Mastering Augmented Reality Development with Unity

Create immersive and engaging AR experiences with Unity

Indika Wijesooriya

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Dedicated to

My beloved wife, ***Thilini***

&

My mother, ***Swarna***

About the Author

Indika Wijesooriya has over 8 years of extensive experience working with Unity, coupled with a profound involvement in crafting AR applications since 2014. In 2017, he successfully attained a degree in Engineering intertwined with Computer Science, further solidifying his expertise in the field.

Notably, Indika held the distinguished position of Chief of Innovation at Arimac, a prominent end-to-end digital solutions provider renowned for its active engagement in the development of AR and VR applications on a global scale. His instrumental contributions to the advancement of immersive and emergent technologies have garnered both local and international accolades.

Indika's passion is towards 3D real-time development, AR VR, and research and sharing his knowledge with enthusiasts around the world.

About the Reviewer

Sumaya is a visionary Unity XR developer with a passion for exploring the realms of the Metaverse and Gen AI concepts. With a profound love for merging technology and creativity, Sumaya has become a trailblazer in the world of virtual reality (VR) and augmented reality (AR) development. Having spent years honing her skills in Unity, Sumaya's expertise lies in crafting captivating XR experiences that blur the lines between the physical and digital worlds. Her fascination with the potential of the Metaverse and Gen AI has driven her to delve deeper into cutting-edge XR technologies, constantly seeking new ways to shape the future of immersive digital experiences. With an ever-curious mind and openness to new ideas, Sumaya continues to push the boundaries of XR development, inspiring others to join her in shaping the world of tomorrow.

Acknowledgement

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I would like to extend my appreciation to Lou, Mike, and Jerry from Circuit Stream. Their support and guidance have helped me discover my passion for teaching and sharing knowledge with others. Their expertise and collaboration have been instrumental in shaping the content of this book. I would also like to acknowledge Dejan, my dear friend, for his unwavering motivation and continuous support. His belief in my abilities has been a driving force throughout this writing process. I am grateful to Mana Saei and Leena Prasad for their insightful reviews and valuable comments on the manuscript. Their expertise and constructive feedback have immensely contributed to the quality of this book.

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Finally, I would like to express my sincere appreciation to all the readers and supporters of this book. Your interest and enthusiasm for augmented reality development have been the driving force behind my commitment to sharing knowledge and empowering others in this exciting field. Thank you for joining me on this journey.

Preface

Augmented Reality has been a key component of immersive technologies in the past decade. With the entrance of web3 and related technologies, Augmented reality has become a key player in providing extended user experiences for the people around the world. Whether its education, training, manufacturing, healthcare or military, Augmented reality can help people augment and enhance the core components of them. One of the major challenges for an enthusiast to start building AR applications is the knowledge of the tools as there are many available in the current context.

This book will introduce Augmented reality, their use cases, and the history to better understand about it. The second section will focus mainly on the available tools and technologies to develop AR applications. Later on, the book will introduce the Unity 3D engine, fundamentals of C# programming with Unity, vector mathematics and implementing AR applications with Unity followed by the best practices in building AR applications.

By the end of the book, readers will have a comprehensive knowledge on bringing an idea into an augmented reality application and use C# and Unity 3D engine to design and develop a prototype, or maybe a finished application.

Chapter 1: Getting Started with Augmented Reality- In this chapter, we are going to learn about the key concept of Augmented Reality. The technology behind AR applications and the principles of content recognition. The idea is to get some knowledge about the underlying technology to better understand the behaviour. Also, it provides a brief history of Augmented Reality and the existing and future use cases of the technology.

Chapter 2: Visualizing AR Environment and Components- In this chapter, we will be discussing about the placement of objects in a virtual world and how these are mapped to generate the illusion of Augmented Reality. Realizing how different Augmented Reality setups work is provided and to better understand these principles, an introduction to basic mathematical theories is discussed.

Chapter 3: Exploring Tools and Development Platforms- This chapter provides an in-depth introduction to currently available tools and technologies to build AR applications and experiences, and their running platforms. We also compare the pros and cons of each available tool and discuss about multiple use cases to better understand what platform and tools suits the best for the fulfilment of that use case.

