

Modern Technologies and Concepts for Education

I – 3D Video, Virtual and Augmented Reality

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Annotation

This module deals with a topic of 3D modelling and its use for virtual and augmented realities. The material introduces modelling of 3D objects, capturing 3D objects and visualization of 3D objects. Basic principles of virtual and augmented realities are discussed, as well. Specific camera systems for capturing 3D objects and 3D scenes are analysed, too. Special complex systems and applications for experience-based videoconferencing based on virtual teleport are presented at the end of this document.

Objectives

Through the study of the module, students will gain an overview in 3D modelling and topics related to 3D modelling. Student will learn the entire process of 3D modelling from capturing, modelling and visualisation of 3D objects and scenes.

The student should understand the main direction and trends of virtual teleport-based videoconferencing.

Keywords

3D modelling, capturing of 3D objects, visualization of 3D objects, virtual teleport

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Literature

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CHAPTER 1

3D Graphics and 3D Models

DEFINITION

In 3D computer graphics, 3D modelling is the process of developing a mathematical representation of any three-dimensional surface of an object (whether inanimate or living) using specialized software.

The product is called a 3D model. It is basically a vector graphic represented in three dimensions.

It can be displayed as a two-dimensional image through a process called 3D rendering or used in computer simulation of physical phenomena. The model can also be created physically using 3D printing devices.

1.1 3D Model Types

Solid - These models define the volume of the object they represent (as a stone). These are more realistic, but more difficult to build. Fixed models are mostly used for simulations in medicine or engineering, for CAD and specialized visual applications, such as ray tracing and constructive body geometry, as they have a substantial mass or material they represent (stone, metal object, etc.).

Shell / boundary - these models represent a surface, e.g. the boundary of the object, not its volume (like an infinitely thin eggshell). These are much easier to work with than fixed models. Almost all visual models used in games and movies are surface models.

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1.2 3D Model representation

DEFINITION

Polygonal modelling - Points in 3D space, called vertices, are connected by lines to form a polygonal network. Most 3D models today are made as textured polygonal models because they are flexible, and computers can render them so quickly. However, polygons are planar and can only approximate curved surfaces with many polygons.

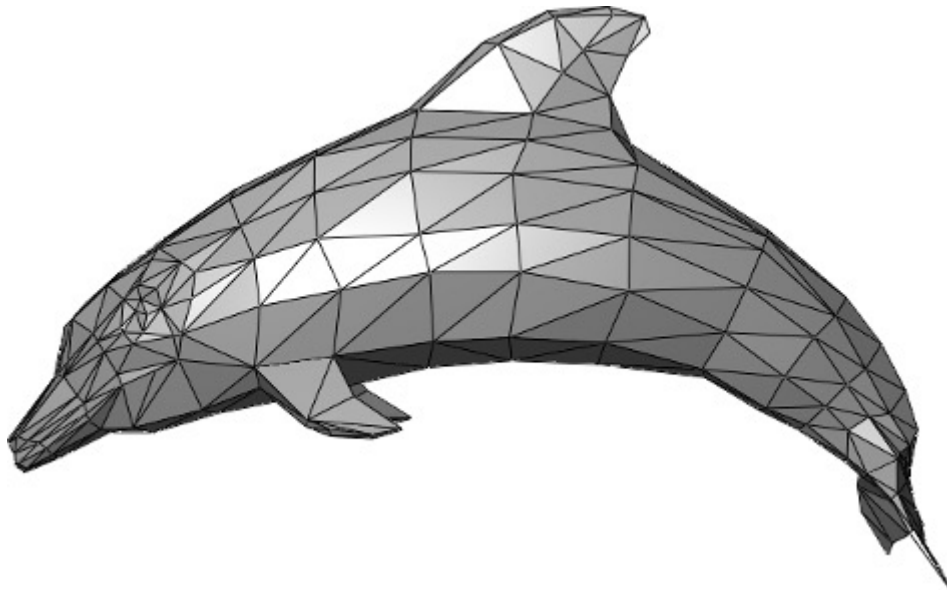


Fig. 1. Polygonal representation (source: behance.net)

DEFINITION

Curve modelling - Surfaces are defined by curves that are affected by weighted control points. The curve follows the points. Increasing the weight of the point will bring the curve closer to that point.

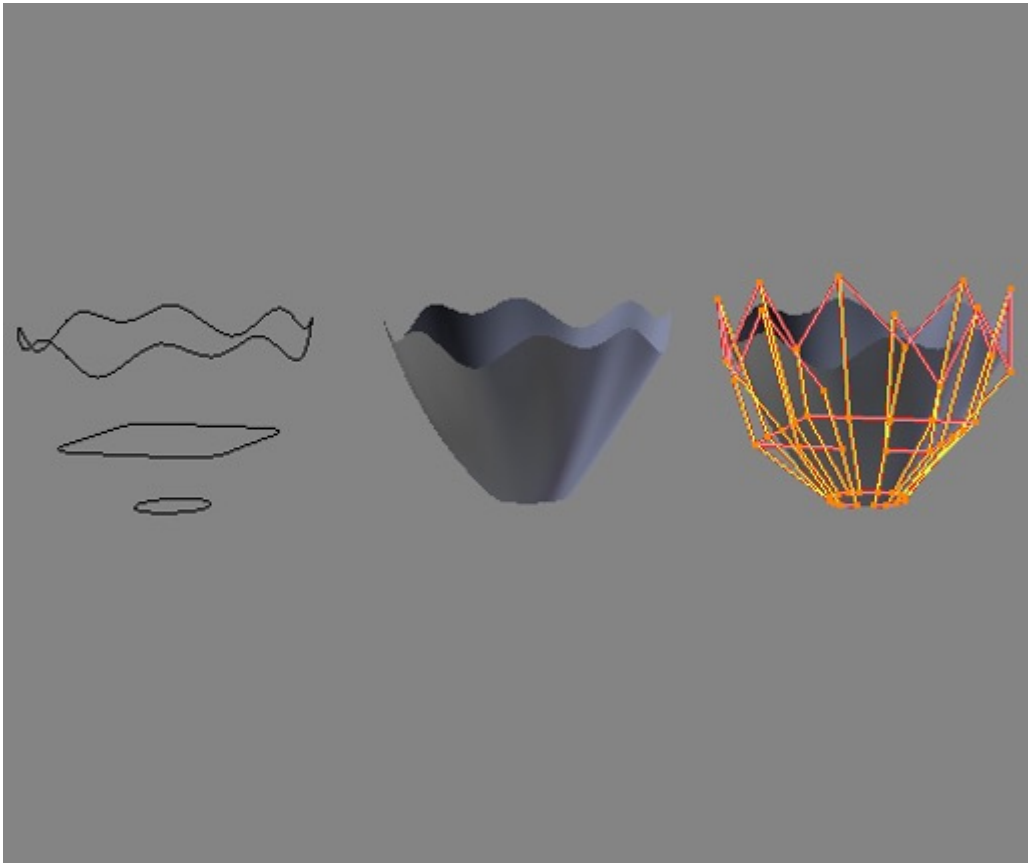


Fig. 2. Curve representation (source: blenderartists.org)

DEFINITION

Digital sculpture - still a relatively new method of modelling, 3D sculpture has become very popular in the few years that it has existed. There are currently 3 types of digital sculpture:

- **Displacement**, which is currently the most widely used among displacement techniques, uses a dense model, and stores new positions for vertex positions using a 32-bit image map that stores adjusted positions.
- **Volumetric**, which is loosely based on voxels (volume particle, has 3 dimensions), has similar abilities as displacement, but does not suffer from expanding polygons when there are not enough polygons in the region to achieve deformation.
- **Dynamic tessellation** divides the surface by triangulation to maintain a smooth surface and allow finer details. The new network will usually have the original high-resolution network information transferred to the offset data.



