Unity® Virtual Reality Development with VRTK4

A No-Coding Approach to Developing Immersive VR Experiences, Games, & Apps

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Christopher Coutinho

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Any source code or other supplementary material referenced by the author in this book is available to readers on GitHub via the book's product page, located at https://github.com/Apress/VR-Development-with-Unity-VRTK. For more detailed information, please visit http://www.apress.com/source-code.

Printed on acid-free paper

To all VR enthusiasts . . .
wherever you are

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About the Author

Christopher Coutinho is the founder of GameWorks, a Mumbai-based game development studio specializing in VR and virtual product development using Unity and VRTK 4. GameWorks provides development services to clients in game creation, Unity tools creation, and VR simulation-training development. Christopher is highly active on the VRTK's Discord channel. He is also known for his highly acclaimed online virtual reality courses on Udemy using Unity and VRTK 4.

About the Technical Reviewer

Dr. Kevin Tan is an associate professor at the Game School, which is part of Inland Norway University of Applied Science in Norway. He is also the course leader for the Augmented and Virtual Reality add-on program at the Game School.

Before Kevin joined the Game School in 2019, he received a Bachelor of Science degree with Honors in computer science, with a concentration in software engineering, from the University of Greenwich; a Master of Science degree in computer vision, visual, and virtual environments from the University of Leeds; and a PhD in bimanual interaction in virtual environments from the University of Salford, all in the United Kingdom.

After receiving his PhD, Kevin served as a postdoctoral research assistant at the Materials Science Center at the University of Manchester and went on to become a senior lecturer and course leader in the Computer Games Development course at Manchester Metropolitan University.

Kevin's research interests lie in developing Extended Reality (XR) for crossdisciplinary enterprise applications. In the past, he was involved in neural networks and artificial intelligence for gaming. He is now researching the emotion and personality of AI and the use of emotional traits to represent facial expressions in digital learning with VR. Besides that, Kevin also researches the achievement of realistic interactions with physical objects in VR environments.

Kevin's research focuses on the following areas:

- The use of Augmented Reality (AR) and VR technology in using game engines such as Unity3D and Unreal Engine.
- The research applications of the hybrid versions of augmented and virtual reality for health care, art, and tourism.

- The use of deep-learning algorithms for the prediction of microfacial expressions in simulation and games.
- Human-oriented cognitive issues that are integrated into neural network systems in the human-computer interaction environment.

Kevin is also a Unity-certified associate programmer.

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I want to thank Apress publishing for allowing me to write this book. The experience of working with the editors Spandana Chatterjee and Divya Modi has been a true pleasure from inception to completion.

A big thank you must also go to Kevin Tan, my technical reviewer, whose frank and precise comments made this a much easier-to-understand book. I also would like to thank the developer of the VRTK, Harvey Ball, also known as "the stone fox," whose insightful explanations have always been helpful and whose perspicacious ability is commendable. Additionally, I want to thank the VRTK community that I often frequent to learn from others and answer questions.

Last, I'd like to recognize the people who have made my experience with Unity a fruitful one. That, of course, starts with those at Unity Technologies, the company that makes the game engine at Unity.

Introduction

Who Is This Book Written For?

This book is for game developers interested in developing immersive virtual reality (VR) experiences, games, apps, and tool kits using Unity and the VRTK. It uses a no-coding approach, so you don't need to know C# programming and you won't be called upon to launch Visual Studio even once.

The book is aimed at beginner-to-intermediate Unity game developers who want to know get know their way around the Unity editor for basic scene editing. A basic knowledge of how Unity prefabs function, of how its events work in general, and of programming logic would be beneficial. You don't need to be able to write any event code to do the exercises in this book. However, if you're an absolute beginner to Unity, this is not the book for you.

What Are We Building?

This book is structured for building a complete VR framework over the course of 22 chapters. You'll learn to set up state-of-the-art VR mechanics as part of the VR framework you build.

It uses version 4 of the VRTK, which is free to download. This makes understanding VRTK 4 super easy, and the framework you develop will be one massive, cohesive, lean and mean machine. By the end of this book, you'll have an advanced VR framework that you can even publish yourself.

Using Unity and VRTK 4, we'll build an advanced VR framework from scratch that can be used as the foundation for creating any VR game or experience. In the last chapter, you'll utilize the VR framework you built to create your very own minigame, without writing a single line of code.

What Is Required for This Book

To do the exercises in this book, you'll need access to a six-DOF (degrees of freedom) headset of Steam VR or Oculus. A three-DOF headset won't work, as you need to be able to move around within your world.

