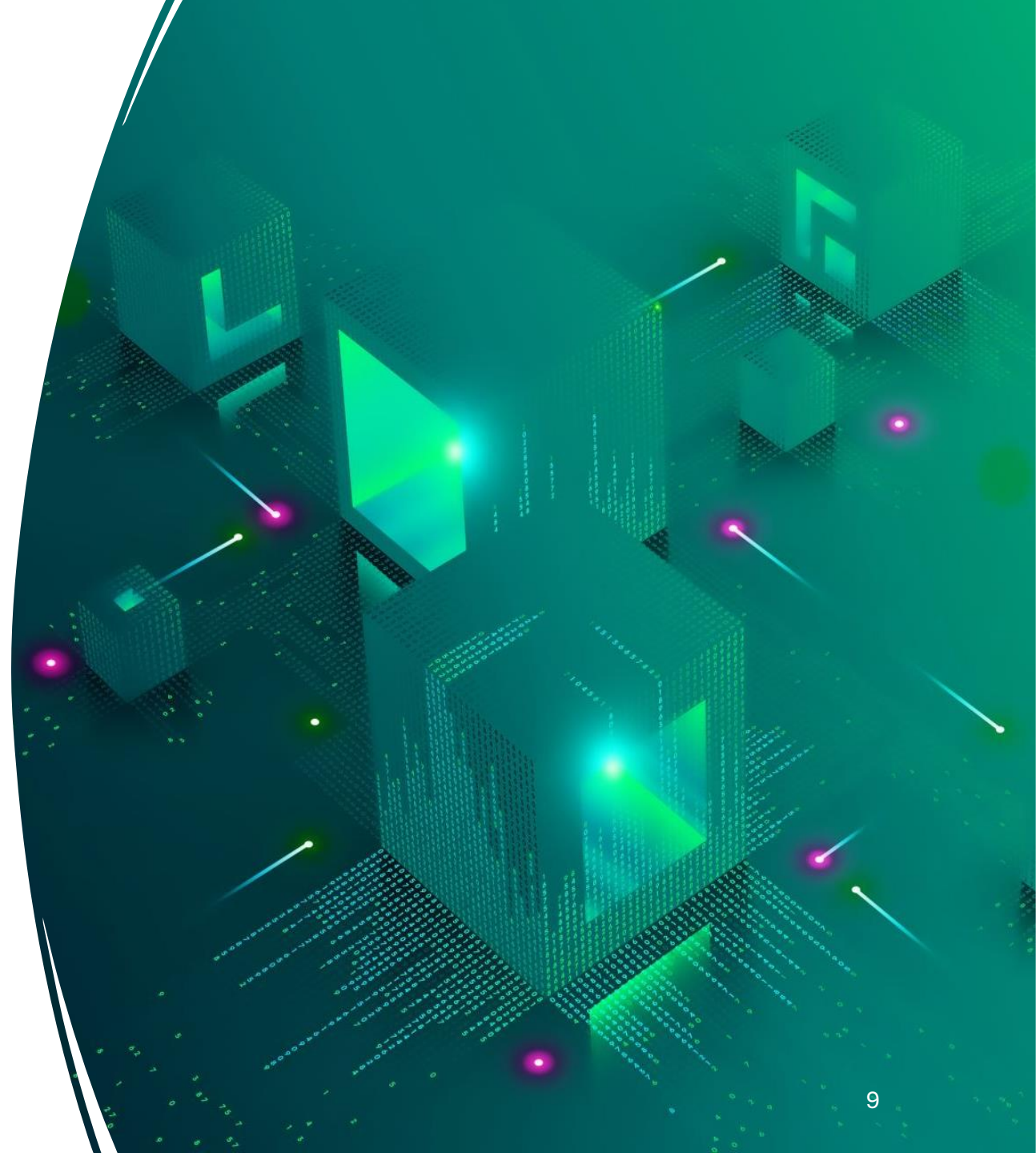
WebGL

- ## History

- During the 1990s, there were numerous 3D graphics languages and libraries available, each offering sophisticated and advanced features for their time. However, a significant drawback of many of these solutions was their reliance on specific platforms or hardware, limiting their cross-platform compatibility. For example, an application developed for Windows would not be able to run on Mac OS.