Fig. 3. Digital sculpture (source: behance.net)

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1.3 Process of Creating a 3D Model

Often there is very little difference between what is real and what is imaginary. This is often the case with 3D modelling and today's technologies, as scenes can come to life and be created in highly realistic ways. Whether it's animation development, model creation for a website or video games, the basics of 3D creation remain the same. In this section, we will take a closer look at the process of creating a 3D model until it is finalized.

Graphic designers use powerful tools such as Blender to create objects and surfaces or MakeHuman software to design human avatars to design these models.

1.3.1 Blocking

During the first step, the graphic designer creates rough models of 3D objects and arranges them into a scene. It focuses on the shell of objects and object boundaries. This step represents the key deployment, rotation, and placement of the objects or characters that will be created.



Fig. 4. Result of blocking

1.3.2 Detailing

In this phase, details are added to the initial blocks of the 3D model. The models look smoother and more detailed; they are close to their final shape. In this step, some graphic designers also adjust the lighting

and location of the camera to prepare the scene for texturing.



Fig. 5. Result of detailing

1.3.3 Texturing

Texture makes a model look more realistic by adding colours, patterns, and textures. In other words, it represents the art of dressing up 3D models. At this stage you need to have knowledge of UV mapping and how textures are used in different applications, their optimization for end devices. When dressing the scene, make sure that the details are not too perfect, because too perfect a scene loses credibility. For this reason, various imperfections of the scene are added, such as smudges, splinters, scratches, smudges, and the like.



Fig. 6. Result of texturing

1.3.4 Rendering

As the scene becomes more detailed and accurate, we get closer to the result. Now that the textures and lighting are complete, the graphic designer continues to render the scene. This process usually reveals mistakes, and the artist adapts his work accordingly. Imperfections are part of the real world, so big ones must be part of the perfect model to make the 3D model look more vivid.



Fig. 7. Rendered scene

1.3.5 Post processing

The last phase of each rendered scene is post processing. This is the stage when the graphic designer uses the post-processing software to further improve the final rendering to show even more detail. The scene usually receives colour correction, and effects and photo filters are added to make the scene more attractive.

At this stage, lighting is also necessary to make the 3D model look as realistic as possible. Carefully crafted lighting has the potential to create more compelling scenes. The final processing of a 3D model is usually time consuming and requires a lot of concentration to achieve the desired result. Lastly, before the final output, it is necessary to set the orientation of the camera capturing the scene so that the resulting image has the right angle and reflects the desired atmosphere.



Fig. 8. Final image after post processing

1.4 Creation Software

It should be noted that 3D modelling software is a subset of 3D computer graphics software used to create 3D models. The individual programs in this set are called modelling applications.

SketchUp (formerly: Google Sketchup) is a 3D modelling program for applications such as architecture, interior design, civil and mechanical engineering, film design, and video game design. There is a free version of SketchUp Make and a paid version with additional features of SketchUp Pro.

NOTE

There are many 3D modelling programs. Some are freely available, and others are paid.

1.4.1 Blender

INTERESTING

Swiss military tool for 3D modelling. Blender includes several tools for various 3D graphics industries. It's an excellent free 3D design platform that provides a dizzying array of modelling tools and absolutely nothing. You can solve 3D modelling in Blender in many different approaches: using digital shaping, network modelling and parametric modelling.

Blender also offers a range of tools for later stages of production. You can easily use Blender to animate, render, edit videos, or visual effects - which means you only need one tool to expand the scope of your work.

NOTE

No better free tool like Blender can be found in 3D modelling.

Blender is open-source software, which means that the community uses it back, it contributes to improving it and shifting its usability and feature set.



Fig. 9. Blender Studio screenshot (source: blender.org)

1.4.2 Cinema4D

Cinema 4D, animation power with advanced simulation capabilities is often one of the programs behind the most fascinating visual effects.

INTERESTING

In fact, Cinema 4D's capabilities are that it is used in Hollywood movies with a high VFX content. Pacific Rim and Tron: Legacy are two examples of photorealistic imagination you can achieve with Cinema 4D.

Despite being one of the more advanced programs, Cinema 4D has a reputation for ease of use. Experienced users praise the well-organized interface and advanced features for streamlining modelling and animation workflows. Both novice and experienced 3D artists benefit from this, as the intuitive layout puts you in mind with the most important tools to familiarize yourself with what you need most and speed up the process for those who know what they are looking for. Cinema 4D also has a good community around it, which offers several tutorials and helps new artists acquire skills.



Fig. 10. Cinema4D Studio screenshot (source: techgage.com)

CHAPTER 2

3D Capture

2.1 Deep vision technology SL (Structured Light)

DEFINITION

The principle of structured light works based on active stereo perception.

In principle, it works in such a way that a pre-configured sequence of infrared light is projected at regular intervals onto the observed object. This sequence is subject to deformations caused by the geometric shape of the observed object and is subsequently captured by a camera sensing this deformation of the reflected light. This captured deformed sequence is then analysed and processed into the resulting depth map.

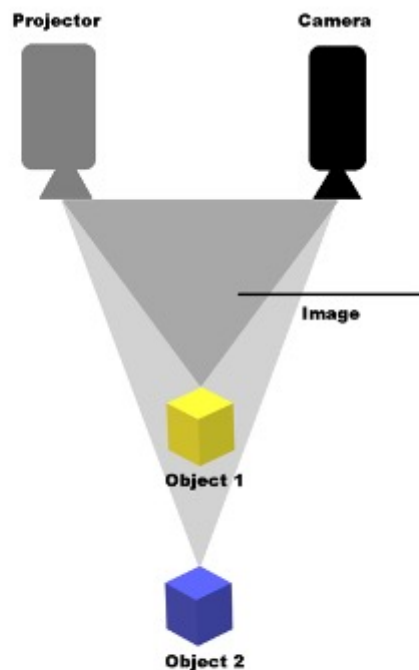


Fig. 11. Structured light technique

2.2 Depth vision technology ToF (Time of Flight)

DEFINITION

ToF technology is based on measuring the time that travels through the light from the moment when it leaves the light unit to the moment when it is captured again by light sensors.