Chapter 4: Up and Running with Unity 3D- In this chapter, we use Unity3D engine as the core development tool for the rest of the book and we go through the steps of installing the necessary tools and setup the computer for development. Also, we will be building a 3D scene in Unity 3D. This will be useful to know about the Unity engine, the tools, and an introduction to 3D concepts that helps us build AR application in future chapters. Additionally, we dive deep into the key components of Unity. We learn the structure of GameObject and the components, and the main components in Unity will be discussed.

Chapter 5: Creating Your First Custom Component- In this chapter, we get an introduction to C# with Unity creating our first custom component. We go through the steps of creating a base script, understand the basic components of a C# script and how the execution of a C# script works. Finally, we will be creating a simple Clock using the concepts we learnt throughout the chapter.

Chapter 6: Refreshing C# Concepts with Unity- In this chapter, we will be exploring the C# programming to build functionality. Throughout this chapter, we will be building an endless top-down shooting game that are targeted towards mobile. We will be learning C# concepts with Unity, using the key unity components that are relevant in building interactive applications.

Chapter 7: Trying Out First 3D Mobile App Development- During this chapter, we continue the development of the top-down shooter game and install the application on the mobile device. We go through two different mobile platforms, Android and iOS understanding each device requirement, and how you set up the project settings accordingly. Alternatively, we check different debugging methods while your app is running in your device.

Chapter 8: Building Marker-based AR Apps with Vuforia- In this chapter, we will be building an Augmented Reality treasure hunt game using the Vuforia AR SDK. This section covers the introduction to marker-based tracking with Vuforia SDK, its key capabilities and use of Marker based tracking. We go through the steps of creating a Vuforia account, registering the application, and using the Vuforia portal to configure the project trackers. We also download the SDK, install it in Unity and test with the PC web camera.

Chapter 9: Developing Marker-based Dynamic AR Apps- In this chapter, we go beyond the default use cases of marker-based AR to dynamic application design. We will be building two AR applications. One is a sample AR machine inspection tool, and the other is a dynamic AR billboard that changes the experience without app updates. In the sample AR inspection tool, we will be using a marker system to uniquely identify different objects without making significant changes to the marker graphic. In the dynamic billboard, we go beyond Unity to host files in the cloud to build a dynamic AR app that can change the content and markers without updating the app.

Chapter 10: Marker-less AR Apps with AR Kit and AR Core- In this chapter, we will be building multiple mini projects that covers most AR detection modes provided by ARKit and ARCore that works with iPhones/iPads and Androids subsequently. We will learn the similarities in both and use AR Foundation as a cross-platform method to build the AR apps.

Chapter 11: World Scale AR App with Niantic Lightship- In this chapter, we will be developing mini projects that uses the Niantic lightship SDK. The objective of this is to get started with building world scale AR applications that reacts to the environment obstacles including collision and occlusion. During the first project development, we understand the environment capturing by the SDK to build a simple throwing experience in AR. The second project will learn the process of scanning an environment to build custom (private/public) area-based AR applications.

Chapter 12: Best Practices in Augmented Reality Application Design- In this chapter, we talk about different best practices in AR application design and development. This can be categorised as design-based practices, development practices and Sample project snippet for all the best practices mentioned below.

Chapter 13: AR App Performance Optimization- In this chapter, we will be learning key performance metrics that can be considered in building AR applications and optimization techniques to optimize our AR apps to reduce the resource requirements needed. We will identify key necessary actions to mitigate the performance related challenges in your app.

Code Bundle and Coloured Images

Please follow the link to download the
Code Bundle and the ***Coloured Images*** of the book:

https://rebrand.ly/z6y0enl

The code bundle for the book is also hosted on GitHub at **https://github.com/bpbpublications/Mastering-Augmented-Reality-Development-with-Unity**. In case there's an update to the code, it will be updated on the existing GitHub repository.

We have code bundles from our rich catalogue of books and videos available at **https://github.com/bpbpublications**. Check them out!

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CHAPTER 1
Getting Started with Augmented Reality

Introduction

Before building **Augmented Reality** (**AR**) applications, we must understand what AR is and how hardware and software technology is combined to present an AR application to the end user. The second decade of the 21st century can be seen as a pivotal period for Immersive technology, mainly AR and virtual reality. One of the main reasons for the exponential growth in the AR field can be the escalated CPU power of mobile smartphones. The processing power required to perform real-time image processing calculations while estimating virtual element poses was unavailable in mobile devices. Therefore, technology did not have a better reach towards the masses.

A practical definition for AR can be: It is a view of the real physical world in which some elements are computer generated and graphically enhanced, allowing extended capabilities in terms of input and output.