- In response, the Group, a non-profit organization, Khronos was founded in 2000.

WebGL

- In March 2011, the Khronos Group officially released WebGL 1.0. This browser-based 3D graphics library gained significant traction, and leading organizations started porting their applications to the web using WebGL. In 2017, WebGL 2.0 was released, further enhancing its capabilities. Similar to OpenGL, WebGL is cross-platform and can run on various computer hardware and operating systems. However, unlike OpenGL, which requires libraries to be installed and linked, WebGL is a browser-based library.

- Today, numerous prominent industry players extend their software services to the web using the underlying WebGL API. Examples include AutoCAD 360 and Fusion 360 by Autodesk, SketchUp by Google, SculptGL by Sketchfab, and many others. An illustrative application is "Experience Curiosity," an interactive 3D web application released by NASA's Jet Propulsion Laboratory, which showcases the capabilities of WebGL.

Khronos Offerings

Khronos Offerings

- **OpenGL:** A widely adopted graphics API for desktop-based 3D graphics programming.

- **Vulkan**: A high-performance and cross-platform graphics API designed for modern GPUs.

- **glTF:** A standardized 3D model format that enables efficient transmission and loading of 3D assets.

- **OpenGL ES:** A standard API for 3D graphics on embedded and mobile devices, ensuring portability across different platforms.

- **OpenXR:** An open and royalty-free standard for accessing augmented reality (AR) and virtual reality (VR) applications.

- **COLLADA:** A schema for exchanging digital assets between various 3D authoring tools and runtime environments.

Features of WebGL

- **Open Standard:** One of the key aspects of WebGL is its royalty-free Open Standard. It means there is no condition of royalty sharing to consider, before developing applications with WebGL.

- **GLSL language:** One have concerns about the performance of WebGL based applications compared to popular desktop-based 2D/3D development platforms that use C++ as their underlying language, due to the inherent scripting nature of HTML and JS. However, WebGL offers optimal performance for 2D/3D experiences. This is due to its efficient utilization of the GPU (Graphics Processing Unit), which is responsible for rendering graphics.

- **GPU utilization:** Despite being coded in JavaScript, WebGL is able to achieve impressive performance in rendering high-quality graphics on the web. This is primarily due to its ability to harness the processing power of the client's graphics processing unit (GPU).

Features of WebGL

- **Low level programming:** To program in WebGL, one must delve into low-level programming concepts, such as creating memory buffers to store data and defining the structure of data organization.

- **Client Side processing:** It is important to note that websites running WebGL-powered graphics rely on the client's resources, including memory and processing power. The 3D models and programming scripts are downloaded to the client's machine through web browsers and are rendered locally. This approach enables each client to handle the graphics operations, which would be otherwise impractical for the server machine to handle the enormous internet traffic.

Features of WebGL

- **Zero Installation:** To run WebGL applications, end users do not need to install any software package or library. Only a web browser is required to render the WebGL-based graphics applications. This makes it convenient for users as they can access and experience WebGL content directly within their browser without the need for additional installations and configurations.

- **Zero installation/library for Developers:** For application programmers, developing a complete 2D/3D graphics experience for end users using WebGL does not require any additional library or software installations.

- **Compilation:** In WebGL, the code written by the programmer needs to follow the syntax and rules of the WebGL specification, which will then be compiled by the browser's WebGL implementation. The compilation happens on the GPU side, allowing the code to take advantage of the GPU's processing capabilities.

Frameworks

- In software development, a framework is a collection of libraries, tools, and abstractions that provide a higher-level structure for building applications. It simplifies the development process by providing pre-built components, functions, and classes that handle common tasks and abstract away the complexity of the underlying technologies.

