FIRAT UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
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VIRTUAL REALITY FOR ELECTRICAL MACHINE

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Master's Thesis

DEPARTMENT OF COMPUTER ENGINEERING
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THESIS APPROVAL

This thesis, which was prepared according to the thesis writing rules of the Graduate School of Natural and Applied Sciences, Fırat University, was evaluated by the committee members who have signed the following signatures and was unanimously approved after the defense exam made open to the academic audience.

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DECLARATION

I hereby declare that I wrote this Master's Thesis titled “Virtual Reality for Electrical Machine” in consistent with the thesis writing guide of the Graduate School of Natural and Applied Sciences, Firat University. I also declare that all information in it is correct, that I acted according to scientific ethics in producing and presenting the findings, cited all the references I used, express all institutions or organizations or persons who supported the thesis financially. I have never used the data and information I provide here in order to get a degree in any way.

02 July 2021

Nechirvan Salman IBRAHIM

PREFACE

Virtual Reality has caught the world's creative mind. Throughout the most recent couple of years, engineers and fans in the large numbers have given innumerable hours to coding, planning, and theorizing about the prospects of this energizing new medium. Moderate equipment frameworks like the Oculus Rift, Samsung Gear VR, and Google Cardboard VR permit purchasers to encounter augmented reality firsthand in the solace of their homes, in a bistro, or on the train to work. Press inclusion has reached past the exchange press and blogosphere to standard distributions praising the virtues of VR, and the prospects appear to be unending: from gaming and film to engineering, instruction, preparing, and medication. Despite the fact that it has far to go, computer generated experience seems ready to turn into the following significant amusement medium, and maybe even the registering foundation of things to come.

Nechirvan Salman IBRAHIM
ELAZIG, 2021

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ABSTRACT

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Virtual Reality (VR) is computer-generated environments or realities that are designed to simulate a person's physical presence in a specific environment that is designed to feel real. It is the way to find, feel and contact with the past, the present and what is to come. It is the vehicle to make our own reality, our own altered reality. It could go from making a computer game to taking a virtual tour of the universe, from wandering through our own fantasy house to finding a walk on a strange planet. With computer-generated reality, we can meet the most frightening and boring circumstances by playing safe and with a learning point of view.

The VR application the user will be able to perform various investigations of the working principles of a permanent magnet synchronous motor. In the background of the VR environment a proper mathematical model will be defined that will simulate the operating principles and performance characteristics of the investigated motor. The 3D models that are going to be designed will be based on authentic devices, according to their technical documentation. The different 3D parts for various electric motors are going to be placed on a shelf. The user will have a task to assemble a certain type of electric motor based on its selection done at the beginning of the exercise.

Mechanical maintenance preparation requires significant investment. Must be legitimate public information personnel before playing out any support on apparent devices and must have an appropriate maintenance and security setting applicable to the specific device support is performed on. Two organizations and scientific institutions face preparing limits when ordering maintenance for replacers or workers.

Virtual Reality situations deal with the issue of access, cost, support, firm plan, and well-being. Virtual reality situations using Game-Engine phases (for this mode, Unity), Computer-Aided-Design display and C# programming to execute what is needed in a VR reality head where a student is perfectly suited to speak with environmental factors through kidnapping, contact, holding, dropping, tossing and more through existing virtual reality controllers.

Keywords: Virtual Reality (VR), Argument Reality (AR), Mechanical and Electrical Engineering, 3D Models, AC Motor and Unity.

ÖZET

Elektrik Makinesi için Sanal Gerçeklik

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Sanal Gerçeklik "Virtual Reality," (VR), bir kişinin fiziksel varlığını, belirli bir ortamda gerçekmış gibi hissetmesi için tasarlanmış, bilgisayar tarafından oluşturulan ortamlar veya gerçekliklerdir. Geçmişi, bugünü ve gelecek olanı bulmanın, hissetmenin ve onunla iletişim kurmanın yoludur. Kendi gerçekliğimizi, kendi değiştirilmiş gerçekliğimizi yaratmanın aracıdır. Bir bilgisayar oyunu yapmaktan evrende sanal bir tur atmaya, kendi fantezi evimizde dolaşmaktan garip bir gezegende yürüyüşe çıkmaya kadar gidebilir. Bilgisayarla oluşturulan gerçeklik ile en korkutucu ve sıkıcı durumları güvenli oynayarak ve öğrenen bir bakış açısıyla karşılayabiliriz.

VR uygulaması ile kullanıcı, sabit mıknatıslı senkron motorun çalışma prensipleri hakkında çeşitli incelemeler yapabilecektir. VR ortamının arka planında, incelenen motorun çalışma prensiplerini ve performans özelliklerini simüle etmek için uygun bir matematiksel model tanımlanacaktır. Tasarlanacak 3D modeller, teknik dokümantasyonlarına göre orijinal cihazlara dayalı olacaktır. Çeşitli elektrik motorları için farklı 3D parçalar bir rafa yerleştirilecek. Kullanıcı, alıştırmanın başında yaptığı seçime göre belirli bir elektrik motorunu monte etme görevine sahip olacaktır.

Mekanik bakım hazırlığı önemli yatırım gerektirir. Görünür cihazlarda herhangi bir destek uygulamadan önce yasal kamu bilgilendirme personeli olmalı ve üzerinde gerçekleştirilen belirli cihaz desteğine uygulanabilen uygun bir bakım ve güvenlik ayarına sahip olmalıdır. İki kuruluş ve bilimsel kurum, değiştiriciler veya işçiler için bakım siparişi verirken hazırlık sınırlarıyla karşı karşıyadır.

Sanal Gerçeklik durumları erişim, maliyet, destek, firma planı ve refah konularıyla ilgilenir. "Game-Engine," aşamalarını bu mod için, "Unity" programa, Bilgisayar Destekli Tasarım ekranını ve C# programlamayı kullanan sanal gerçeklik durumları, bir öğrencinin kaçırma yoluyla çevresel faktörlerle konuşmak için mükemmel şekilde uygun olduğu bir Sanal Gerçeklik

VR (Virtual Reality) gerçeklik başlığında ihtiyaç duyulanları yürütmek, iletişim, mevcut sanal gerçeklik denetleyicileri aracılığıyla tutma, bırakma, fırlatma ve daha fazlası.

Anahtar Kelimeler: Sanal Gerçeklik, Argüman Gerçeklik, Makine ve Elektrik Mühendisliği, 3 Boyutlu Modeller, Alternatif Akım Motoru ve Unity programa.

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SYMBOLS AND ABBREVIATIONS

Symbols

%	: Percentage
°	: Degrees
°C	: Celsius temperature
Bd	: Baud
cm	: Centimeters
cm2	: Centimeters Squared
cm3	: Centimeters Cubed
Ft	: Foot
H_L	: Left Ear
H_R	: Right Ear
Hz	: Hertz
in.	: Inches
Kbps	: Kilobit Per Second
KHz	: Kilohertz
m	: Meters
m2	: Meters Squared
m3	: Meters Cubed
Mbps	: Megabit per Second
ms	: Milliseconds
Oz	: Ounces
S_L	: Left Sound
S_R	: Right Sound
Tk	: Air temperature in degrees Kelvin
V	: Volt
X	: X-axis
Y	: Y-axis
Z	: Z-axis

Abbreviations

2-D	: Two Dimensional
3-D	: Three Dimensional
4-K	: 4,000 Pixels
AC	: Alternating Current
ADSL	: Asymmetric Digital Subscriber Line
AGP	: Accelerated Graphics Port
API	: Application Programming Interface
AR	: Argument Reality
CAD	: Computer Aided Design
CAVE	: Cave Automatic Virtual Environment
CAX	: Computer Aided tools
CCD	: Charge Coupled Gadget
CPU	: Central Processing Unit
CRT	: Cathode Ray Tube