You could use a Steam VR headset like the HTC Vive, an Oculus headset like the Oculus Rift, or the Oculus Quest (both 1 and 2 will work fine). These are some of the more popular six-DOF headsets available, and the ones this book's content has been tested with. The content of this book hasn't been tested with a Windows Mixed Reality headset, so you'll need to use one of the headsets just mentioned.

If you intend to use the Oculus Quest, it would be advisable to have a link cable, as deploying a build to the headset each time you test is not very practical and would be time consuming. You aren't required to get the Oculus-approved link cable, as several cheaper options are available online from Anchor, Belkin, and Amazon.

You need to have a computer running Windows 10 and the 2020 version of Unity LTS (Long Term Support). Your computer hardware should be compatible with your VR headset in terms of the graphics card it uses and the amount of RAM it requires. If you can play VR games while being tethered to your computer without any issues, your computer should already be compatible for development.

Both Oculus and Steam VR provide system tools that allow you to check whether your computer meets the minimum requirements to be VR ready. Head over to `www.vive.com/eu/setup/` or `www.oculus.com/setup/`, and go through the guided installation and setup process listed on either site. Last, ensure that you have your VR headset set to Developer Mode.

Downloadable Content

Most chapters in this book include some form of downloadable content that lets you experiment with and implement the advanced VR mechanics taught here. Most of this downloadable content has been provided to you as Unity package files and a single manifest.json file. The book's chapters explain how these files are to be used.

In addition, you've been provided with the complete working VR framework and minigame as a .rar file download (VR_Playground.rar) so that you can quickly examine how various individual VR mechanics have been set up as part of this framework. Upon decompressing the VR_Playground.rar file, you need to ensure that you load this project

using version 2020.3.15f2 of Unity LTS only, as this is the version the project was created in. Unity 2020 is notorious for breaking a project if used with a version different from the one in which the project was created. If you intend to use the provided VR_Playground project, it must be launched using version 2020.3.15f2 to be functional. Launching the project with any other version of Unity will result in colliders missing and many other issues cropping up.

All downloadable content for this book can be accessed on the following page: https://github.com/Apress/VR-Development-with-Unity-VRTK.

CHAPTER 1

Introduction

In this introductory chapter, you will get acquainted with Unity virtual reality development, a no-coding approach that you can use to create immersive virtual reality (VR) experiences. You will find out two ways that you can approach the material covered in the book. I will also discuss the other alternatives available for VR development and point out the advantages of using the no-coding approach. Finally, I will list the VR hardware required to follow along with this book.

A No-Coding Approach to VR Development

The goal of this book is to show you everything you need to know to develop truly immersive VR experiences using Unity without the need to write a single line of code.

This no-coding approach is made possible by version 4 of the Virtual Reality Toolkit (VRTK) by Extend Reality Ltd. VRTK is available for free and licensed by MIT (Massachusetts Institute of Technology).

Every VR developer knows that getting their VR framework right is fundamental to having a great VR experience. The proper framework involves a mix of the latest and greatest VR mechanics you see within VR games and experiences today. In this book, you will learn to build your own VR framework from scratch, using some advanced VR mechanics. The VR framework you build can be transferred from one VR project to another, using as few or as many VR mechanics as you require. Using the VR framework you built, you will be able to create almost any type of VR game or experience you desire.

By the end of this book, you will have not only implemented some exciting game mechanics but will have also created your very own minigame.

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Two Ways to Approach the Material Covered in This Book

Every chapter in this book utilizes a practical, hands-on approach for implementing the content in your Unity project. Learning by practice is the ideal way to get to know VR development.

There are two ways to approach the material covered in this book; namely, a top-down approach and a bottom-up approach.

Beginners in VR development should use the top-down approach, starting with Chapter 1 and proceeding sequentially through the chapters in the book, implementing the concepts taught within their project. Using this approach, you will utilize several provided Unity packages, which you will download and import, as explained in each chapter. In my opinion, this is the best way to get the most out of this book, especially if you are a beginner in VR development or version 4 of the VRTK. I suggest that you first review each chapter to get an overall idea of the concepts and then review the chapters a second time to implement the content in your Unity project.

If you're not a beginner in VR development or version 4 of the VRTK, you're probably looking to jump right into working with the VR framework and use it to build your very own game, app, or experience. In this case, I would suggest the bottom-up approach, where you directly download the complete VR framework ZIP file and then launch it using Unity's latest LTS (Long Term Support) version 2020.3.x. With this, you can browse through chapters that interest you and explore how the various prefabs have been set up. It would help to quickly learn how to use the framework. You can always go back through the chapters sequentially when you have the time.