The definition seems unrealistic, but the motivation for AR has been there since decades ago through science fiction stories. Almost a century ago, the golden age of comics introduced many superheroes and characters with superhuman and *augmented* abilities, who were placed in scenarios where these characters used AR technologies as in science fiction. **Holograms** have been one of the key elements to demonstrate advanced technologies within the stories. These holograms and augmented elements in the physical world had many things in common, such as interactivity with hands or voice, feedback from the elements with animations, showing information with text or sound effects, and the flexibility to spawn them anywhere, regardless of the context. Even though humans are not advanced as they predicted to be in the movies, we can see rapid development in research and development to invent such concepts.

Structure

In this chapter, we will cover the following topics:

- Augmented reality implementation and application.
- History of augmented reality.
- Augmented reality across the world.
- Augmented reality enabling technologies.
- Machine learning and artificial intelligence.

Objectives

By the end of this chapter, you will know that AR was not invented during the last decade but is a topic with a history of many decades. You will also learn the fundamental technologies used to create AR applications and the use cases of AR in different industries.

Augmented reality implementation and application

Let us consider a holographic AR implementation that may be implemented in the future. The technology behind the implementation must first capture and identify the context. There may be a hardware component with built-in sensors to recognize the people, objects, planes, and the world around them.

And once the context has been captured, the collected data must be converted into a virtual environment so that a virtual object can be placed on top of it. This conversion may be done using computer algorithms placed within the holographic device. This process can also be identified as the transformation layer.

The final steps of the implementation may include a presentation layer, which consists of all the audio and visual feedback, interactions, logic, etc. The users of the holographic device may use this presentation layer to generate AR content. The final layer would be the output layer which generates the accumulated set of components so that the user can see the final implementation. In a hologram, this is the final holographic output. In 2023, we still have a long way to go and years of research and development to implement a non-blocking output layer for a real hologram. *Figure 1.1* represents the conceptual representation of a Holographic AR implementation:

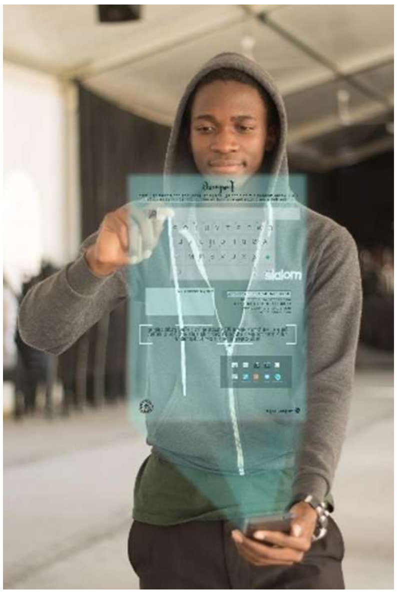

Figure 1.1: *Conceptual representation of a hologram*

*(**Source**: https://pixabay.com/photos/science-hologram-artificial-fiction-4642115/)*

Currently, existing AR systems are very advanced but are not yet able to visualize the AR content without another screen or a wearable in between the actual and virtual worlds. Consider a wearable AR device as an example. Such a device contains a camera and other sensors at the front to capture the world around it and uses software to recognize the context. Like the hologram example above, objects can be placed in the virtual environment generated within the presentation layer. Finally, the generated 3D content will render on the wearable screen, mapping to the physical world that can be seen through the glass.

A smartphone-based AR application would be the same, except that the final output layer would be through the mobile screen, having the camera input as the background. In these AR applications, the camera input must be captured and rendered inside the 3D space behind the 3D models, giving an illusion of how the 3D models are placed in the real-world context. *Figure 1.2* illustrates the structure of an AR application:

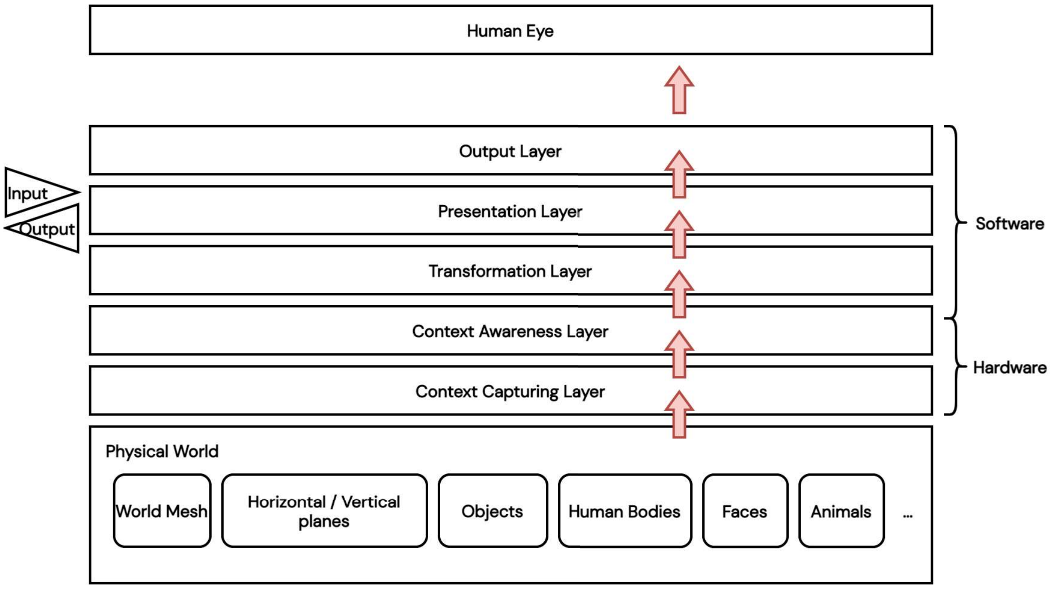

Figure 1.2: *Structure of an AR application*

History of augmented reality

In order to understand where we stand with widespread AR development, it is better to know the brief history of AR and where everything started.

1968 – The Sword of Damocles

The first implementation of AR that can be found in the history books is not through a computer screen but a prototype head-mounted display. *Prof. Ivan Sutherland*, an American computer scientist and a widely known computer graphics expert, created the first head-mounted display in 1968, known as **The Sword of Damocles**. The fundamental of that device is to create an illusion on the transparent display depending on a concept known as the *kinetic depth effect*.

The display is fixed to the ceiling of a room and can be worn by the user. The linkage in the ceiling measures the pose of the head and transfers that data to the computer program. A miniature cathode ray tube attached to the side of the display projects the image onto the eyeglass display optics, changing the orientation of the image based on the movement of the head. The research paper on this implementation can be obtained within chapter *A head-mounted three-dimensional display* of the Fall Joint Computer Conference journal in 1968. *Figure 1.3* features the above-mentioned display:

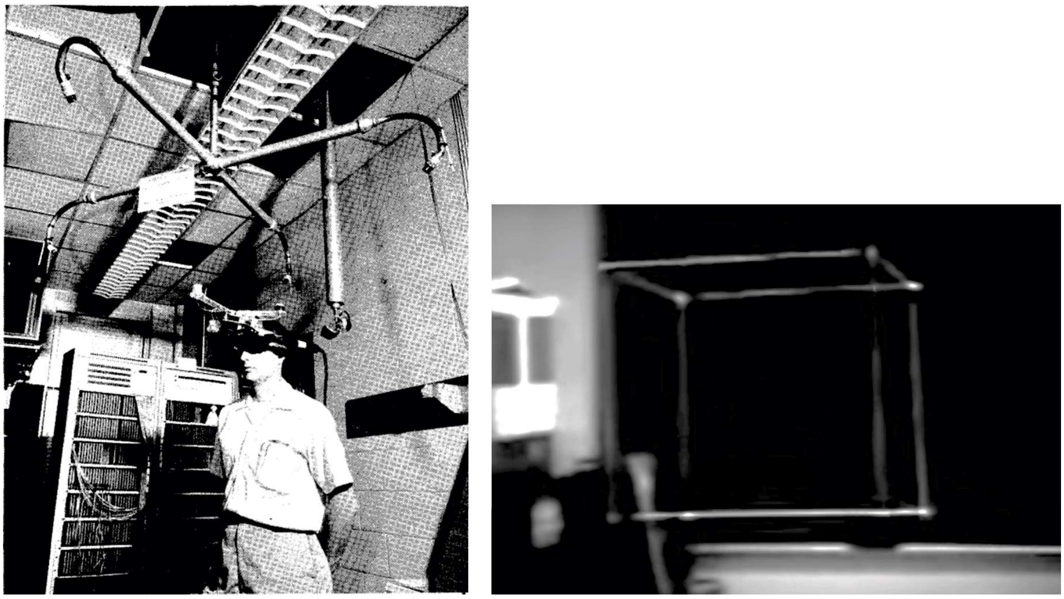

Figure 1.3: *The first head-mounted display and how a 3D object can be seen through it.*
*(**Ref**: Fall Joint Computer Conference Journal, 1968)*

1975 – Videoplace by Myron Krueger

Another implementation of artificial reality, even though it is not directly an augmented reality, can be seen through one of the first augmented interactive applications, which was known as **Videoplace**. The idea behind the application is to use external sensors and capture the context and interactivity without the use of goggles, buttons, gloves, or anything attached to the user.