Abbreviations

DC	: Direct current
DFFD	: Direct Free-Form Deformation
DIS	: Distributed Interactive Simulation
EMF	: Electro Motive Force
FA	: Fast Adapting
FILO	: First-In-Last-Out
FOV	: Field Of View
GPS	: Global Positioning System
GPS	: Global Positioning System
GPU	: Graphics Processing Unit
GUI	: Graphic User Interface
HD	: High Definition
HMD	: Head Mounted Display
HRTFs	: Head-Related Transfer Function
HSD	: Hand Supported Display
I/O	: Input/Output
IPD	: Interpapillary Distance
IPMSM	: Interior Permanent Magnet Synchronous Motor
IR	: Infrared
LAN	: Local Area Network
LCD	: Liquid Crystal Display
LED	: Light Emitting Diode
LOD	: Level-Of-Detail
MMF	: Magneto Motive Force
MR	: Mixed Reality
OSVR	: Open Source Virtual Reality
PC	: Personal Computer
PMSM	: Permanent Magnet Synchronous Motor
PWM	: Pulse width modulation
RAM	: Random Access Memory
SA	: Slow Adapting
SDK	: Software Development Kit
TCP/IP	: Transmission Control Protocol/Internet Protocol
UHD	: Ultra High Definition
UI	: User Interface
VE	: Virtual Environment
VR	: Virtual Reality
WAN	: Wide Area Network
XR	: Expanded Reality

1. INTRODUCTION

In recent years, Virtual Reality (VR) became an innovation with the development of created devices that have been used in a number of fruitful exhibits. These days, a wide range of innovations are accessible, for example, Cavern frames, reality theaters, power dividers, holdbacks, individual vivid frames, including Mixed Reality (MR) previews, speech frames, and haptic devices. Furthermore, although specialized frameworks have been improved and expanded, the cost of business forms steadily decreased, consequently developing the ubiquity of the framework among customers, specifically within the modern area.

Simultaneously, Computer Aided tools for engineering purposes (CAX software) presently accessible have been dramatically improved and improved covering essentially all applications in the article life cycle. In any case, the association with the customer within this product is generally done through the CRT/LCD screen and the mouse, which are simply Two Dimensional 2-D gadgets. At the same time the mathematical dataset has long been three-dimensional, including the now expanded data, features, and information, the innovation of cooperation has not fundamentally changed since the 1980s [1].

VR is the main theme of the book. In view of the 1990s, the particular innovations have improved essentially and are currently accessible in commercial versions at lower costs, reasonable in any case, for medium and small companies. This topic included three talks and three chosen engagements that offer a decent outline of accessible advancements, as well as expected ways of combining with respect to multimodal interfaces.

We remained at the doors of another innovative scene. As we watched out at the virtual land attempting to sort out exactly how and what to work there, it was clear there is a great deal to find. In the virtual world, there are no legislative issues or boundaries to what we can insight and what we can work for others to encounter. Similarly as early producers needed to discover how to recount their accounts up on the film screen, we are just barely starting to investigate the sentence structure of Virtual Reality (VR). Indeed, even the actual fundamentals of interfaces: how our kindred cybernauts cooperate with the virtual world, is as yet uncertain. What is the syntax of VR? What feels normal in the virtual world? How would we move around, contact things, feel protests, and control the climate? The quantity of individuals with admittance to the apparatuses to make virtual substance has never been so wide going, and we have more individuals than any other time in recent memory concocting new and energizing increases to our virtual encounters. In the competition to give innovation to oblige new encounters, equipment producers are running as quick as possible to improve VR, more grounded, and quicker. Regardless of how rapidly we race to keep up, the innovation does not quit advancing and evolving. Technology will keep moving. We will never stop learning.

At the point when you arrive at the finish of this paper, it will be dependent upon you to get included and to conceivably begin molding VR's future. Try not to be reluctant to toss out show and do things that are different to the manners in which we have interfaced with games or reenactments previously. You are a visionary who could help shape the VR scene of tomorrow. The virtual encounters of things to come will be based upon the encounters of today, so test and make astounding new things! Make sure to have a good time, take care of yourself, and be pleasant to one another.

Virtual conditions or virtual situations are specially crafted three-dimensional virtual universes made out of three-dimensional models, which permit learners to associate and submerge themselves in world that are removed, costly, dangerous, or blocked off. Virtual situations are otherwise called, "artificial reality", virtual worlds and environments. Some Augmented Experience situations, similar to the ones depicted in this paper, presenting a complete immersion in the virtual world through the computer generated simulated headphones from the VR based organizations [2].

The main programming used during this exploration is known as Unity, and it is the stage of the crossover game engine. It is a product which permits the advancement of three-dimensional conditions explicitly intended for computer game turn of events; also called a physical science engine. Unity establishes a three-dimensional climate with genuine conduct through scripting and full association with the client just as similarity with VR hardware like Oculus Go.

2. VIRTUAL REALITY

Stanley G. Weinbaum can follow the creation of virtual reality (VR) back to the novel "Pygmalion's Displays" in 1935 show Figure 2.1. This story portrays the creation of exceptional goggles that play films with which the wearer of the goggles can interact [3]. This thought was additionally evolved in 1955 by cinematographer Morton Heilig, who designed a multi-tangible mechanical assembly called the "Sensorama" Figure 2.2 [4]. This gadget incorporated a three-dimensional stereoscopic presentation, speakers and haptics criticism through the vibration of the client's seat. Morton Heilig is thus named the "Father of Computer generated Reality" for his invention. This arcade machine-style mechanical bureau was worked to animate the faculties and is illustrative of numerous highlights present in innovative head-mounted displays (HMDs). Post-"Sensorama," the first historically speaking HMD was made, which based on similar standards, giving a client binocular 3-D visuals and sound.

The term Virtual Reality has multiple definitions. The Merriam-Webster word reference characterizes augmented reality as: "a counterfeit world that comprises of pictures and sounds made by a PC and that is influenced by the activities of an individual who is encountering it."[5] Conversationally, the expression frequently addresses an existential fake world. The expression "computer generated reality" is a paradoxical expression, in any case, as in it infers that such a the truth isn't genuine that it is inalienably "virtual" Figure 2.3. Augmented Reality is, truth be told, something undeniable; it is a reality that should be recognized from being named not genuine, and all things being equal, as non-physical. Thus, this proposition centers around the specialized meaning of Computer generated Reality, as a vivid counterfeit climate that is seen through specific gear Figure 2.4. This specialized definition expresses that computer generated experience is a reenactment innovation carried out using headsets and actual props, like regulators and sensors, to force a practical multi-extended climate on a client. VR invigorates and brings a client into a delivered scene by permitting them to glance around Figure 2.5 explore and communicate with objects in the fake climate.

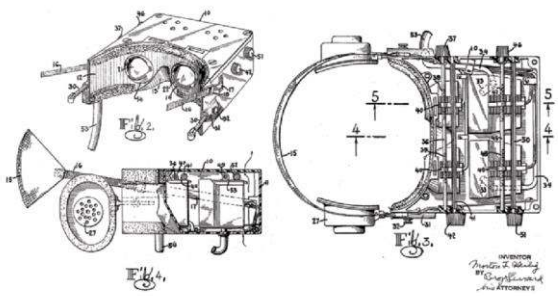

Figure 2.1. Drawing of Morton Heilig's Forte.

Figure 2.2. Sketch and pictures of the Sensorama Test system.

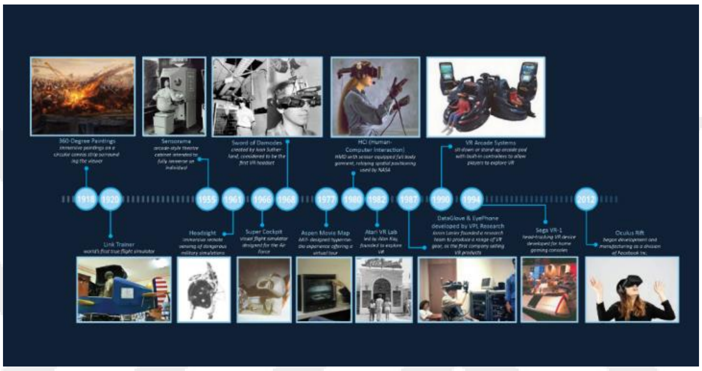

Figure 2.3. Timetable of Authentic Occasions Encompassing VR Creation and Execution.

Figure 2.4. Astonishing New Media and Amusement VR Experiences.

Figure 2.5. The Astounding Ways Honeywell Utilizing AR and AR.