In recent years, this principle has found its application and thus a completely new category of devices called ToF cameras has been created.

In addition, the advanced intensity modulation used in ToF cameras is clearly Continuous Wave Intensity Modulation. The principle is that the observed scene is actively illuminated with intensity-modulated infrared light. The reflection of this light is then captured by the sensor and thanks to the time shift and the constant speed of light, we can transform this shift into the distance between the sensor and the observed object.

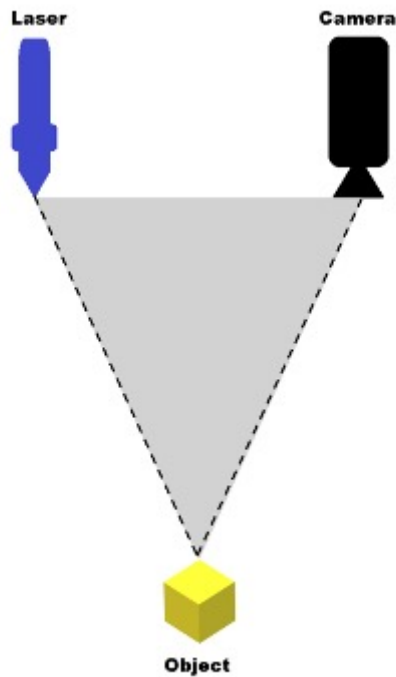


Fig. 12. Time of flight technique

2.3 Stereoscopic depth vision technology

INTERESTING

Active infrared stereoscopic technology is inspired by human vision.

DEFINITION

It relies on two parallel-mounted infrared cameras that transmit texture images to the observed object and look for common points between these images. The depth is then estimated due to the differences between these common points.

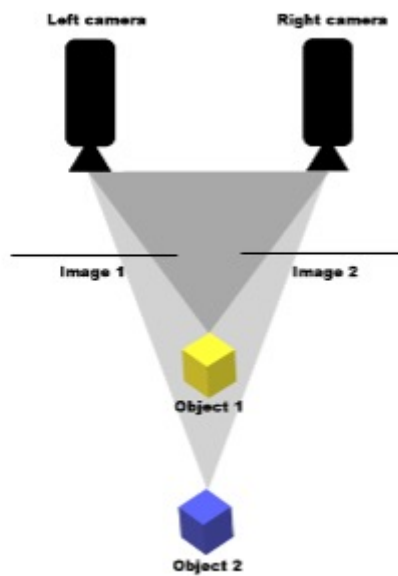


Fig. 13. Stereoscopic technique

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2.4 Capturing sensors

2.4.1 Kinect Azure - sensor for capturing 3D scenes

One of the most used sensors for capturing a 3D scene is Kinect Azure. This device allows your camera system to capture detailed scenes in front of you using ToF technology. The device has 2 cameras with which it evaluates the whole scene and sends the obtained 3D images to the computer via USB interface. The output of this device can be imagined as a 3D video that carries information not only in the X and Y axis but also in the Z axis.



Fig. 14. Azure Kinect sensor (source: microsoft.com)

2.4.1.1 Hardware specifications

The Azure Kinect camera consists of an RGB camera and an infrared camera. The RGB camera offers various resolution modes where the highest possible resolution is 3840×2160 px at 30 Hz.

INTERESTING

The infrared camera has the highest resolution of 1024×1024 px and uses the ToF principle. In addition, both cameras support different field of view modes.

Azure Kinect also has an IMU sensor, consisting of a triaxial accelerometer and a gyroscope, with which the device can estimate its own position in space. Microsoft also offers a Body Tracking SDK with the device that can detect and track the movements of multiple users, each with 32 joints.

This development package is available for Windows and Linux operating systems and the C++ and C# programming languages.

NOTE

Contrary to the skeleton definition of the former generation of Kinect, the current definition includes multiple joints in the face, such as the ears and eyes.

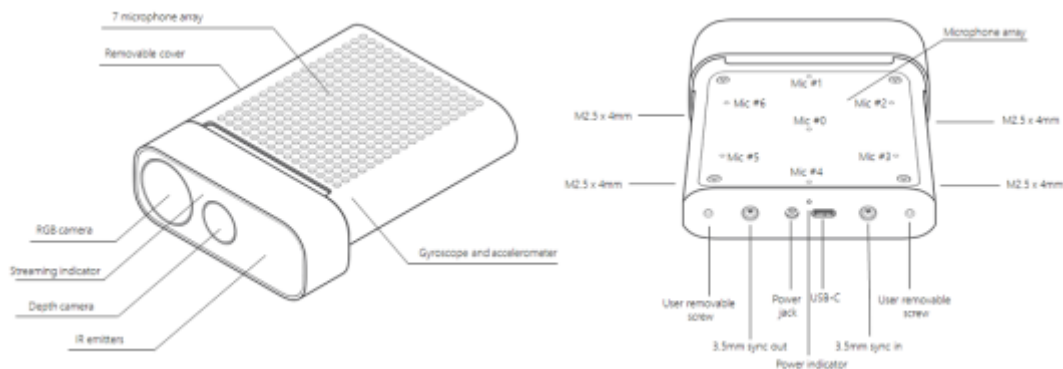


Fig. 15. Azure Kinect parts (source: microsoft.com)

2.4.1.2 Body tracking

Azure Kinect supports capturing multiple people at once in real time. Each person is identified by their own temporary identifier, which allows the classification to re-recognize the same person even after leaving the scene and returning. The skeleton is formed by points in space that are connected. Their position and orientation are estimated in millimetres and expressed as a normalized quaternion.

INTERESTING

The scanned skeleton consists of 32 individual connected joints that spring from the centre of the body to the limbs. Each connection between these points can be called a bone and represents the connection between the parent point and the offspring point.

The following image shows all available joints and bones of the complete skeleton represented by Azure Kinect.