The application used a camera to capture the user in front of a projector screen in front of the person. The captured video is transmitted to a computer, which performs image processing to generate a silhouette of the person with an additional interactive element as a separate layer. The layers are generated in different flat colors to differentiate each. The processed final image is then projected to the same projection screen using a back projector. This does not completely fulfill the requirement of AR, but it can be recognized as a step towards artificial reality and contained image recognition algorithms. *Figure 1.4* is an illustration of the videoplace system:

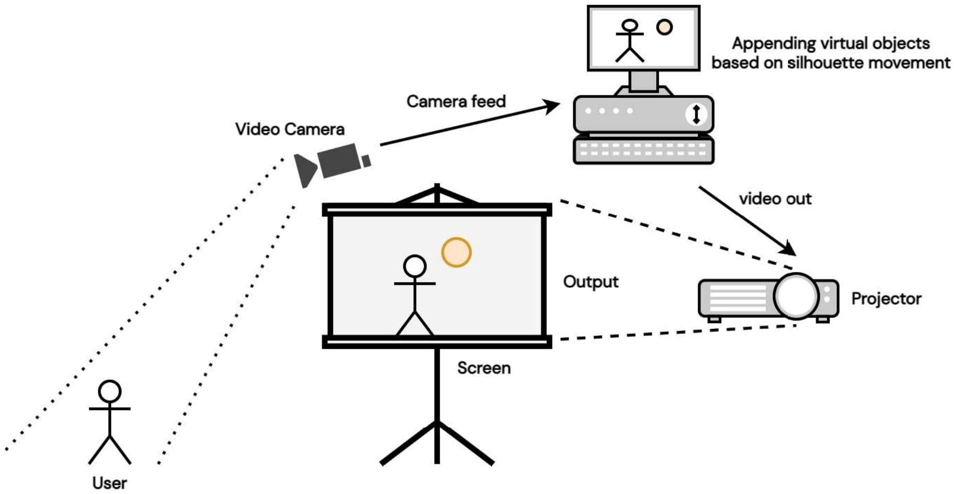

Figure 1.4: *Structure of the videoplace system*

1999 – AR Toolkit

Ever since the first AR implementations, technology has improved to move away from hardware-only solutions to programmable software solutions. One of the major implementations of such solutions is the AR Toolkit, which is a library that was developed in 1999 by *Dr. Hirokazu Kato* of Nara Institute of Science and Technology.

AR Toolkit was known as the world's first Mobile Augmented Reality Software Development Toolkit was incorporated after it, and a version was released to the public. The library was used in early OS-based smartphone devices such as Symbian around 2005, all the way to iOS and Android during the 2010 era.

Early versions of the AR Toolkit focused on predefined physical AR trackers (also known as **Fiducial markers**) to recognize the planes and visualize virtual 3D objects following the orientation of the trackers. Later versions of the AR Toolkit introduced *Natural Feature Tracking*, which allowed developers to train natural features of colorful images rather than using predefined AR trackers.

Figure 1.5 illustrates an AR Toolkit fiducial tracker, which is an example of an AR target:

Figure 1.5: *Example of an AR target (AR Toolkit fiducial tracker)*

More information on AR Toolkit can be found at:

http://www.hitl.washington.edu/artoolkit.html

Augmented reality over the years

Ever since the development of the AR Toolkit, many developers and organizations have stepped into the field of research and development of AR software development kits and supportive hardware. This was followed by the development of smartphone devices and their easy accessibility, which encouraged engineers and developers to focus more on handheld devices. Early software-based AR applications leveraged the power of desktop computers and attached web cameras to generate 3D models using magazine covers as image targets. A magazine advertisement done for MINI in 2008 is an example of one of the first AR implementations as a commercial use case. It can be found at:

https://www.youtube.com/watch?v=HTYeuo6pIjY

Esquire magazine worked with Hollywood actor *Robert Downey Jr*. to color their magazine with AR, and it can be found at:

https://www.youtube.com/watch?v=wp2z36kKn0s

The introduction of Google Glass in 2014 has become one of the key events in the history of AR. It was the first AR-inspired wearable device targeted at consumers. From 2010 to 2015, many software-based development kits and libraries were developed, targeting mainly mobile operating systems. Qualcomm Vuforia, AR Toolkit open source, MetaIO (acquired by Apple to develop its current AR SDK, ARKit), Wikitude, and ARMedia are some of the early adaptors of AR in the domain of smart handheld devices.

In 2016, Microsoft joined the AR market by introducing the *HoloLens*, which is the world's first wearable augmented reality tracking and meshing device, as can be seen in *Figure 1.6*:

Figure 1.6: *Microsoft HoloLens. Kai Kowalewski, CC BY-SA 4.0*
*(**Source**: https://creativecommons.org/licenses/by-sa/4.0, via Wikimedia Commons)*

Apple released its native AR SDK, known as AR kit, and Google started working on a hardware-software implementation known as Google Tango. The project was discontinued and later announced again as a complete software-based implementation known as ARCore. Google also invested in a wearable AR device, Magic Leap, an alternative to Microsoft HoloLens.

In the later chapters of this book, we will dive into some of the most popular AR development tools currently available to develop AR applications in cross-platform devices.

Augmented reality across the world

In order to build AR applications, it is better to research and understand the use cases of AR in various disciplines. Emerging technologies during the last couple of decades have been used in various applications outside the field of computer science. This section explores some of the use cases of AR currently in the world.

Augmented reality in entertainment

Many use cases of AR that are consumer-based circle around entertainment. In 2016, *Niantic* released its widely popular location-based game Pokémon Go. Niantic has been working with location-based games before stepping into AR, such as Ingress.

Pokémon Go innovatively implemented *catching a Pokémon using a pokéball* interaction using an AR interface within the game. This was a major boost for AR technology as more people could experience AR for the first time.

With the release of Pokémon go and smartphones having native AR capabilities, many games were developed that used AR as the backbone. Minecraft World, Harry Potter Wizards Unite, and Jurassic World Alive are some of the popular games that have been released since then. Stepping out of the mass outreach of AR games, the technology has also been used in various physical activations and live events. Video-based AR technologies such as Vizrt and Wtvision have taken over the world, offering real-time AR over broadcast. We have seen how various augmented content appear on television news, sports events, and other live shows to make the shows more interesting through television. Vizrt technologies have been used over thousands of TV events around the world. Mainly covering sports events and news, some of their customer stories include Eurovision, ausbiz, Mediacorp in Singapore, CNN-NEWS18, Al-Jazeera documentaries, and many more.

Figure 1.7 features the use of AR in a museum:

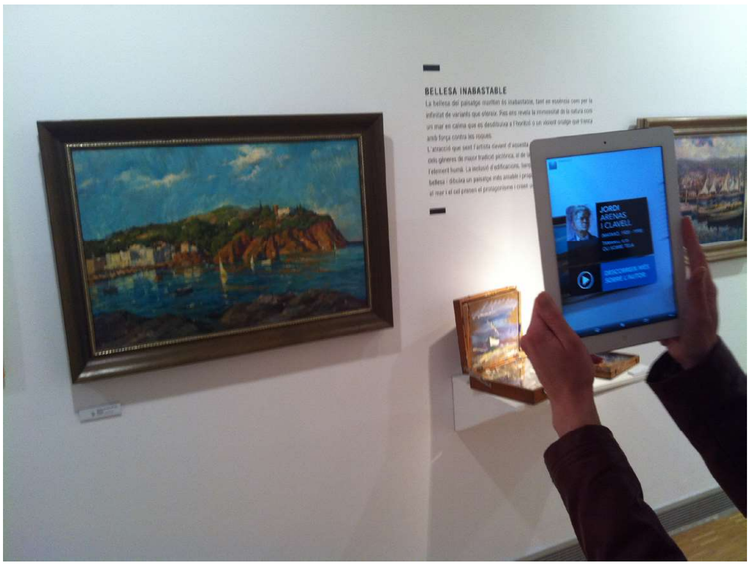

Figure 1.7: *Augmented reality at Museu de Mataró linking to Catalan*

*(**Source**: Kippelboy, CC BY-SA 3.0, https://creativecommons.org/licenses/by-sa/3.0>, via Wikimedia Commons)*