VR conditions regularly coordinate transmissions as vibrations and sensations to make haptic encounters for the client inside the fake scene. In spite of the fact that VR is additionally regularly utilized as an umbrella term for vivid encounters, inside this theory, it alludes explicitly to the one of a kind encounter of setting a viewfinder headset on a client to permit them to encounter a reenacted advanced scene. VR conditions are normally deterred from the actual world as headsets execute the utilization of earphones to shut out sound and the viewfinder is put straightforwardly ridiculous to shut out sight. In spite of the fact that VR equipment may appear to be modern and the product very mind boggling, the outcome is the creation of two moving pictures that are joined with focal points to deliver the reproduction of a virtual environment.

Virtual Reality recently existed exclusively in the lab area, explicitly as a mechanism for innovative work purposes in the instructive, clinical and rehabilitative fields. In the previous decade, the forward leap of open augmented experience into the public domain has prodded a profound premium in the innovation by originators, planners, and perception specialists. Media outlets have energetically delivered consumer selection of computer generated reality innovation, which sells general society on the guarantee that VR. Holds. [6] This guarantee is addressed in the subjects of blockbuster films, books, and TV shows inside the most recent twenty years (like Ready Player One, the Matrix, Star Trek, and Black Mirror). These media discharges present utopias of mystically vivid encounters. The general population has been sold on the guideline of effortlessness in augmented simulation, by setting progressed all-encompassing viewfinder goggles on their heads to be immediately transported into "completely acknowledged" holographic scenes. Any room can be established as a virtual climate into which a client can step, and which can reproduce the presence of really being inside that climate.

Using Virtual Reality Technologies: From gaming, to motion pictures, to medication, the utilizations for Virtual Reality, Augmented Reality, and Mixed Reality are extending.

Electrical: For preparing and learning.

Medical services: For preparing, for example, for careful reproductions.

Film and television: For motion pictures and shows to make special encounters.

Virtual Travel: For virtual outings to an artisanship gallery or another planet all from home.

Gaming: For more than 1,000 games effectively accessible, from first-individual shooters to procedure games to pretending undertakings.

2.1. Immersion Technologies

Before considering the software and hardware components, the proper technology must be determined as it limits the pool from which components can be drawn show Figure 2.6. The two main types of immersion technologies are virtual and augmented reality. It is imperative to highlight the differences between them as each technology has its purpose and suitable applications. Furthermore, the level of immersion and realism of each one is discussed.

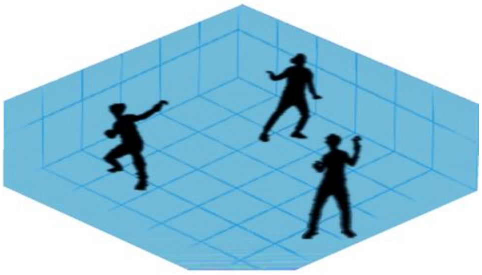

Figure 2.6. Full Immersion in Virtual Reality.

2.1.1. Virtual Reality VR

VR is the most immersive technology as it uses computer-generated graphics to engulf its user in an artificial environment. On the one hand, this environment could be designed to mimic the scenes of real-life places and objects and allow the user to interact with them. Moreover, it could be programmed to obey natural laws such as gravity by grounding the objects to an artificial ground. On the other hand, the environment could be a completely foreign scene with its own reality. It can provide a multiple sensory experience by incorporating auditory, visual, and haptic interact ants. Creating an environment in VR requires time and great effort to create and program scenes that resemble reality.

VR is mostly known for its use in entertainment. Several gaming companies have used this technology to draw more audience by engaging them in the reality of the game. Furthermore, virtual reality has been used in education due to its usability to present theoretical concepts in a user-friendly manner through immersive 3-D simulations. Another common use for VR is in the mental health field as a way of treating patients. For example, the technology may be used to help patients suffering from social anxiety and stage fright by immersing them in a safe artificial setting that mimics reality. Figure 2.7 depicts a user of the VR technology interacting with the artificial environment shown in the screen.

Figure 2.7. An Example of the Virtual Reality Technology.

2.1.2. Augmented Reality AR

AR, also known as mixed reality, is on the spectrum between complete virtual immersion and real life. The main purpose of this technology is to enhance the existing environment by using a camera to render artificial objects onto it. The targeted sensory aspects are visual and auditory interact ants. Typically, a smartphone or tablet's camera is utilized to measure the depth and distance of the surrounding environment with its objects. Using these measurements and calculations, interactive artificial objects are displayed on the device's screen, usually accompanied by sound such as music. The user is able to use their finger movement on the device's screen to activate interactions with the artificial world. This technology is mainly targeted for use on mobile smartphones [7].

The entertainment and business sectors are among the main utilizers of this technology. Several mobile games have quickly become a trend due to their accessibility and simple interactive user interface such as in Figure 2.8. Furthermore, social media mobile applications have long used this technology to attract a larger following. Face filters are among the most popular examples of social media use of this technology. Several artists and galleries have taken advantage of this technology to present interactive art and paintings, thereby attracting more audience. As for the educational sector, engineering companies have integrated this technology as part of their employee training by introducing trainees to machinery through superimposing detailed and interactive components on the machinery.

Figure 2.8. An Example of Using Augmented Reality Technology for Mobile Games.

2.1.3. Mixed Reality MR

MR unites genuine world and computerized components. In blended reality, you interface with and control both physical and virtual things and conditions, utilizing cutting edge detecting and imaging advances. Blended Reality permits you to see and submerge yourself in your general surroundings even as you collaborate with a virtual climate utilizing your own hands—all while never eliminating your headset. It gives the capacity to have one foot (or hand) in reality, and the other in a nonexistent spot, separating essential ideas among genuine and fanciful, offering an encounter that can change the manner in which you game and work today.

Mixed Reality (MR) is the converging of genuine and virtual universes to create new conditions and perceptions, where physical and advanced items exist together and communicate progressively. Mixed reality does not only occur in either the physical or virtual world, however is a crossover of the real world and augmented reality see Figure 2.9. There are numerous functional uses of blended reality, including plan, diversion, military preparing, and far off working. There are likewise unique presentation advances used to encourage the connection among clients and blended reality applications[8].

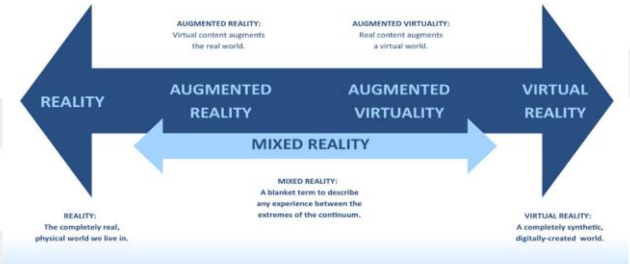

Figure 2.9. Paul Milgram's Reality-Virtuality Continuum.

2.2. Differences between AR, MR and VR

Expanded Reality (XR) is the umbrella term that incorporates the full range of realities. These real factors, specifically Virtual, Mixed and Augmented, are guaranteed to successfully "blur the line between reality and illusion, pushing limits of our imagination and granting us access to any experience imaginable." This is refined contrastingly by every one of the three real factors. With a solid seeing effectively that augmented experience comes from setting a HMD on one's head (which incorporate earphones), two fundamental tangible sources (sight and sound) are dominated. Because of this, VR conditions are normally cut off from the actual world. Augmented Reality is a method of survey this present reality straightforwardly (or through a gadget with a camera that makes a visual of the genuine encompassing world) and afterward augmenting this world with a PC produced visual info. Computer generated reality and expanded reality get two altogether different things done in two altogether different manners, in spite of the comparable plans of the actual gadgets. VR replaces reality, taking the client to a better place. AR adds to the real world, extending data on top of what one is now seeing. The virtual expansion is made through still illustrations, sound or video age onto this present reality. Enlarged reality contrasts from VR in that it adds to this present reality as opposed to making all aspects of the visual experience without any preparation. With augmented reality, information, instructional data, emotive articles and characters are enlivened absurd perspective, including a layer top of the current genuine world.

AR is frequently carried out through more modest gadgets like a cell phone or tablet. An amazingly effective application called Pokémon GO is an illustration of AR, as it includes virtual characters enlarged into this present reality and seen through the telephone's camera. Another model, more practical in utilization to the building calling, would be a designer distantly showing a development specialist how a particular divider determination is intended to be constructed. Instances of this product incorporate Apple's ARkit and Google's ARcore, which check the actual world, project an advanced layer on this world, and can even project computerized shadows on physical items. AR furnishes no connection with the increased advanced world, while Mixed Reality (MR) permits such collaborations show Figure 2.10.