Advantages of VRTK over Alternative Solutions

Version 4 of the VRTK is not the only solution available for getting started with VR development. Unity, Oculus, and Steam VR also provide their SDKs (Software Development Kit) for VR development. It is also possible to purchase assets from the Unity asset store to achieve the VR-specific functionality you desire.

Unity's Extended Reality (XR) Interaction Toolkit is another high-level component-based interaction system for creating VR experiences. Oculus and Steam VR, on the other hand, provide SDKs for their respective platforms.

However, the most significant advantage of version 4 of the VRTK is that it provides a simple yet extensible framework that works across multiple platforms. It is also both free and open source.

The VRTK is a VR development tool kit that provides a wide range of built-in support for the core components of VR, such as locomotion, interaction with 3D objects, and 2D and 3D controls. It reduces the amount of code you need to write to get started with VR development, allowing you to concentrate on developing the parts of your game or application without having to worry about input management , character controllers, locomotion methods, climbing and grabbing mechanics, UI interactions, and a lot of other fundamentals you probably have come to expect from a VR framework.

Building this whole extensive VR framework by yourself from scratch will give you a much deeper level of understanding of how to put it to use in building different VR games and experiences. By the end of this book, you will have built an extremely sophisticated VR framework, way better than you would get with most other free and paid VR frameworks and tool kits out there.

Summary

In this introductory chapter, you learned about the no-coding approach that you find with version 4 of the VRTK. You have also been introduced to the two ways you can approach the material covered in this book. You then explored the other solutions available for VR development and some of the advantages that version 4 of the VRTK provides over them. Lastly, the VR hardware that you will need to follow along with the content matter in this book was discussed.

CHAPTER 2

A New Reality through Virtual Reality

In this chapter, I will explain what virtual reality (VR) is and why it is worth your time to become a VR pioneer as well as some of the areas within which it is being used. You will also learn about three essential concepts in VR: the place illusion, the plausibility illusion, and the embodiment illusion, which are essential for creating genuine immersion in VR. Additionally, you will find out about the popular headsets currently on the market that you will need to follow along with this book and be introduced to the term *degrees of freedom*.

What Is Virtual Reality?

There is much excitement around the topic of virtual reality, also known as VR. The definition of *virtual reality* can be extensive, encompassing everything that happens in the digital world, like social networking, online marketing, and so forth. However, more often, the term is used to refer to a medium that immerses users in a computer-generated, simulated representation of a natural or fantasy world, allowing them to see, feel, hear, and interact with the simulated environment and the objects within it. As users are completely immersed in and engaged with this interactive experience, they can look around, move about, and interact with objects without ever having to break the illusion of being in a virtual world. VR is made possible by using a headset, input controllers, gloves, or even full bodysuits.

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Become a VR pioneer now, and create the future!

Since the VR market is still very young, a lot of room remains for breakthroughs. Creating something completely new is a unique opportunity that VR provides you.

It took approximately 27 years for PCs to grow from representing 2% to representing 70% of the type of computer most used in the United States, approximately 13 years for the Internet to reach that level, and approximately eight years for smartphones to get there. Many analysts have predicted that VR will reach this point within the next five to seven years. This leaves you two to three years to get trained in VR development and three to four years to create something that will significantly impact the VR ecosystem.

Creating features for a new product is complex, involving testing, failing, and then testing again. Given that the whole VR industry is currently in the test-and-fail mode, rapid prototyping in VR is what will gain you maximum leverage, and that is what this book is all about.

What Can You Do with VR?

You may believe that VR is only suitable for entertainment or gaming, but the fact is, other industries have started to take note of its potential and popularity as well. VR is still in infancy, and we are currently only in the first generation of consumer VR hardware. Having not even come close to discovering everything we could do with VR, you could be the one to discover something new and become a VR pioneer.

Medical and Mental Health

The use of 3D visualization is not new to the medical industry. X-rays, CT scans, and MRIs have helped doctors immensely in diagnosis and treatment for years. Likewise, VR has the potential to have profound effects in medicine, neuroscience, psychology, and pain management. VR has already been extremely effective with helping treat fears, phobias, stress-related disorders, bipolar disorders, cognitive rehabilitation, and other psychological conditions. It has benefitted health care professionals and patients across a multitude of disciplines.

Automotive Engineering and Design

VR has also been an effective tool for engineering and design applications. VR design eliminates the need for building physical prototypes. The automotive industry uses VR to help visualize products within virtual environments before physical prototypes are made, allowing designers to see how parts fit together. VR is also being used in this industry to help customers get a sense of how their car would look and feel before ordering it.