AR has been used in art galleries and museums around the world. In 2021 the *Muséum National d'Histoire Naturelle* in Paris launched an AR experience. The experience was called REVIRE and allowed visitors to hire a Microsoft HoloLens and interact with digital animals throughout the museum. The National Museum of Singapore has an AR installation called **Story of the Forest**. An AR installation known as ReBlink is available at the Art Gallery of Ontario, Toronto enhancing the art experience of the artwork within the gallery. Google has a virtual museum with AR capabilities, allowing users to visit an AR gallery virtually. It can be found at:

https://artsandculture.google.com/project/ar

These are just a fraction of the thousands of AR installations all around the world.

We explored some of the existing AR-related use cases in the world. Thinking of the future, AR can replace many entertainment channels such as television, billboards, and live events. Think of an AR wearable device that can turn your living room into a stadium with live matches running on your coffee table. Imagine how a wall in your room can be converted to a large cinema screen where you can watch the latest movies without stepping out of your room. The possibilities of AR in the entertainment world are endless, provided the correct tools and technologies.

AR in manufacturing and logistics

Google Glass had many challenges in reaching the consumer market even though it is the first ever widely announced wearable display device. The device has a camera mounted to the front of it, and there is no indication to the outside world whether the user is capturing the surrounding and streaming a video to a third party. This caused many conflicts with regard to security and privacy. Ultimately, Google discontinued the product to the public as a consumer device and revived it to be used in enterprise applications, mainly focusing on manufacturing, logistics, and anything that requires hands-free work but with access to additional information. Currently, Google Glass provides real-time collaboration, access to training visualizations, and voice input, enhancing the capabilities of factory workers. Even though this is not a completely AR-enabled device, this has been used by many larger organizations across the world, including DHL, Schenker, Samsung, and Volkswagen.

Mainly, AR has been used in factories for maintenance assistance, machine operation training, and data visualization in real-time for machinery data retrieval and preventive maintenance. Dynamic arrangement of manufacturing facilities leverages AR for navigation within the factories. Imagine a logistics facility that rearranges the inside of the facility rapidly based on its dynamic adaptations. This may be an overhead for the facility to change the navigation system along with its rearrangements. This can be easily overcome by setting up navigation in AR that can instantly replace the data points. Imagine a wearable within a factory that allows machine supervisors to just look at the machine and visualize its sensory and machinery data in real-time next to the machine itself. This reduces the overhead time the teams spend searching through data logs through a separate interface matching the data to the machines. Imagine a 3D machine or vehicle construction that can be previewed through AR in a collaborative environment. This allows the designers and engineers working together to visualize the elements on a real-life scale and thus reduces the time required to make foam models of the machine. There are limitless possibilities where AR can be beneficial in the manufacturing industry.

Real estate

In 2020, Unity, a leading 3D development engine, teamed up with Autodesk Revit, a **Building Information Modelling** (**BIM**), to create a tool known as Unity Reflect. This allowed creators to link BIM model data to a 3D environment in real-time. Unity, known for AR, used the same links to visualize 3D models of buildings and architecture in real time in an AR environment. A great use case of this turned out to be the client's ability to visualize their building design exactly on the building site as a 1:1 scale on-site in AR while the architects change the model data in real time according to the client's needs.

Similarly, many real estate agencies use AR to enhance the customer experience in buying real estate by providing AR virtual tours. Imagine an application allowing people to go to real estate locations and visualize the price charts and how different buildings appear without spending for concept creators. Imagine, as a real-estate agency, your customers being able to freely walk around within any available houses with the AR app providing additional information to their needs. Using AR technologies, the realtors get a competitive advantage in providing more unique personalized experiences to their customers.

Health

Imagine visualizing a 3D reconstruction of the bone structure of a patient while walking around it instead of taking multiple X-ray images. AR can allow that to happen, provided the hardware and software required to obtain scan data of a patient are available. AR is a great alternative to the current healthcare imaging solutions. Many of the imaging output channels can be replaced by a simple AR wearable that can use its surroundings to import as many 3D visualizations to the environment as possible. Imagine a surgeon performing surgery and being able to visualize patients' vital data on top of the patient's body parts. The surgery can be done faster, reducing the time required for the professionals to look away from the patient. Also, such use cases reduce the surgeons making errors due to misreading information.