Mixed Reality (MR) takes this present reality and coordinates PC created substance to connect with the perspective on this present reality. It conveys the capacity to take completely created advanced conditions and associate them to certifiable items, making it the solitary innovation ready to join the simple and computerized realities. Henceforth, each of the three of these advances (VR, AR and MR) allude to exceptionally vivid and virtual encounters that convey esteem in a conversation of virtual spaces [9]. At the structural setting, this fundamental estimation of being inside a virtual form of a structure project at genuine scale is that it considers the proposed client to appreciate, associate, or study a task in the most normal manner, while it is yet being imagined or built into this present reality. To comprehend the distinction between these advancements, we can likewise look to Paul Milgram's "world virtuality continuum," a virtuality scale used to gauge an innovation's measure of virtualness or conversely, realness.

Among these various real factors, VR has all the earmarks of being the most ideal approach to get to the impression of inundation, or the feeling of being, in a completely virtual climate. In the engineering domain, most of undertakings center around considering and envisioning new conditions, consequently requiring full virtual drenching when these conditions are exhibited to customers or friends.

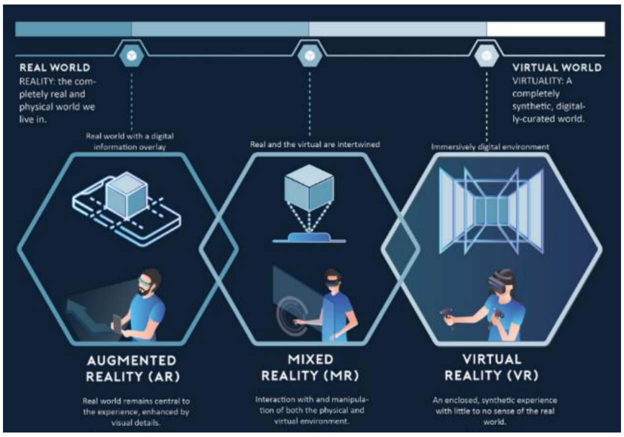

Figure 2.10. Contrasts between VR, MR and AR (Immersion Levels).

As VR shuts a client off from the actual world by laying hold of sight, it tends to be utilized to consider any space essentially, whether or not or not the engineering space exists in the present. Thus, this makes it all the more differently pertinent to the whole scope of work in the structural domain. Ultimately, despite the fact that MR can be relied upon to give both VR and AR (and switch between the two), the innovation still cannot seem to arrive at transformative development. In addition, its assessment inside the compositional circle must be made once it goes through the Publicity Cycle or is investigated in the customer market in a similar way experienced by VR. Despite the fact that market achievement is not basic for MR to make an effect inside the plan practice, it is all the more significantly a marker of the purchaser or a design expert's capacity to utilize the inventive innovation. The shopper side, overall, drags along the venture universe of technology. Just an item that is generally welcomed in the market is illustrative of mechanical development and convenience inside a wide segment (counting architects and designers), stating that MR is right now too youthful to even think about being assessed inside the compositional circle.

2.3. Virtual Reality Sickness

If you are building virtual reality (VR), it may be a benefit to under-stand how much of an issue VR sickness currently is and why. There is inhibit widespread adoption. At such an early stage in VR evolution, we are all ambassadors for the virtual world, and our experiences may very well help to shape its future. It is every VR content creator's responsibility to try to lessen or find workarounds for VR sickness if we are going to see this generation of VR succeed.

This subject is not about forcing anyone to build VR experiences in a particular way, or even saying that you should not create experiences that may make people feel ill. Honestly, if you want to go ahead and target the groups of people who are not affected by sickness, you should go ahead and do that because there will be people who can enjoy it without an issue. On the other hand, providing options to turn on or off sickness prevention systems could be a great selling point for your game, and we need to understand that everyone is different and people are affected in different ways by VR sickness. For that reason, I am providing problems and solutions in this chapter so that you may consider the options and take what you want from them[10].

2.3.1. What is VR Sickness?

VR sickness is also known as simulator sickness or cyber sickness. It can manifest as a range of symptoms like sweating, nausea, sickness, headaches, and drowsiness, and other symptoms like those experienced by motion sickness sufferers who get sick in cars, boats, or planes.

Despite years of research, we still do not know exactly what causes it. The most popular theory is that VR sickness is caused by a mismatch between what a viewer experiences versus what the viewer's brain thinks it is experiencing Figure 2.11. This is known as cue conflict theory [11]. Cue conflict theory is when the brain thinks that the input (sight, sound, and so on) is not real or correct. Our minds perform "safety checks" to make sure that the body is in a healthy state. The detection system looks for cues or clues to abnormalities, such as tying movement and sight together to build up a body of information to confirm that what you are experiencing is correct. When the cues do not match up, the brain switches into a defensive mode. Tis mode would normally be triggered when the body is under threat from poison or a similar attack. A rejection system kicks in as the brain attempts to rid the body of any poisons, through bodily fluid (sweat secretion and/or vomiting depending on severity).

Figure 2.11. Virtual Reality Sickness.

2.3.2. VR Sickness Symptoms and Cues

VR visitors are affected in different ways and by different situations. Some people exhibit all the signs and symptoms, whereas others only experience a few or none. Kennedy and Fowlkes noted that simulator sickness is polysymptomatic. Humans experience the world in very different ways. If cue theory is to be believed, the cues may work under an entirely different set of parameters per person. The way one person moves could vary dramatically from a disabled person, for example, which may mean a difference in the perception of cues. There are so many potential cues, with influence levels varying from person to person, combined with individual physical factors, and a huge number of variables we need to factor in. This is by no means an exhaustive list, but listed are some of the variables in play.

3. SYSTEM ARCHITECTURE

Describe devices use to intervene the client's contribution to, and input from, the VR reenactment. We take a gander at the figuring equipment supporting such continuous connection, which we call the VR motor. This term is a deliberation, which compares to different actual equipment designs, from a solitary PC to many arranged PCs supporting a given reproduction.

3.1. Input Devices

One of the three I's characterizing computer generated reality represents intelligence. To permit human-PC cooperation it is important to utilize uncommon interfaces intended to include a client's orders into the PC and to give criticism from the reproduction to the client. The present VR interfaces are fluctuated in usefulness and reason, as they address a few human sensorial channels. For instance, body movement is estimated with three-dimensional position trackers or utilizing detecting suits, hand motions are digitized by detecting gloves, visual input is shipped off sound system HMDs and enormous volume shows, virtual sound is figured by three-dimensional sound generators, and so on A portion of these info/yield (I/O) gadgets are monetarily accessible; some are still models in a field that has become a functioning examination region.

Some domains of computer applications, such as navigation, ballistic missile tracking, ubiquitous computing, education, architecture, biomechanics, robotics, biomechanics, architecture, computer-aided-design (CAD), and virtual reality, require real-time position awareness and orientation of moving objects within a frame of reference[12]. These applications have varying requirements in terms of parameters such as measurement range, accuracy, and temporal update rates. Global Positioning System (GPS) transducers, for example, report position with an accuracy of 1 to 5 m (95% of the time) on a global scale. This is great for car navigation, but VR has much stricter precision requirements. On the other hand, the scale of distances measured for virtual reality interactions is usually no larger than a room or a laboratory.

An object moving in three-dimensional space has six degrees of freedom, three for translations and three for rotations. If a Cartesian coordinate system is attached to the moving object (as illustrated in Figure 3.1), then its translations are along the X, Y, and Z-axes. Rotations of objects about these axes are called roll, pitch and yaw, respectively. These define a data set of six numbers that must be measured quickly enough, since the object may be moving at great speed.

Definition “The special-purpose hardware used in VR to measure the real-time change in a three-dimensional object place and orientation is named a tracker”.

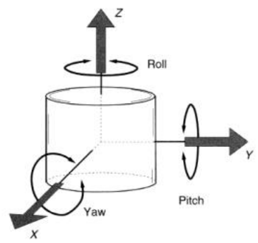

Figure 3.1. Coordinate system of a Three-Dimensional object in motion.