- In the case of WebGL, due to its low-level and detailed nature, several open-source frameworks have emerged to simplify and accelerate the development of graphics applications. These frameworks provide a set of ready-to-use functions, utilities, and abstractions specifically designed for WebGL, allowing developers to focus on the application logic rather than dealing with low-level coding.

WebGL Frameworks

- **THREE JS:**

- Ricardo Cabello, also known as Mr. doob, is the creator of Three.js framework. He released the source code of Three.js as an open-source project on GitHub, making it accessible to developers worldwide. Thanks to his efforts, Three.js has become one of the most popular and widely used WebGL frameworks.

Explore https://threejs.org/examples/#webgl_animation_keyframes
Image Source: threejs.org

WebGL Frameworks

- **Babylon JS:**

- Babylon.js is developed by David Catuhe and other contributors, and it is supported by Microsoft. The framework provides a comprehensive set of advanced features for WebGL application development.

- Babylon.js offers a wide range of functionalities including lighting, camera controls, materials, audio support, collision detection, and the ability to load external 3D assets. These features enable developers to create rich and immersive 3D experiences.

Explore https://www.babylonjs.com/
Image Source: www.babylonjs.com
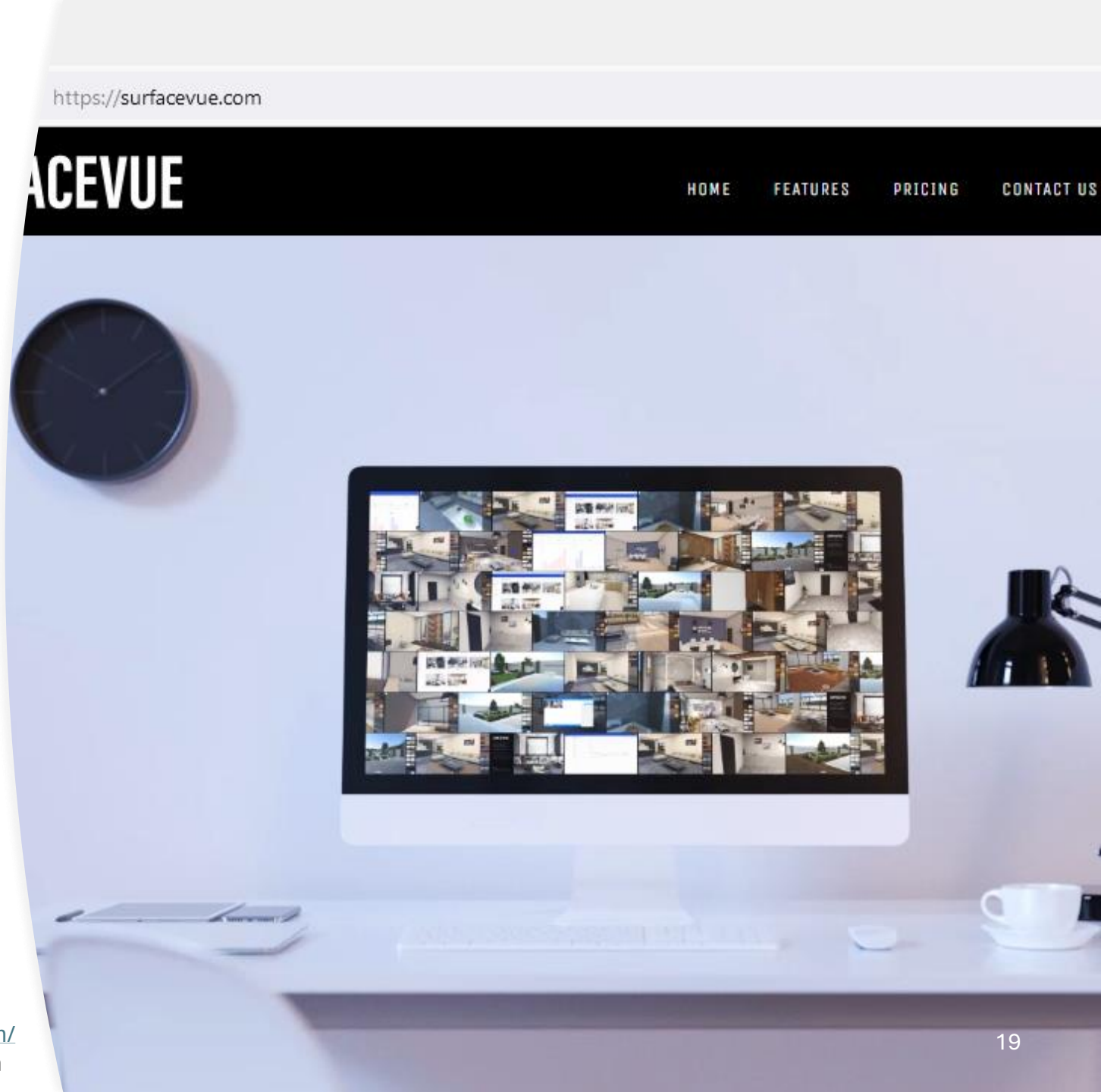
WebGL Frameworks