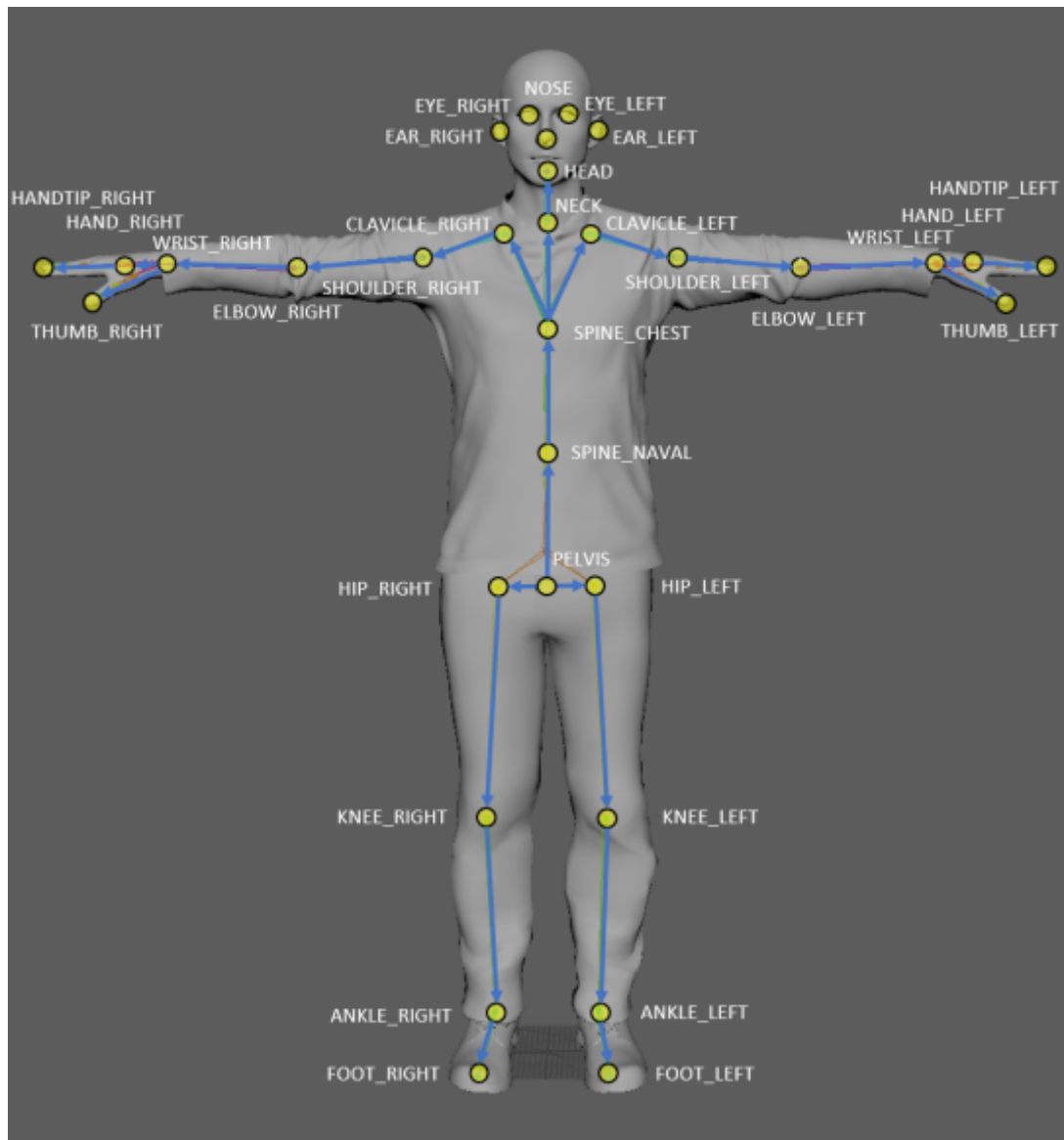


Fig. 16. Azure Kinect – skeletal tracking (source: microsoft.com)

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2.4.2 Stereoscopic Capture

2.4.2.1 Spatial 3D spherical camera system

Camera rig for capturing spherical stereoscopic scenes

Spatial 3D spherical camera system is a model that contains 20 nests and 120 cameras mounted on them. The nest is a hexagonal shape to which cameras can be attached. The nests are located on the tops of the dodecahedron. The camera rig can record 360-degree spherical stereoscopic images that can be projected into virtual scenes and programs. There are 6 cameras mounted on the nest, which are located at the edges of the hexagon and thanks to that they are able to record 360 degrees to a certain plane. Each camera records full HD video at 60 frames per second. To create the ability to look in any direction, it is necessary to combine the individual nests into one image and thus create an omnidirectional stereoscopic vision. The image interconnection is provided by a powerful computer system that ensures smooth operation and communication between the spatial 3D spherical camera system and a display unit such as a VR headset. A user wearing a VR headset can look in any direction. The most difficult part is to display connected images so that there are no unevenness, bending of space or distortion.

ADVANTAGE

Benefits Spatial 3D spherical camera system to Horizontal 3D spherical camera system:

- The user wearing the VR headset can look in any direction.
- The combination of a higher number of cameras improves the resulting image quality.
- The layout of the cameras creates better image connection options and records the surroundings in more detail



Fig. 17. Spatial 3D spherical camera system

2.4.2.2 *Horizontal 3D spherical camera system*

Camera rig for capturing horizontal stereoscopic scenes

Horizontal 3D spherical camera system is a model that contains 6 nests on which 36 cameras are located. The arrangement of the nests is around the circumference of the hexagon, and they occupy the whole 360 degrees. The cameras arranged in this way are able to record spherical stereoscopic video. The advantage of the model is compactness and the ability to record horizontal plane shots. Both the spatial 3D spherical camera system and the Horizontal 3D spherical camera system contain cameras that are capable of shooting at full HD resolution at 60 frames per second. In order to create a quality image and display all the angles that the user can look at, it is necessary to combine the individual outputs from the cameras into one combined image. The images thus combined are then displayed in a display unit such as a VR headset. A user wearing a VR headset can look in different directions in a horizontal position. To process and combine the image, it is necessary to connect the device to a powerful computer unit that has sufficient graphics power to perform individual tasks.

ADVANTAGE

Benefits Horizontal 3D spherical camera system to Spatial 3D spherical camera system:

- Smaller and more compact device.
- Less computational power required to merge images.
- Easier operation of the device and installation.