Another tangible methodology of augmented reality that utilizations data from the tracker is three-dimensional sound, which in Figure 3.2 is introduced through earphones. The tracker information permits the PC to put sound sources with virtual items that the client finds in the recreation. The estimation exactness necessities for 3-D sound application are substantially less severe than those needed for graphical criticism [13]. Various competitive tracking technologies are available, such as mechanical, magnetic, optical, ultrasonic, and hybrid. Therefore, it is necessary to observe the performance parameters of the tracker to adapt its measurement capabilities to different requirements of the sensory channel and available budgets [14].

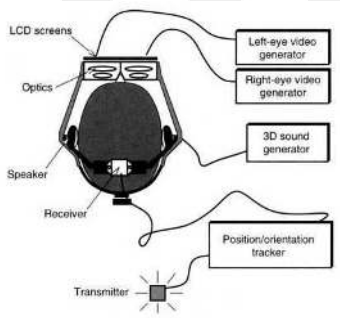

Figure 3.2. A Three-Dimensional magnetic sensor in a HMD.

3.1.1. 3D Place Magnetic Trackers

Whatever three-dimensional measurement technique is used, it should not be intrusive, and should not hinder the user's freedom of motion in the process of tracking him or her. In view of this requirement, noncontact three-dimensional measurement techniques have largely replaced the earlier mechanical ones. The three-dimensional noncontact trackers available today use either magnetic fields, ultrasound, infrared cameras and LEDs, or accelerometers and gyroscopes. We start our discussion with magnetic trackers, since they are the most prevalent today[15].

Definition “An attractive tracker is a noncontact position estimation gadget that uses an attractive field delivered by a fixed transmitter to decide the ongoing situation of a moving collector component”.

The transmitter comprises of three receiving wires comprised of three commonly symmetrical curls twisted on a ferromagnetic block. These gathering devices are invigorated successively to make three balanced attractive fields. These are subbing fields of 7-14 kHz for AC attractive trackers or beat fields for DC attractive trackers Figure 3.3. The fields penetrate the recipient conveying a sign including nine voltages three for all of the transmitter's even fields. DC attractive trackers add another three voltages obtained when the transmitter is off. These voltages contrast with the close by assessment of the World's DC attractive field. The beneficiary contains three minimal even circles while using AC attractive fields and three magnetometers (or on the other hand Corridor Impact sensors) while using DC attractive fields. An electronic unit that utilizes an alignment calculation to decide the position/direction of the collector corresponding to the transmitter tests the beneficiary voltages. These information bundles (three positions and three points of pivot) are hence sent to a host PC through correspondence lines.

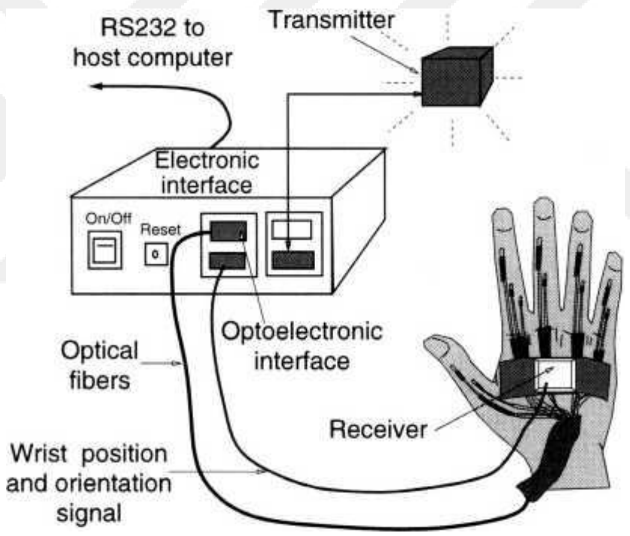

Figure 3.3. Three-Dimensional magnetic tracker used by the VPL DataGlove.

3.1.2. 3D Place AC Magnetic Trackers

The first trackers used in VR simulations were Polhemus Isotrack AC magnetic trackers integrated with the VPL DataGlove [16], the tracker receiver was attached to a rubber/foam bridge over the glove optical sensors. Its electronics was integrated in the same box that housed the electrooptical circuitry necessary to read the glove bending sensors. The Isotrack latency was large (about 30 ms) owing to limitations in the settling time of the tracker analog signal. Furthermore, the Isotrack had large jitter noise (almost 1° rotation), which became even larger at the limits of the sensor range. When sampled by the host computer this noise resulted in a tremor of the virtual hand and blurred graphics.

3.1.3. 3D Place DC Magnetic Trackers

In order to alleviate the eddy current problem proposed replacing the transmitter AC magnetic field with a DC one. His idea was to induce a short time delay between the excitation of the transmitter and the sampling of the receiver to allow for the disappearance of eddy currents. The functioning of a typical DC magnetic tracker. It contains an embedded microprocessor that controls the amplitude of the transmitter DC magnetic pulses. This is realized by sending analog voltages to current sources connected to the transmitter coils. The higher the control voltage, the higher is the current produced by the current source, and thus the amplitude of the magnetic pulse. A multiplexer allows the microprocessor to cycle the current sources, such that three orthogonal DC magnetic fields are produced[17].

Correlation of AC and DC Attractive Trackers:

DC and AC attractive trackers measure the distance $\boldsymbol{d_{transmitter-receiver}}$ based on the local value of the attractive field of the transmitter v. This intensity falls with the cube of the distance from the transmitter, and the relative importance of the unwanted disturbances Av grows accordingly [18].Colleagues and Nixon. Determined that the positional measurement error due to ambient noise is given by

$$e_{ambient} = K_a(d_{transmitter-receiver})^4 \tag{3.1}$$

3.1.4. 3D Place Ultrasonic Trackers

An alternative tracking solution that does not suffer from metal interference uses three-dimensional ultrasound trackers.

Definition "An ultrasound tracker is a noncontact position estimation gadget that uses an ultrasonic sign delivered by a fixed transmitter to decide the continuous situation of a moving collector component".

Ultrasound trackers have three segments, a transmitter, a recipient, and an electronic unit, like their attractive partners. In addition, the collector is a bunch of three amplifiers mounted on a more modest unbending three-sided outline see Table 3.1. This three-sided outline is set at the highest point of the head mounted presentation. Then again the receivers might be important for three-dimensional mice, sound system glasses (talked about in the following section), or other interface gadgets. Because of their straightforwardness, ultrasound trackers address a less expensive option in contrast to the attractive ones.

Table 3.1. Shows a performance comparison between the Fastrack and the Flock of Birds.

Specification	Fastrack	Flock of Birds
Operation radius		
Normal	0.75m (30 in.)	1.2m (48 in.)
Extended	2.25m (90 in.)	3m (120 in.)
Angular range	All attitudes	±180° azimuth and roll ±90° elevation
Translation accuracy	0.03 in. RMS	0.1 in. RMS
Translation resolution	0.0002 in./in. range	0.03 in. RMS
Angular accuracy	0.15° RMS	0.05° RMS
Angular resolution	0.025° RMS	0.1° RMS at 12 in
Update rate (measurements/sec)	120 (1 receiver) 60 (2 receivers) 30 (4 receivers)	144 (≤30 receivers)
Latency (single receiver)	8.5 ms (no filtering)	7.5 ms (no filtering)
Metal interference	Ferrite, mild steel, copper, stainless steel, brass, aluminum	Ferrite, mild steel, copper
Interface	RS232 (selected Bd rates to 115,200) or IEEE-488 (up to 100 kBd/sec)	RS232 (selected Bd rates to 115,200) or RS422/485 (select Bd rates to 500,000)
Data format	ASCII or binary	Binary
Modes	Point or stream	Point or stream

The speed of sound in air changes for room temperature dependent on the law

$$c = (167.6 + 0.6Tk) \tag{3.2}$$

Where $\boldsymbol{c}$ is the speed of sound in m/sec and $\boldsymbol{Tk}$ is the air temperature in degrees Kelvin. For a given temperature, the speed of sound is known and can be utilized to quantify distances dependent on schedule of flight. The ultrasound tracker estimations depend on triangulation. Every speaker is actuated in cycle and the three good ways from it to the three amplifiers in the recipient are determined. Nine distances is estimated to decide the position and direction of the plane that contains the three mouthpieces. The control unit central processor CPU tests the receivers Figure 3.4, changes over their readings into position and direction dependent on alignment constants, at that point communicates the information to the host PC for illustrations scene delivering. When four receivers are tracked simultaneously, the update rate drops to (only) 12 datasets/sec! Using a single transmitter with multiple receivers has the additional drawback of limiting the total volume where the user's head and hands have to be. A typical range might be 1.52 m (5 ft.) from the ultrasound transmitter, but this is reduced significantly by the relative humidity of the air.