Training and Education

Training and education is another field in which VR has been a potent tool. While many other types of media communicate verbally via ideas, VR communicates via direct, hands-on experience. This is possible due to VR's combination of interaction and true immersion. Aircraft pilots, firefighters, oil field workers, and others are some professions where training is done by VR. It is also used in education, helping students to learn new languages by using VR environments with applications like Linguisticator.

Architecture, Construction, and Real Estate

VR provides an immersive experience that allows a user to explore space on a real-world scale in a way that is not possible via other mediums. In the world of construction, traditional designs have made use of flat technical drawings and 3D models. However, VR has changed what is possible by creating a realistic representation of spaces. Architects and engineers can now explore every inch of a construction project and identify any issues before construction begins, potentially avoiding delays and unnecessary costs. VR has also been tremendously helpful in real estate, wherein the environment can either be fully modeled in 3D or photographed as a 360-degree panorama, which provides an immersive sense of the space and its surroundings that the user would not be able to experience without visiting the actual physical location.

Entertainment and Journalism

The ability of VR to create the simulated experience of being present through immersion makes it a compelling medium with which to narrate a story with a deep sense of empathy, something that is harder to achieve on a flat screen. The entertainment

industry, gaming in particular, is where VR is making the most waves. However, there are other areas of entertainment, such as music and cinema, where VR is making an impact as well. Music concerts put on by famous artists have been released as VR events that allow viewers to recreate the experience of front-row seating. Oculus and Netflix have also released their version of a cinematic experience, allowing viewers to watch films in a different way. Virtual tourism and documentaries are other exciting aspects of VR cinema.

VR is also being used in what is known as immersive journalism, where news is produced in a form where people can gain first-person experiences of the events or situations described in news stories. By having viewers wear a VR headset, they enter virtual worlds and scenarios where they can experience the news events firsthand.

Advertising and Retail

VR offers a range of ways for customers to experience products. A person wanting to purchase a car can experience the car in virtual reality, make color choices, select the car's interior features, and more, all from within the comforts of their home. It enables retailers to reach customers who cannot visit their showrooms, increasing the likelihood of making a sale. It also allows the customer the opportunity to try out the product before buying it. VR is also used in advertising to build an emotional connection with a brand by immersing a customer in a virtual experience that creates a deep sense of connection with the product.

Gaming in VR

It is no secret that VR has changed the overall gaming experience. VR does not just show you the game as you play it; it immerses you directly in the game, allowing you to become the protagonist and have experiences and interactions with actors and objects within the game world as if you were really in it. There are also input controllers with haptic feedback to simulate tactile sensations that allow for complex interactions, immersion, and presence, which wouldn't be possible using traditional game controllers. The ability provided to the player to interact with actors and objects all around them, along with the ability to move about in the virtual world, is what makes gaming in VR truly incredible.

Immersion and Presence in VR

Now that we've gotten a good idea of what VR is and the many things you can do with it, it is time to delve further into what makes VR work.

Let us begin by talking about immersion in VR. Immersion is often used to describe the perceived experience of being physically present in a virtual world . For an experience to be genuinely immersive, certain illusions need to be created.

Place Illusion

The place illusion creates the feeling of being in a physical place even though you realize you're not there. Your brain decides that you are in the virtual world rather than the real world. Place illusion can occur even if nothing is happening in the virtual world at the time. Because you are in a virtual world and you can look around, your brain decides that this is where you are. The place illusion is the first of the three illusions that lead to true immersion, where your brain believes that events occurring around you are genuinely taking place.

Plausibility Illusion

The plausibility illusion creates the feeling that the events you are engaged with are really happening. Your brain decides that these events feel genuine. It is different from the place illusion, as you can feel like you are in a place but at the same time not believe that anything is actually happening there. The plausibility illusion is the second of the three illusions that leads to true immersion.

Embodiment Illusion

The embodiment illusion is unique to virtual reality in that it has to do with your own body. Where in the real world you can look down and you see your own body, VR can be programmed to recreate that experience by allowing you to see a virtual body in place of your own body when you look down. The embodiment illusion gives rise to the third illusion, which is the illusion of body ownership or embodiment—that is, the belief that the virtual body is actually your body.

True immersion in virtual reality stems from the three illusions occurring at the same time:

1. Believing that you are in a place even though your physical self knows you are not actually there (the place illusion)
2. Events occurring in a place and you responding to them even though your physical self knows they are not actually happening (the plausibility illusion)
3. Looking down and seeing your virtual body and believing and acting like it is your own body even though your physical self knows it is not (the embodiment illusion)

VR Hardware and Technology

The most common way of immersing a user into a virtual world is by using a head-mounted display (HMD). Even though there are other ways of creating VR, the method we will use in this book requires a HMD, also commonly known as a VR headset.