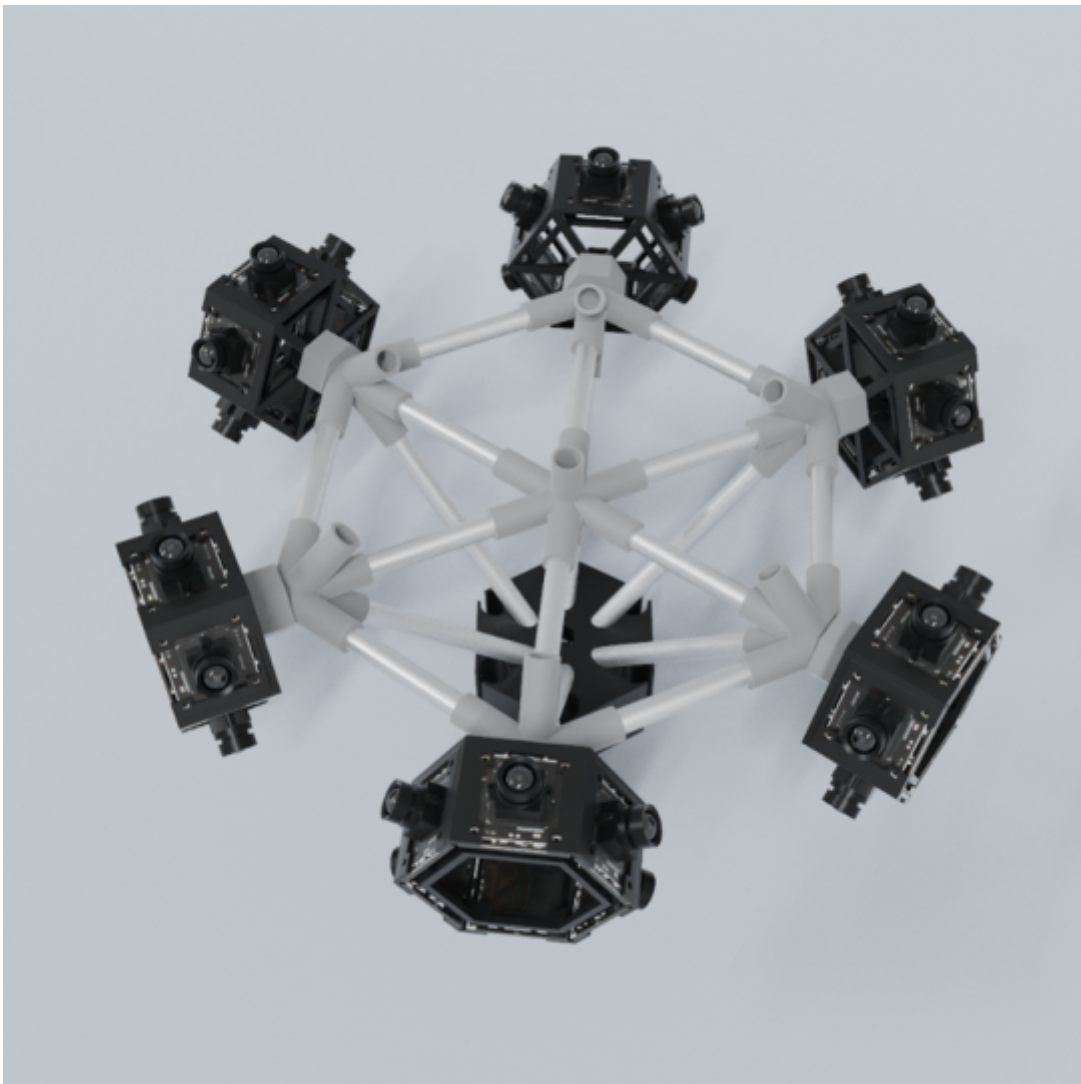


Fig. 18. Horizontal 3D spherical camera system

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CHAPTER 3

Virtual Reality (VR)

3.1 Principles

DEFINITION

Virtual reality is the use of computing to create simulated environments. Virtual reality places the user in a three-dimensional experience. Instead of looking at the screen in front of them, users are immersed in and interacting with 3D worlds. Simulating the human senses - all five - turns a computer into a vehicle into new worlds. The only limit to the excellent VR experience is computing power and content availability.

All three types of VR, from non-immersion, semi-immersion, fully immersion or mixtures thereof, are also referred to as extended reality (XR). Three types of virtual reality experiences provide different levels of computer-generated simulation.

3.1.1 The three main categories of the VR

DEFINITION

Non-immersive virtual reality: This category is often overlooked as VR simply because it is so common. VR-intensive technology includes a computer-generated virtual environment in which the user is simultaneously aware of and controlled by their physical environment. Video games are a prime example of non-immersive VR.

DEFINITION

Semi-immersive virtual reality: This type of VR provides an experience based in part on a virtual environment. This type of VR makes sense for educational and training purposes with graphics computers and large projector systems such as flight simulators for pilots.

DEFINITION

Fully immersive virtual reality: There are currently no fully immersive VR technologies, but progress is so rapid that they may be just around the corner. This type of VR creates the most realistic simulation experience, from sight through sound to sometimes olfactory sensations. Car racing games are an example of immersive virtual reality that gives the user a sense of speed and

driving skills. VR, developed for gaming and other entertainment purposes, is on the rise in other sectors.

NOTE

The definition of virtual technology includes specific shared characteristics. Not only are they immersive, but they are also computer-generated, credible as multidimensional experiences and interactive.

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3.2 Displaying devices

3.2.1 Meta Quest 2 – Glasses for VR

NOTE

Meta Quest 2 is a virtual reality (VR) headset developed by Facebook Reality Labs. As with its predecessor, the Quest 2 can run as both a standalone headset with an internal, Android-based operating system, and with Oculus-compatible VR software running on a desktop computer when connected over USB or Wi-Fi.

The Quest 2 uses the Qualcomm Snapdragon XR2 SoC which is part of a Snapdragon product line designed primarily for VR and augmented reality devices with 6 GB of RAM. Its display is a singular fast-switch LCD panel with an 1832×1920 per eye resolution, which can run at a refresh rate of up to 120 Hz. The headset includes physical interpupillary distance (IPD) adjustment at 58 mm, 63 mm, and 68 mm, adjusted by physically moving the lenses into each position. The included controllers with the Quest 2 are the third generation Oculus Touch controllers. The design of the new controllers was influenced by the original Oculus Rift controllers.

Quest 2 supports all games and software made for the first-generation model, and existing titles can be updated to support higher graphical quality on Quest 2. It also supports Oculus Link, which allows the headset to be used with Oculus Rift-compatible software on a PC. The Quest 2 supports 6 degrees of freedom head and hand tracking through integrated Oculus Insight technology.



Fig. 19. Oculus Quest 2 (source: [oculus.com](https://www.oculus.com))

The basic functions of this device include the following:

- Passthrough - It is a feature that allows you to step outside your view in VR to see a real-time view of your surroundings. Passthrough uses the sensors on your headset to approximate what you would see if you were able to look directly through the front of your headset and into the real world around you.
- Hand tracking - It is a feature that allows you to use your hands in place of your Touch controllers. VR headset will detect the position and orientation of your hands and the configuration of your fingers. Once detected, computer vision algorithms are used to track the movement and orientation of your hands.
- Voice commands - built-in voice commands allow you to move and control the device.
- Support of Steam VR

Other similar devices used to access virtual reality spaces include HTC Vive Pro, PlayStation VR, Pimax Vision and many others.

CHAPTER 4

Augmented reality (AR)

4.1 Principles

DEFINITION

Augmented Reality (AR) is a cousin of VR and does not stimulate the creation of a virtual world. Unlike VR, AR is accessed using mobile phones but AR glasses. AR combines the physical world with computer-generated virtual elements. These elements are then projected onto the physical surfaces in the field of view of people, so with the intention of combining them to complement each other.

Augmented reality inserts or overlays real-world content using devices such as a smartphone screen or a headset. While virtual reality replaces what people see and experience, augmented reality adds content to reality.

NOTE

Using devices like HTC Vive, Oculus Rift or Google Cardboard, virtual reality completely covers and replaces the user's field of view, while AR projects images in front of them into a fixed area.