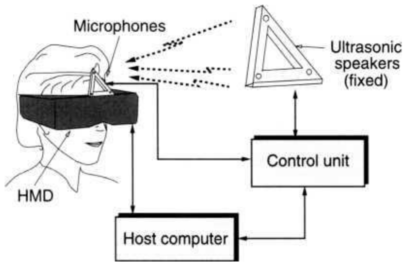

Figure 3.4. Logitech ultrasound head tracker.

An immediate view is needed between the transmitter and the recipient of an ultrasound tracker. This is another huge downside contrasted with attractive trackers Figure 3.5, which do not need direct view. In the event that some item hinders the view between an ultrasound transmitter and recipient or the client's head is dismissed, the tracker signal is lost. The sign is likewise adulterated by foundation clamor in the room just as other ultrasound sources, (for example, the ones utilized in building security)[19].

Certain applications may require a larger user motion volume than is allowed by a single transmitter Figure 3.6. The solution is to spatially multiplex several transmitters with a single receiver. The transmitters have to be placed such that their conic tracking volumes overlap. The computer activates the box based on predictive control, which is, determining the receiver position, velocity, and acceleration. Hysteresis is provided in order to avoid cycling the switches in the overlap zone[20].

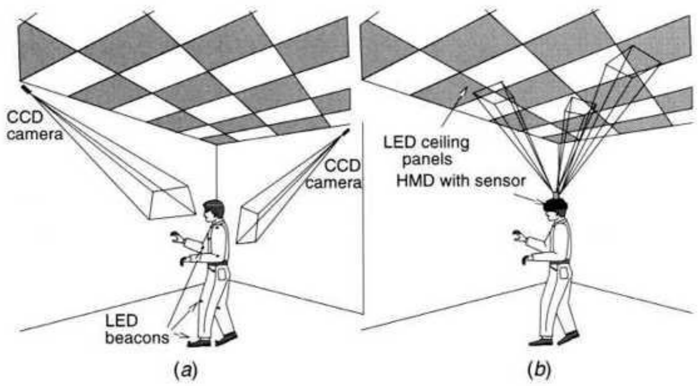

Figure 3.5. Optical tracker arrangesment: (a) Outside-looking-in; (b) Inside-looking-out.

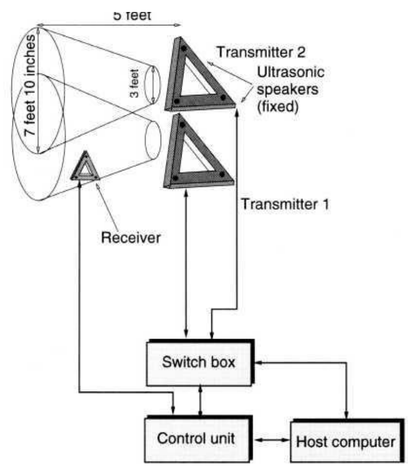

Figure 3.6. Ultrasound tracking over large distances.

3.1.5. Navigation and Manipulation Interfaces

Definition “A route/control interface is a gadget that permits the intuitive difference in the view to the virtual climate and investigation through the choice and control of a virtual object of revenue”.

The navigation/manipulation should be possible in either total directions or relative directions[21]. The trackers depicted so far are supreme, as they return the position and direction of a moving item as for a fixed arrangement of directions. The situation of the VR object controlled on the screen is straightforwardly planned to the supreme situation of the beneficiary on the planet (transmitter) fixed arrangement of directions.

Table 3.2. Performance Comparison of Various Trackers.

(mm/degree) Accuracy	(m) Range	(sec×10-3) Latency	(dataset/sec) Update Rate
0.5/0.03	30×30	0.0002	2000
HiBall	IS-900	Push	HiBall
0.8/0.15	12.2×12.2	1	256
Fastrack	HiBall	HiBall	interTrax2
1/0.5	2	4	240
laser-BIRD	laser-BIRD	laser-BIRD	laser-BIRD
2/0.5	1.52	7	180
Flock of Birds	Logitech	laser-BIRD	IS-900
4/0.2	1.2	7.5	160
IS-900	Flock of Birds	Flock of Birds	3-D BIRD
4/NA	0.75	8.5	144
Push	Fastrack	Fastrack	Flock of Birds
NA/4	**NA**	**10**	**120**
3-D BIRD	3-D BIRD	IS-900	Fastrack
NA/5	**NA**	**15**	**70**
InterTrax2	InterTrax2	3-D BIRD	Push
30	**NA**	**30**	**50**
Logitech	Push	Logitech	Logitech

Another approach to control a VR article's position is through relative sensors. Though total position information are rarely a zero set (regardless of whether the collector is very still), a relative position sensor will consistently return zeros if not followed up on. Route/control in relative directions takes into account gradual position control comparative with the article's past three-dimensional position. The situation of the VR object is increased by six marked amounts at each recreation cycle see Table 3.2. Velocity is indirectly controlled, as a larger translation/rotation increment will result in a larger velocity of the VR object in the simulation [22].

3.2. Output Devices

The past part portrayed three-dimensional trackers, trackballs, and sensing gloves, which are gadgets used to intercede the client's contribution to the VR simulation. Presently we take a gander at unique equipment intended to give criticism from the recreation in light of this information. The sensorial channels took care of back by these interfaces are sight (through illustrations shows), sound (through three-dimensional sound shows), and contact (through haptic presentations).

For reasons of simplicity, this chapter treats each sensorial feedback modality separately. A further simplification here is the decoupling of sensorial feedback from the user's input. Modern VR systems are, however, multimodal, and feedback interfaces usually incorporate hardware to allow user input (such as trackers, pushbuttons, etc.). Furthermore, consolidating a few sensorial modalities improves the recreation authenticity and hence the handiness of VR applications.

Graphics Displays are alternate approaches to portray illustrations shows are as indicated by the sort of picture delivered (stereoscopic or monoscopic), their picture goal (NO. of pixels in the scene), the field of view (part of the eye's survey volume they cover), show innovation (LCD or CRT-based), ergonomic variables (like weight), and cost. The incredible assortment of illustrations shows is a consequence of the way that vision is the most impressive human sensorial channel, with a very huge preparing transmission capacity. Some VR frameworks may not consolidate three-dimensional sound or haptic input interfaces; however, all will have some kind of graphics display.

Definition “A designs show is a PC interface that presents engineered world pictures to one or a few clients connecting with the virtual world”.

3.2.1. The Human Visual System Graphics Displays

Planning or choosing an illustrations show is impossible genuinely without first understanding the human visual framework. A compelling illustrations show needs to coordinate with its picture attributes to those of the client's capacity to see the manufactured scene. In this manner, prior to endeavoring to depict a specific survey equipment, it is important to portray the human visual discernment component.

Another significant trait of the human vision framework is the field of view. This is around 150° evenly and 120° vertically when one eye is utilized and develops to 180° on a level plane and 120° vertically when the two eyes are utilized [23]. A focal bit of this review volume addresses the region of stereopsis, where the two eyes register a similar picture. This binocular cover is roughly 120° on a level plane. A physiological model of human stereoscopic vision adjusted from [24] is outlined in Figure 3.7.

Inside the field of view, the eyes register the articles encompassing the watcher, for example, object A, which is behind object B. The eyes focus on an element of B, zeroing in on an obsession point F. The point between the review hub and the line to the obsession point decides the combination point. This point relies additionally upon the distance between the students of the privilege and left eyes. This distance is known as the interpapillary distance (IPD) and shifts among male and female grown-ups inside a scope of 53-73 mm. The IPD is the standard from which an individual deciphers distances to objects in reality. At the point when a solitary presentation is utilized, the two pictures can be time-sequenced (when utilizing screen glasses) or spatially sequenced (for autostereoscopic shows Figure 3.8).