A VR headset can take you to levels of immersion where you believe you are walking on the moon or trying to survive on a battlefield even though you are just in your living room.

You may be wondering how this all works. The concepts for displaying VR content across different types of available HMD devices are similar. Two streams of content are sent to the headset, whether to one display or two. A set of lenses inside the headset focuses and reshapes the content each eye sees, creating a stereoscopic 3D image. This is done by adjusting the 2D images to mimic how your eyes view the world in real life.

VR headsets can be either tethered or untethered. A tethered device like the Oculus Rift, HTC Vive, or Sony's PSVR requires wires that attach the VR headset to a desktop, laptop, or console to deliver VR content. A headset such as the Oculus Quest or Vive Focus, on the other hand, is an untethered headset that does not need to be connected to a desktop or a laptop.

Some VR headsets only track the user's direction, while others track changes to the user's position. The term *degrees of freedom* (DoF) is used to distinguish between headsets that only track direction and those that track both direction and position.

Input Controllers

Although the VR headset is the main component of a VR system, most VR headsets also come with input controllers that allow users to interact within the VR world.

3DOF devices have input controllers that are essentially pointers, allowing users to take aim but not to reach out and grab something.

6DOF high-end devices have special controllers that function like virtual hands and are tracked by the same sensors that track the HMDs. These controllers allow you to use your hands in various ways within VR through a combination of buttons, triggers, and thumb sticks.

3DOF

A VR device that only tracks rotation but does not track position is referred to as a 3DOF device, as it only tracks three DOF in terms of rotation: the degree to which the device is rotating around its upward-pointing y-axis (*yaw*), or rotating sideways, the degree to which it is rotating around its forward-pointing z-axis (*roll*), and the degree to which it is tilting forward or backward on its horizontal x-axis (*pitch*).

3DOF devices track rotation only, so users can look around and point but cannot move from side to side.

The Oculus Go and Samsung Gear headsets are examples of 3DOF devices.

6DOF

A VR device that tracks both position and rotation is referred to as a 6DOF device. This device tracks all six degrees of freedom: yaw, roll, pitch, up-down movement, side-to-side movement, and forward-backward movement.

6DOF devices track both positions and rotation, so that users can look and move around.

Most first-generation 6DOF devices like the original HTC Vive and the Oculus Rift required base stations to provide positional tracking on desktop systems. However, untethered headsets like the Oculus Quest and the Vive Focus use camera arrays to track the headset's position within the room, so they do not require base stations. This technology is referred to as inside-out tracking.

The HTC Vive, Oculus Rift, HTC Vive Focus, and Oculus Quest headsets are 6DOF devices. You will need to have one of these to follow along with this book.

Summary

In this chapter, we went over virtual reality and why now is the best time to get into VR development. We also looked at the areas where VR is currently being used. You learned about the importance of immersion in VR and the three illusions of place, plausibility, and embodiment that create true immersion in VR. You also learned about the various types of VR headsets available, both tethered and untethered, and the degrees of freedom they support, as well as the benefits of input controller peripherals that accompany VR systems.

CHAPTER 3

Setting Up Your Project for VR Development

The goal of this chapter is to set up a Unity3D project for virtual reality development. I will discuss the VR hardware requirements and the versions of Windows and Unity that you will be using. I will walk you through setting up the required SDKs, Unity's XR plugin management, choosing the various Player settings within Unity, and finally, switching your platform for Android development. You will also import your first Unity package, which will serve as the environment in which you will build your VR framework.

VR Hardware Prerequisites

To follow along with the content in this book, you'll need to have either an Oculus Rift, Oculus Rift S, Oculus Quest, or an HTC Vive headset, which are all 6DOF. As we proceed, I'll assume that you have already set up your headset and ensured it is working, indicating that your computer is VR ready. If you haven't, now is a good time to do this. Both Oculus and Steam VR provide system tools that allow you to check whether your computer meets the minimum requirements to be VR ready. Head to `www.vive.com/eu/setup/` or `www.oculus.com/setup/`, and run through the guided installation and setup process listed there. Lastly, ensure that you have your VR headset set to developer mode . Be sure to test out your headset and ensure that it is working before setting up your development environment.

If the VR system you're using is Oculus Quest, it would be good to connect your Oculus Quest to your PC or laptop with a link cable and playtest using link mode. Doing this would be more convenient than having to deploy a complete build to the Oculus Quest each time you need to do a test run. You do not need to get the Oculus-approved link cable. There are several cheaper options available online from Anchor, Belkin, and Amazon. I use a six-foot Anchor USB C to USB 3 cable.

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