4.2 Displaying device

4.2.1 Microsoft HoloLens 2 – Glasses for AR

DEFINITION

Microsoft HoloLens 2 is the second iteration of a revolutionary mixed reality device. It's a device with a shield on your eyes that you put on your head, which allows a completely new way of interacting with information. It is a stand-alone device with an on-board computer and a built-in Wi-Fi module that acts as a data client on a stand-alone device, the Azure cloud, or the web in general.

HoloLens 2 runs on the Windows Holographic OS, which is very similar to Windows 10 and provides users, administrators, and developers with a robust, powerful, and secure platform. Compared to its predecessor, this is an almost brand-new product with more computing power, better sensors, longer battery life and a few extra features that should be mentioned. It has a larger FOV - a display field that allows the user to see more information and makes the device more interesting to use with applications that provide a large amount of information.

Brand new, more intuitive hand gestures are available to make content easier to manipulate. Any command can be executed by combining the user's hand movement with voice control. The most visible improvement over the old model is that the device is smaller and lighter. This makes it much more comfortable to wear and work with.

INTERESTING

HoloLens 2 contains several sensors, namely - 4 cameras (visible light) for head tracking, 2 infrared cameras for eye tracking, 1 megapixel depth camera, accelerometer, gyroscope, magnetometer and one 8-megapixel camera with HD resolution.



Fig. 20. Microsoft HoloLens 2 (source: microsoft.com)

The basic functions of this device include the following:

- World-anchoring - HoloLens 2 understands the workspace so digital content and holograms remain anchored where they were created
- Hand tracking - allows you to touch, grab and scroll holograms in a natural way
- Eye tracking - the device captures where the user is looking, so he can understand the intent and adjust the holograms to his eyes in real time
- Voice enabled - built-in voice commands allow you to move and control the device quickly while your hands are busy with a task
- Azure-powered stream - allows you to stream 3D content using the Microsoft Azure cloud platform
- Mixed reality capture - allows you to document all experiences, whether as a photo or as a video that can be shared with others
- Ergonomic - the device is heavy (3.28 kg) and you can move freely without cables or external packaging

Microsoft offers multiple approaches to content development for HoloLens devices. For example, it provides cloud services on the Microsoft Azure platform, which are not difficult to use and can serve as a starting point for application development. For developers who at some points do not have access to the physical representation of these glasses, a software emulator is available on which they are able to develop and test their applications. Application development for HoloLens devices needs to target the Universal Windows Platform to work properly. (Alternative when developing applications for HoloLens devices, we will focus on the target Universal Windows Platform).

INTERESTING

Other similar devices used to access augmented reality spaces include: Google Glass, Vuzix Blade AR, Raptor AR and many others.

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CHAPTER 5

Methods and software for designing VR and AR

5.1 Unity – Game Engine

Unity is a 3D/2D game engine and powerful cross-platform IDE for developers. As a game engine, Unity can provide many of the most important built-in features that make a game work. That means things like physics, 3D rendering, and collision detection. As well as a game engine, Unity is an IDE. IDE stands for “integrated development environment,” which describes an interface that gives you access to all the tools you need for development in one place. The Unity software has a visual editor that allows creators to simply drag and drop elements into scenes and then manipulate their properties.

ADVANTAGE

Unity also offers excellent VR support. The Unity editor is supported on Windows, macOS, and the Linux platform, while the engine itself currently supports building games for more than 19 different platforms, including mobile, desktop, consoles, and virtual reality.

Officially supported platforms as of Unity 2022 LTS are:

- Mobile platforms iOS, Android (Android TV), tvOS
- Desktop platforms Windows (Universal Windows Platform), Mac, Linux
- Web platform WebGL
- Console platforms PlayStation (PS4, PS5), Xbox (Xbox One, Xbox Series X/S), Nintendo Switch, Stadia
- Virtual/Extended reality platforms Oculus, PlayStation VR, Google's ARCore, Apple's ARKit, Windows Mixed Reality (HoloLens), Magic Leap, and via Unity XR SDK Steam VR, Google Cardboard

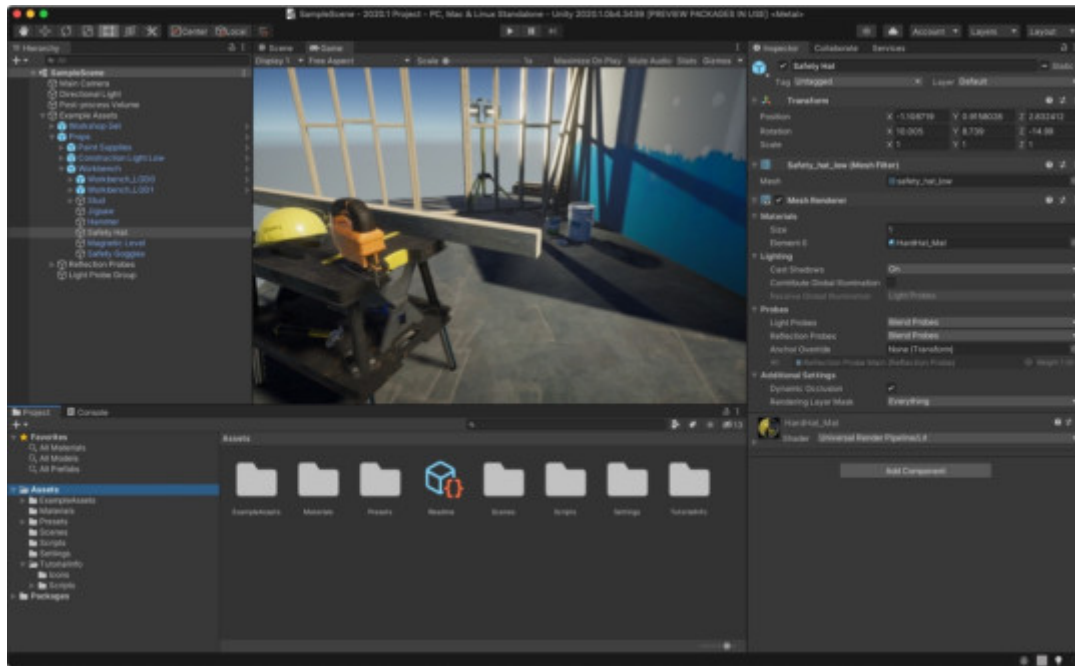


Fig. 21. Unity Studio (source: unity3d.com)

The Unity contains an important element Asset Store. Asset Store is a growing library of Assets. Both Unity Technologies and members of the community create these Assets and publish them to the store. There are various types of Assets in the store ranging from textures, animations and models to entire Project examples, tutorials and Editor extensions.