- **PlayCanvas:**
- PlayCanvas is a powerful framework specifically designed for building 3D games and interactive applications. It offers features that facilitate collaborative development, allowing multiple developers to work simultaneously on a project from different computers connected over a network.

Explore https://playcanvas.com/explore
Image Source: playcanvas.com

WebGL Frameworks

- **A Frame:**
- A-Frame is a web framework for building virtual reality experiences. It simplifies the development of VR applications by providing an entity- component system and a declarative HTML-like syntax. It is built on top of Three.js and provides easy integration with other web technologies.

Explore https://aframe.io/
Image Source: aframe.io
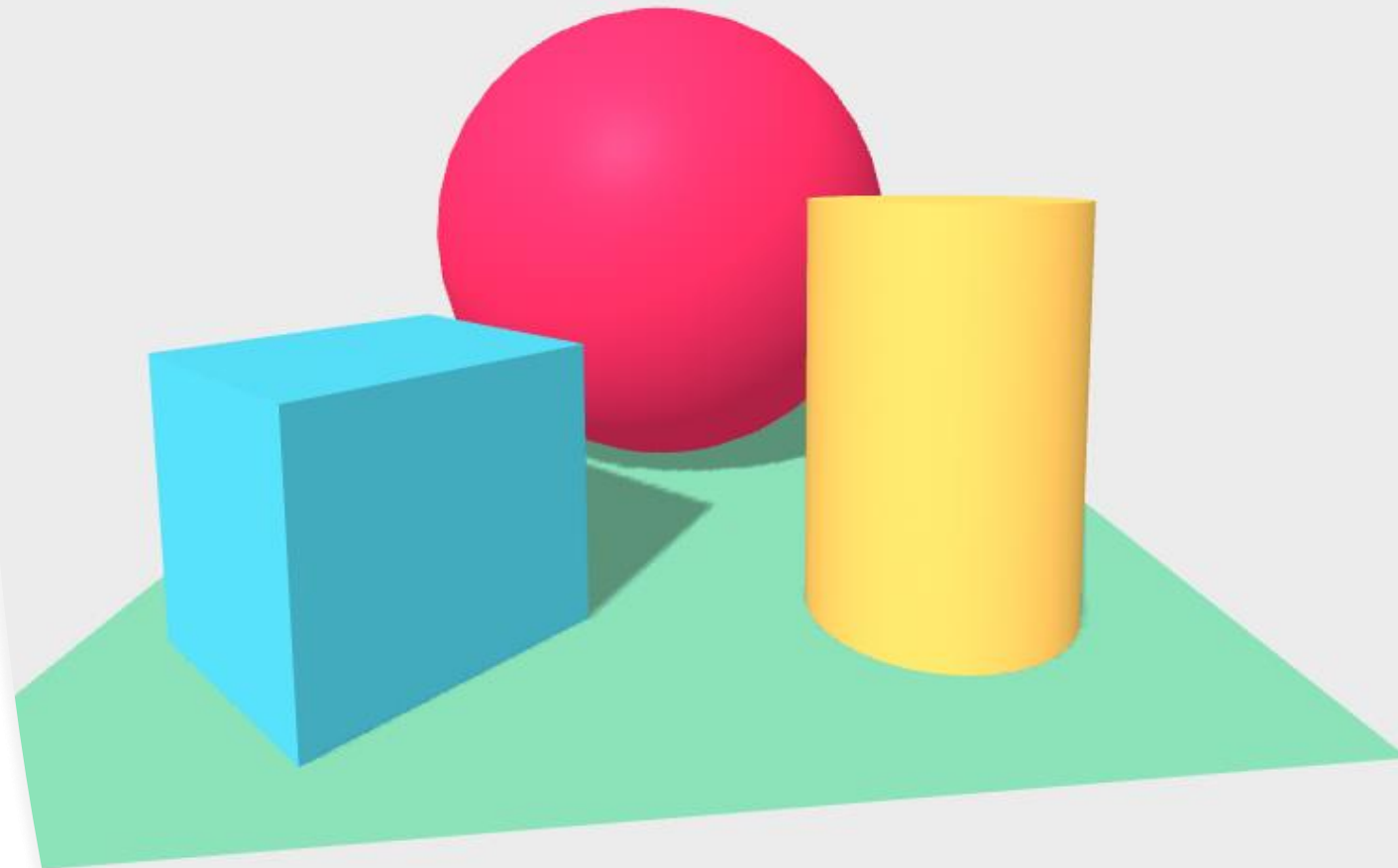
Benefits of Learning WebGL