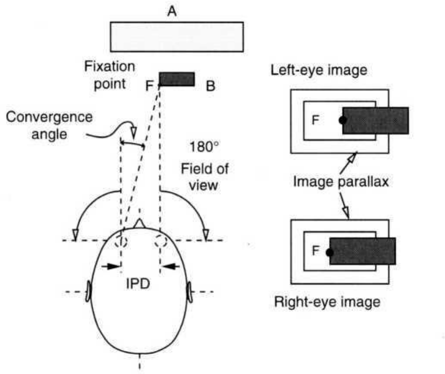

Figure 3.7. Physiological model of stereoscopic vision. IPD, Interpapillary distance.

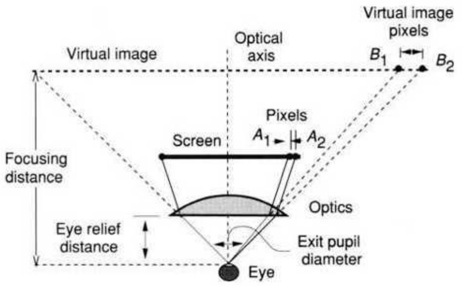

Figure 3.8. Simplified optics model of an HMD.

3.2.2. Personal Graphics Displays

Inside the individual showcase classification are assembled head-mounted presentations (HMDs), hand-upheld shows, floor-upheld shows, and autostereoscopic screens.

Definition “An illustrations show that yields a virtual scene bound to be seen by a solitary client is known as an individual designs show. Such pictures might be monoscopic or stereoscopic, monocular (for a solitary eye), or binocular (showed on the two eyes)”.

Head-Mounted Displays.

These undertaking a picture skimming some 1-5 m (3-15 ft.) before the client. They utilize exceptional optics set between the HMD little picture boards and the client's eyes to permit the eyes to center at such brief distances without tiring without any problem. Optics is additionally expected to amplify the little board picture to fill however much as could be expected of the eyes' Field Of View (FOV). As can be found in Figure 3.9 the disastrous side effect is that the distance between show pixels (At, A2) is enhanced also. In this way, the "granularity" of the HMD shows (communicated in curve minutes/pixel) gets obvious in the virtual picture. The lower the HMD goal and the higher the FOV, the more noteworthy is the quantity of circular segment minutes of eye see comparing to every pixel. More established HMDs had low goal (as show Figure 3.10) and consolidated a diffuser sheet overlaid on the contribution to their optics. These diffusers obscured the edges between pixels fairly, and the picture was seen to be better. Current HMDs have goals up to broadened video designs cluster (XVGA; 1024 x 768) or better. Indeed, even these goals might be inadmissible if the optics enhances the pixel measurement a lot to grow the obvious FOV. Moreover, extremely huge FOVs power enormous leave student breadths, which can deliver shadows around the edges of the apparent picture [25].

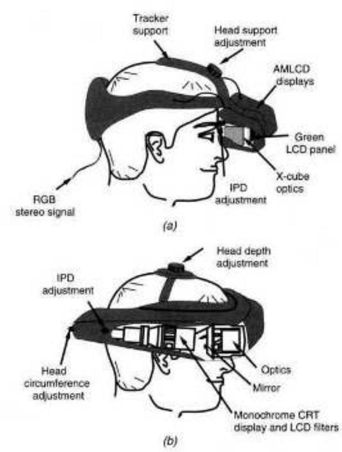

Figure 3.9. Head-mounted display (HMD) Integration in a VR system for. (a) Consumer (monoscopic) HMD. (b) Professional (stereoscopic) HMD.

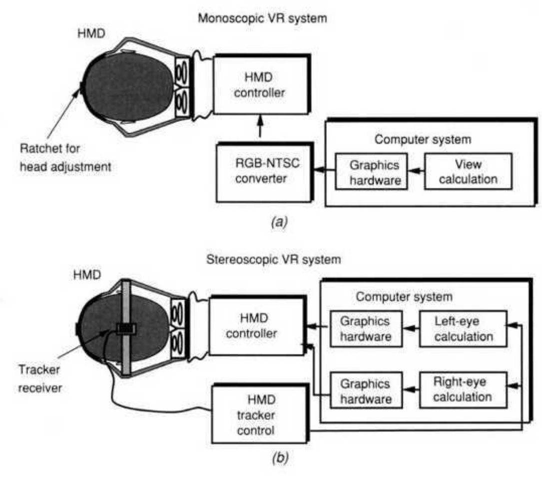

Figure 3.10. Stereoscopic HMDs. (a) ProView XL35. (b) Datavisor HiRes.

3.2.3. L-Volume Graphics Displays

Definition “Designs shows that permit a few clients situated in nearness to all the while see a sound system or monoscopic picture of the virtual world are called huge volume shows”.

Table 3.3 makes clear the value/execution contrasts that exist in close to home designs shows. Moreover, it is difficult to legitimize the excessive cost of expert evaluation items when just a single watcher is obliged. In a perfect world, a few clients found together ought to have the option to take a gander at a similar picture, share thoughts, and work cooperatively.

Based on the type and size of the display they use, enormous volume presentations can be additionally delegated screen based (single or side-by-side CRTs) and projector based (workbenches, CAVEs, display walls, and domes). Their logically bigger work envelope improves clients' opportunity of movement and regular cooperation ability contrasted with individual showcases. The sound system huge volume shows by and large utilize a fleeting joined illustrations design, implying that a similar showcase substitutes the sound system pair pictures in quick progression.

Table 3.3. Performance Comparison of Various Personal Graphics Displays.

Manufacturer, Display Name	Type	Resolation (Pixels)	FOV (H×V)	Weight (g)
Olympus Eye-Trek	AMLCD, FMD	267×225	30°×23°	100
Daeyang Cy-visor	LCOS, LCD, FMD	800×600	60°×43°	160
Kaise ProView XL35	AMLCD, HMD	1024×768	28°×21°	992
n-vision Inc. Datavisor	CRT, HMD	1280×1024	78°×39°	1,587
NVIS Inc. Virtual binoculars SX	LCOS, LCD, HSD	1280×1024	42° Diagona	1000
Fakespace Labs Boom3C	CRT, FSD	1280×1024	85°×H	NA
Virtual Research Window VR	Flat panel, FSD	1280×1024	21 in. Diagonal	NA
Dimension Technologies Virtual Window	TFT, LCD Auto stereo	1280×1024 2-D, 640×1024 3-D	18.1 in. Diagonal	11,250
Elsa Ag. Ecomo4D	TFT, LCD auto stereo	1280×1024 2-D, 640×1024 3-D	18 in. Diagonal	17,000

Monitor-Based Large-Volume Displays.

The littlest enormous volume sound system show utilizes dynamic glasses regarding one sound system prepared screen. As represented in Figure 3.11a, every client wears a bunch of screen glasses and takes a gander at the screen. The sound system prepared screen is of an uncommon plan that is fit for reviving the screen at twofold the typical sweep rate, or somewhere in the range of 120 and 140 outputs/sec. A PC sends two exchanging; marginally counterbalance pictures to the screen, as delineated in Figure 3.11b. An Infrared (IR) producer situated on top of the CRT show is synchronized with the RGB sign and controls the dynamic glasses in a remote mode.

The immersive sensation felt when wearing followed sound system glasses is unique in relation to that of HMDs[26]. When wearing HMDs clients feel encompassed by the virtual world. With sound system glasses, the client sees the CRT show as a window into a virtual world. On the off chance that the client is sitting at 45 cm from a screen that has 30-cm-wide presentation, at that point the showcase fills just 37° of the client's 180° level field of view. Executing an embellishment factor to influence the field of view requires an expected default client to-screen distance u (for instance, 30 cm). In the event that the head tracker recognizes an alternate distance u from the client's head to the showcase, at that point the projection distance ought to be duplicated by a factor$\boldsymbol{K}$.

$$K = r(u - U) + U \tag{3.3}$$

Where $\boldsymbol{U}$the default is distance and $\boldsymbol{r}$ is the responsiveness factor, and $\boldsymbol{r}$ of 1.25 is an optimal responsiveness factor for both field of view angle and image rotation. Since r amplifies equally the noisy three-dimensional tracker data, jitter will be increased at the edges of the work envelope.

Projector-Based Displays.