A Unity asset is an item that you can use in your game or Project. An asset may come from a file created outside of Unity, such as a 3D model, an audio file, an image, or any of the other types of files that Unity supports. There are also some asset types that you can create within Unity, such as an Animator Controller, an Audio Mixer, or a Render Texture. The Asset store is sorted into the different types of assets available. Here's a breakdown of what each asset type is:

- 3D assets - The 3D assets section includes vehicles, characters, props, vegetation, and animations.
- 2D assets - The 2D assets section includes sprites, textures, characters, environments, fonts, materials, and UI elements.
- Add-ons - Adds-ons are more advanced features you can import into your Project. Browse here for features such as Unity Ads, analytics, and in-app purchases.
- Audio - Audio has a library of sound files that you can use to enrich the user experience of your project. The Unity Asset Store has a variety of free and affordable audio assets, including ambient, music, and sound effects.
- Templates - The Templates section allows you to download various tutorials and starter packs, a great section especially for beginners.

- Tools - There is a wide spectrum of options for what project needs, anything from AI to Visual Scripting.
- VFX – Visual effects which include particle effects and shaders.

Unity allows the creation of one's own Components using scripts. These allow the user to trigger game events, modify Component properties over time and respond to user input in a way that is preferred. Unity supports the C# programming language natively. Unity is an excellent tool for creating games and applications in VR but it is necessary to configure Unity Project for XR. The

INTERESTING

Unity has created a plugin that unifies all SDKs and thus creates a tool that allows you to create applications for a number of headsets.

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CHAPTER 6

Virtual communication spaces

6.1 Spatial

Spatial is currently the best known and most immersive VR / AR video conferencing application. When registering, all you must do is take a photo of your face from the front, which the Spatial application then maps to the 3D avatar you will work with in the application. You can immediately enter the dozen rooms on offer, including NASA's Space X room and various image galleries.

For video conferencing, you have the option of creating your own virtual room (either with a predefined office template or purely empty). Other video conferencing members can be easily invited by email. Each connected member is represented by a 3D avatar, whether connected via a web browser or directly with a VR / AR headset. In the created room, Spatial offers a wide range of support tools that you can use, for example, for presentations - from 3D objects that you can manipulate, to various built-in collaboration applications such as Slido, Figma.

ADVANTAGE

- The basic version, which offers all the above functionalities, is free
- Extensive support for multiple VR / AR headsets
- Create a realistic 3D avatar from just one face photo
- Lots of built-in tools for presentation or virtual collaboration

DISADVANTAGE

- Mouth movement mapping only by voice detection - if audio input comes from the user, the avatar opens the mouth
- Eye tracking is missing



Fig. 22. Spatial App screenshot (source: spatial.io)

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6.2 Microsoft Mesh

Microsoft Mesh provides users with meeting space in different AR / VR spaces, enables interaction with other users and 3D content, while handling all the complex technical parts of sharing multi-user spatial experiences over the web. The main feature and goal of this application is collaboration in a virtual and mixed space - a combination of AR / VR - XR.

Within Microsoft Mesh, companies will be able to create and access applications that allow collaboration on holographic or 3D projects in real time. You can share ideas with team members across half the globe, and sensors can track your movements so you can interact with digital content as if you were working with it in real life. Other key features of this system include animated avatars, modelled to reflect as realistically as possible in the real world, interactive teleconferencing meetings, where much of the functionality is planned for use by the already well-known Microsoft Team commercial platform, application integration where have users be able to use most Microsoft applications as well as other third-party applications during the meeting.

ADVANTAGE

The great advantage of this system is that it can be run on a wide range of devices from AR devices - HoloLens 2 via VR devices - HP Reverb G2 or Oculus Quest 2 to smartphones and tablets with iOS and Android operating systems.

To support a huge number of system functions, there is also a significant part of the hardware load, where the application may not behave smoothly in several tasks (e.g. in detailed modelling).

ADVANTAGE

- You can create really any avatars
- A very specific room can be easily created through the Unity SDK
- Microsoft Mesh supports Full-body tracking, so it doesn't have a "flying polka body"

DISADVANTAGE

- Weak support for detailed face and eye tracking, even though it can track full body movement



Fig. 23. Microsoft Mesh App screenshot (source: microsoft.com)

Interaktivní prvek

6.3 Horizon Workrooms

Horizon Workrooms is a virtual meeting place where you and your colleagues can work together better from anywhere. You can join a VR meeting as an avatar or join a virtual room via your PC via video call. You can use a huge virtual whiteboard to sketch ideas together, for example, transfer your computer and keyboard to VR so you can collaborate with others, or just have expressive conversations that make you feel like you're in person. Horizon Workrooms differs from other solutions in that it maps your personal workspace into reality, but into the same space but in virtual reality.

ADVANTAGE

- Horizon Workrooms is currently free
- It allows you to host meetings attended by up to 50 people
- It integrates a form of mixed reality - mapping a real keyboard and desk into virtual reality

DISADVANTAGE

- Support for Oculus Quest 2 devices only
- Typing on a virtual keyboard is not the best user experience - the letters are small, and it often happens that you do not hit the intended letter



Fig. 24. Horizon Workroom App screenshot (source: vr-expert.com)

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6.4 Metaverse

In January 2020, author and investor Matthew Ball published the most widely cited description of the metaverse: "an extensive network of enduring 3D worlds and real-time simulations that [...] can be synchronously experienced by a truly unlimited number of users, each with an individual sense of presence."

By its definition, a metaverse is a product or service with seven basic attributes, including persistence, synchronicity, and interoperability. However, technology strategist Ben Thompson argued that the description was not far from what the Internet is and does, just "with the 3D layer on top."

6.4.1 Metaverse as a place

DEFINITION

Metaverse has also been described as a place where users can connect, interact, and transfer themselves and their stuff in multiple digital places. Examples that come to mind include gaming and creative platforms such as Roblox, Epic Games 'Fortnite or Manticore Games' Core, in which players and their avatars can seamlessly move from one virtual world to another.



Fig. 25. Metaverse imagination (source: expatguideturkey.com)

6.4.2 Metaverse as a moment

Recently, budding entrepreneur Shaan Puri came up with a different definition that describes the metaverse as a point in time. Specifically, metaverse is the moment when our digital lives - our online identities, experiences, relationships, and assets - become more meaningful to us than our physical lives. This perspective emphasizes human experience, making the transition to metaverse a sociological shift instead of a technological one.

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6.4.3 Metaverse in practice

The third definition is compelling in part because it focuses on those who actually build and use the metaverse: people. Answering questions about what a metaverse can look like and feel - instead of thinking about its features - could prove to be a useful insight into predicting the wave of socio-economic change that the metaverse is expected to unleash. After all, the future is being built by ruthless pragmatists; not cartoon theorists who "meander through the forest of their own words."

And if the technologists are right that 2022 will separate the thinkers from the builders, then the technical advances of previous years will bring the first steps this year towards making the metaverse a reality.

NOTE

Progress will be largely attributed to ever better graphics processing units (GPUs), photorealistic 3D engines, faster content generation through volume video and artificial intelligence, growing cloud computing and 5G expansion, as well as a more sophisticated and better understanding of blockchain infrastructure.