- **Touches Computer Graphics Fundamentals:**

- Learning WebGL can serve as a gateway to gaining a deeper understanding of computer graphics fundamentals. Implementing sophisticated functionality in WebGL requires a solid grasp of mathematical concepts and algorithms commonly used in computer graphics.

- **Understanding of GPU and parallelism:**

- The success of both OpenGL and WebGL can be attributed to their adaptability to modern computer processing architectures and the continuous efforts of the Khronos working group to update and specify the APIs.

Benefits of Learning WebGL

- **Hardware level accessibility to GPU:**

- All the data corresponding to the vertices, such as coordinates, color, texture coordinates, and normals, needs to be loaded into the GPU memory before rendering.

- **Bottom up approach:**

- Learning WebGL follows a bottom-up approach, where one start with the basics of drawing and coloring individual pixels or simple geometric primitives like triangles, and gradually build up to more complex 3D animations and realistic effects.

Live applications utilizing WebGL

Web GIS solutions by ESRI

- Esri, is an American multinational geographic information system software company best known for ArcGIS software.

- It uses WebGL rendering for providing ArcGIS JavaScript capabilities in the browser without any plugins.

Explore

- https://mediaspace.esri.com/media/t/1_rxzws8r7

& Disaster Response

Image Source: esri.com

3D Google Maps

- Google allows developers to use WebGL powered features through JavaScript API for rendering vector maps in 3D.

- Explore

- https://developers.google.com/maps/documentation/javascript/webgl/webgl-overlay-view

Image Source: developers.google.com

Verge3D

• Verge3D simplifies the creation of immersive online experiences by concealing the complexities of the underlying WebGL technology.

Explore.

• https://www.soft8soft.com/.

Image Source: soft8soft.com

My notes and books!

- Getting started with WebGL
  - A short book on starting coding in WebGL
  - Kindle:

- Learn 3D Graphics Programming for the Web Using WebGL
  - A book which explains all the intricacies of developing an application in WebGL
  - Amazon:

- Write to me for your queries and interest
  - bhupendra.bisht59@gmail.com