AR can also be used in medical training. Instead of using custom-made physical dummies for health-related simulations, AR glasses can be used to quickly change training scenarios for the trainees to perform interactions and get trained more efficiently.

Education

As mentioned in the previous sub-section, training can be offered in any competency. It can be the health industry, manufacturing, logistics, and also a common school classroom. Schools invest heavily in chemical and physics laboratories, not only by building new labs but also by maintaining them. Imagine an enhanced school physics laboratory where the students can create AR-based tabletop physical simulations while changing the parameters of the objects dynamically. This allows the students to learn the activities by trying out limitless scenarios without changing any physical object in the lab. Imagine a wearable AR headset that can convert your living room to a classroom with your friends. Microsoft HoloLens provides shared experiences with the help of *spatial anchors* allowing people to connect, share, and learn the same experience. Science books make use of marker-based AR to allow the experiments to be viewed out of the book by using a mobile application. The ability to move around freely to observe 3D constructions enabled the engagement of the students to learn by doing rather than learn by memorizing.

Marketing and retail

One of the widely used AR applications can be found within marketing and retail use cases of AR. IKEA Place is a great initiative done by the company to allow people to add furniture to their own space to visualize whether the piece of furniture fits properly. Dulux has built an AR app to scan any wall and immediately change the color to any available color by them. There are many marketing enabler AR apps currently in the market, such as Blippar, 8^{th} wall (acquired by Niantic), Zappar, and Augment, which allow companies to use their platforms as authoring tools to build content for their marketing campaigns. Children's cereal producers use AR apps to extend their cereal boxes for children to collect and play custom-made games for rewards. E-commerce sites make use of AR product viewers to spawn the 3D models of products into a user’s space to visualize them on a real-life scale. Companies like Nike and Adidas use the power of AI and AR and have built apps such as Wannakicks and Wyking AR to visualize shoes directly attached to your feet. Product visualization, product configurators, and marketing engagement activities have become the key entry points of AR in retail. Unlike decades ago, the spectrum of possibilities has expanded with the introduction of AR. It does not only provide the *wow factor* to the customers but also creates unforgettable memories in their minds about the products and services that have been marketed with AR. Many businesses have been leveraging the use of AR, providing marketing and retail solutions around AR to bigger companies around the world. Leading service-oriented companies, such as Accenture and Volume Global, have already filled their portfolios with AR case studies around the world, and there is more to come.

Any of the readers of this book hopes to provide services with AR solutions, think of the problems that are faced in different disciplines across the world, and evaluate how those problems can be solved using AR. There are many AR use cases that create problems than offering solutions. Therefore, it is vital to understand the requirement and measure the importance of AR, which can replace the existing workflows. Considering the costs, maintainability, and usefulness of AR technology, any industry can leverage it for higher savings, higher profits, and higher engagement.

Augmented reality enabling technologies

AR heavily relies on computer vision. The use of additional data, such as depth sensing for meshing, catalyzes the accuracy of the trackers. Ever since the use of machine learning and AI, the accuracy of target detection and tracking and the extended capabilities of AR have expanded. The following section explores some of the computer vision techniques that enable AR.

Image recognition and tracking

In order to enable AR in a predefined target image (for example, a poster, magazine cover, photo, QR code, and so on), the features of the image must be matched and recognized. This process is known as feature detection and matching. Once the image has been detected, the data can be used to track the image with its movement with respect to the position of the camera. These algorithms are used not only for AR but in many applications. Robot navigation systems, image retrieval, object tracking, motion detection, and segmentation are some of the other applications of feature detection and matching. A feature of an image can be recognized as a piece of information in the image that can be used by the computer program to recognize the image. As an example, the points and edges of an image can be used as features of the image. The challenge of image detection is to detect and capture the features, collect information about the appearance around the feature point, and match similar features with a known feature distribution set. These feature points are identified by various algorithms based on either the brightness of the image or the boundary/edge details of the image.

A feature recognition algorithm gets an image as an input and outputs a series of vectors. The output of an image would be a series of encoded data in a machine-understandable format. This is known as a feature descriptor. The information that is generated from an image is supposed to be independent of the orientation and the transformation of the image. Therefore, the output data remains the same regardless of the movement of the image. This provides one of the fundamental abilities of AR, which is the ability to track a detected image based on the image features by