Fig. 26. Metaverse imagination (source: asia.nikkei.com)

However, in terms of human experience, one development stands out from all the others: extended reality (XR) technologies. These include virtual reality (VR), augmented reality (AR), and brain-computer interfaces (BCIs), which are being built together as additional computing platforms in their own right.

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6.5 Metaverse in movies

Recently, we are increasingly encountering concepts such as virtual or augmented reality. The development of technologies and algorithms, together with artificial intelligence, will soon provide the necessary means to realize virtual worlds. Whether people succumb to such an idea and begin to prefer living in a virtual environment to living in reality will remain an unanswered question for a while. Today, however, we also meet in cinematography with ideas about what such a life might look like in virtual reality and what it could bring to humanity or take away.

6.5.1 Ready Player One

The film takes place in 2045 when the world is a very inhospitable place. High school student Wade Watts, like most of humanity, escapes from the bleak reality of a virtual utopia called OASIS, where anyone can be as long as they want. There are thousands of planets on which you can live, play, but also fall in love. OASIS creator James Halliday died without descendants and decided to donate his fabulous wealth together with OASIS to a man who will solve puzzles and fulfil the tasks scattered in his creation.

Millions of people have been trying in vain for years to unravel the dense network of references to pop culture of the late twentieth century. Until Wade one day finds the key to solving the first riddle and rebounding, he faces thousands of opponents in a desperate race to seize the grand prize. However, it is not just a tempting win, but especially the terrifying impact of the race on the real world, which will change fundamentally.



Fig. 27. Ready Player One movie cover (source: roadtovr.com)

6.5.2 Free Guy

Guy is a bank clerk at Free City Bank and leads a simple life. He radiates positivity and joyful optimism and is always willing to go for a good coffee. Together with his best friend Buddy, he has a huge zest for life, but everything suddenly changes when he discovers that he is actually a character against the background of a very violent open-world video game: "Free City".

"Free City" is a very popular game where chaos and destruction reign. Players in it lead a life without rules and move to higher levels by committing unjustified acts of violence and vandalism. Guy meets Molotovgirl and is fascinated by her, she is the one who helps him get through the game and deal with the fact that the only life he knows is not real. Molotovgirl's name is Millie in real life, and she has unfinished accounts with Soon.

When Guy becomes more active in his role as a good man - an idealist in a cynical world without rules - he becomes a supporter of players and other NPCs (unplayable characters) and a hero of his own story, which he already writes himself. Guy's popularity is growing, and Antwan realizes that this is seriously jeopardizing the future of "Free City" and especially the planned sequel to "Free City: Massacre," so he instructs Keys and another Soonami programmer named Mouser to permanently remove Guy from the game. And suddenly it's up to Guy to save his world in his own way.



Fig. 28. Free Guy movie screenshot (source: wired.com)

CHAPTER 7

Test

How many connected joints can Kinect Azure recognize?

- 16
- 32
- 64
- 128

Two parallel-mounted infrared cameras that transmit texture images to

- observed object and look for common points between images
- look for common point between image only
- Observe object only
- nun of them

What technology doesn't belong to deep vision?

- Time of Flight
- Structured Light
- Length of Wave
- Stereoscopic

The main categories of VR are-

- Non-immersive VR
- Partial immersive VR

- Semi-immersive VR
- Fully immersive VR

What meeting space solution actually allows you to host meetings attended by up to 50 people

- Spatial
- Microsoft Mesh
- Horizon Workrooms
- Facebook Metaverse

The main functions of Meta Quest 2 VR Glasses

- Passthrough
- Hand tracking
- Voice commands
- None of the above

The graphic designer creates rough models of 3D objects and arranging them into a scene which focuses on the

- shell of object
- object boundaries
- Both of them
- Nun of them

Which are the components of Microsoft HoloLens 2?

- Magnetometer
- Accelerometer
- Transistor

Receptor

Unity software is used for-

- Developing games
- Multiphysics
- Designing software
- Supporting virtual reality

what kind of adjustment helps designers to prepare the scene for texture?

- lighting
- lighting and location
- smoothing
- rotation

what is the art of dressing up 3D models?

- Texturing
- Adding colours
- Patterns
- Smudges

Unity consists of-

- 1D assets
- 2D assets
- 3D assets
- 4D assets

What are the advantages of Microsoft Mesh?

- It cannot create really an avtar
- It can create a specific room using unity SDK
- It does not support body tracking.
- It can run on wide range of devices.

In post processing what make the scene more realistic?

- Photo filter
- lighting
- colour correction
- Effects

According to the definition of a metaverse, which of these are attributes of it?

- Displacement
- Flexibility
- Persistance
- Interoperability

which process provides the right angle and desired atmosphere for resuting image?

- Set the orientation of the camera
- Crafted lighting
- Rendering
- Detailing

What is the highest possible resolution for Azure Kinect RGB camera

- 3840*2160px
- 1024*1024
- 2840*1024
- 3024*2160

Blender is used for

- Network modelling
- Digital shaping
- parametric modelling
- 3D modelling

Named a free open-source software for 3D modelling?

- Blender
- Cinema4D
- Google Sketchup
- Swiss military tool

virtual reality completely covers and replaces the user's field of view using devices like

- HTC Vive
- Oculus Rift
- Google Cardboard
- HTC Vive, Oculus Rift

What is depth map?

- camera sensing
- capture deformed sequence

- Pre configured sequence
- None

most important built-in features that make a game work in Unity

- 3D rendering, game engine and collision detection
- 3D rendering only
- game engine
- collision detection

In the context of polygon modeling what are connected by lines to form a polygon?

- Planes
- Curve
- Vertices
- None

The Unity software has a visual editor that allows creators to

- simply drag and drop elements into scenes
- manipulate their properties
- provide VR support
- collision detection

The 3D assets section includes

- characters and environments
- vehicles, characters, props, vegetation and animations.
- fonts, materials and UI elements.

includes sprites and textures

Which of these is one of the types of digital Scriptures?

- Spatial
- Volumetric
- Distance
- Surficial

While creating a 3D model, imperfections like a splinter, and scratches occur during which step?

- Detailing
- Blocking
- Texturing
- Rendering

Which of these given approaches is not a approach for 3D modeling in Blender

- Parametric modeling
- Network Modeling
- Digital Shaping modeling
- Volumetric Modeling

Kinet Azure is a sensor used for capturing 3D scenes in a devices uses how many cameras?

- 4
- 3

2

1

Which of the components of Azure Kinect belongs to the hardware of the system.

Triaxial Accelerometer

Gyroscope

IMU Sensor

All of the above

The position and orientation of the skeleton in the in space are connected by Azure Kinect in...

Nanometer

Millimeter

Centimeter

Micrometer

Which of the following depth-sensing technology is used by Real Sense system?

Structured Light Pattern
projection

Active IR Stereo

Time-of-flight

None of the above