These address the arrangement of decision for permitting numerous firmly found clients to partake in a VR reproduction. Such illustrations shows have customarily consolidated CRT projectors to deliver the sound system pair picture. A CRT projector utilizes three cylinders (R, G, B) to deliver a high-goal (1280 x 1024 pixels) picture at 120 Hz. While working in outline consecutive sound system mode, the projector parts the quantity of output lines in two, and the client wearing dynamic glasses sees a sound system picture invigorated at 60 Hz.

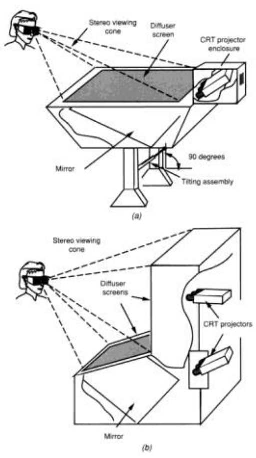

Figure 3.11. Workbench displays. (a) Single-projector tilting configuration. (b) Dual-projector L-shaped configuration.

CAVE-like displays become too small for more than a dozen users. Graphics displays that produce large enough images to accommodate many more viewers are walls and domes. Such displays have image dimensions of 7.11mx2.13m for the PanoWall, 7.32mx2.44m for the WorkWall, and an even larger diameter for the V-Dome. In order for a single projector to cover such large image surfaces, it needs to be moved far from the screen, which in turn reduces image brightness substantially. Furthermore, the larger the screen, the lower is the ratio of pixels/surface area that the eye sees, which means increased image granularity. If a single projector with a resolution of 1280x1024 is used with the PanoWall, then this ratio is 8.6 pixels/cm2. Such an image resolution may be inadequate for visually demanding applications typically associated with wall-size displays.

Table 3.4 summarizes the characteristics of the large-volume graphics displays discussed in this chapter. The resolution is given in million pixels/m22 in order to eliminate the dependence on display shape. Listed prices do not include the computer driving the large-volume display. It becomes apparent from this data summary that prices increase significantly with the size of the display, while at the same time the resolution drops by orders of magnitude. Increasing the resolution of very large displays to that of workstations would involve many more projectors and an even larger cost than those given in Table 3.4.

Table 3.4. Comparison of Various Large-Volume Graphics Displays.

Manufacturer, Display Name	Type	Resolation (106 Pixels/m2)	Image Size	Number Of Users
StereoGraphics CrystalEyes3	Active glasses	18.2	0.36×0.2 m2	~4
Panoram PV290	3-Panel monitor	12.2	1.11×0.29 m2	~3
Barco Barcon	Tilt workbench	1.9	1.36×0.71 m2	~4
Trimension V-Desk 6	L-Shaped workbench	1.0	1.36×1.73 m2	~4
Fakespace Immersive WorkRoom	4-Wall CAVE	0.1	3.0×3.0×4 m3	12
Fakespace RAVE	Modula CAVE	0.2	2.3×2.4×4 m3	Variable
Panoram PanoWall	Wall (3 Projector)	0.2	7.11×2.13 m2	Variable
Trimension V-Dome	Dome (6 Projector)	0.009	21 m Diameter	400

Sound Displays

Definition “Sound showcases are PC interfaces that give engineered sound criticism to clients communicating with the virtual world. The sound can be monaural (the two ears hear a similar sound) or binaural (every ear hears an alternate sound)”.

Sound displays play a significant part in expanding the reenactment authenticity by supplementing the visual input given by the illustrations shows recently examined. Accept a client is taking a gander at a virtual ball skipping in a virtual room that is shown on a CRT screen. The client's brain says that the person ought to likewise hear a natural "thud" sound. At the point when sound is added, the client's intuitiveness, drenching, and saw picture quality increment. In this situation, straightforward monaural sound is adequate, as the ball is consistently before the client and being shown by the screen. Allow us currently to think about another client, who takes a gander at a similar virtual world, this time showed by a HMD. On the off chance that the ball ricochets away, outside the field of view (as balls in reality once in a while do), at that point the client can't tell where the ball went dependent on visual data or on monaural sound alone. Presently the reproduction needs a gadget that gives binaural sound to confine the "thud" sound in three-dimensional space comparative with the client.

3.2.4. The Human Auditory System Sound Displays

Three-dimensional sound displays cannot be effective without an understanding of the way we localize sound sources in space. Humans perceive sound through vibrations arriving at the brain via the skeletal system or via the ear canal. Within the scope of this research, we are interested in the ear's ability to detect the position of a sound source relative to the head below Figure 3.12.

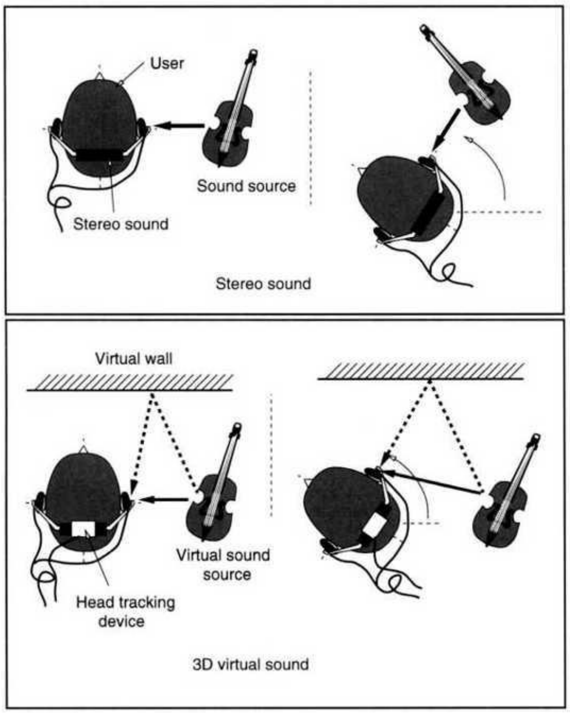

Figure 3.12. Stereo sound versus three-dimensional virtual sound.

Azimuth Cues.

Since sound has a fixed proliferation speed in air, it will arrive from the outset the ear that is nearer to the source. The sound falter stores the correct ear last, since it needs to travel an additional distance of $\boldsymbol{a}9$ + a wrongdoing 0. The distinction in the appearance season of the sound at the two ears, called the interaural time difference, ($\boldsymbol{ITD}$), is given by

$$ITD = ac(9 + sin\, 9) \tag{3.4}$$

Where $\boldsymbol{a}$ is the head radius, $\boldsymbol{c}$ is the speed of sound (around 343 m/sec), and 9 is the source azimuth. This time contrast is most extreme when 9 is 90° and zero when the source is straightforwardly before or straightforwardly behind the head.

Head-Related Transfer Functions.

Three-dimensional sound equipment configuration accepts that the area of the sound source is known. It then necessities a model of the relating sound arriving at the inward ear. Wonder multidimensionality, singular anatomical varieties, and our incomplete comprehension of the hear-able framework muddle the demonstrating task, notwithstanding. A substitute methodology is to put individuals inside an arch with spatially limited sound sources (amplifiers) and fit them with smaller than normal mouthpieces set near the eardrum [27]. At the point when the amplifiers are turned on in grouping, the receiver yield is put away and digitized. It is subsequently conceivable to quantify the reaction as two capacities (one for every ear), called Head-Related Motivation Reactions (HRIRs). The comparing Fourier changes, called Head-Related Exchange Capacities (HRTFs), catch every one of the actual signals utilized in source confinement. As talked about in the previous, HRTFs rely upon the source azimuth, height, territory, and recurrence. For sources in the far field, HRTFs rely just upon azimuth, height, and recurrence.

3.2.5. Speaker-Based 3D Sound Displays

The high price of the Huron 20 makes it impractical for consumers who want to add three-dimensional sound to their PC or home theater electronics. Such setups typically do not incorporate head trackers, and display sound on multiple loudspeakers rather than on headphones.

The simplest multi speaker audio system is the stereo format, which produces sound that appears to come from the plane defined by the two speakers. An improvement is the quad format, where two speakers are in front and two are behind the user. Another setting is the "5.1 surround" format, in which three speakers are in front of the user, two are lateral (left and right), and one is a subwoofer. Such multichannel audio systems produce a richer sound than stereo, but are more expensive and complex and occupy more space.

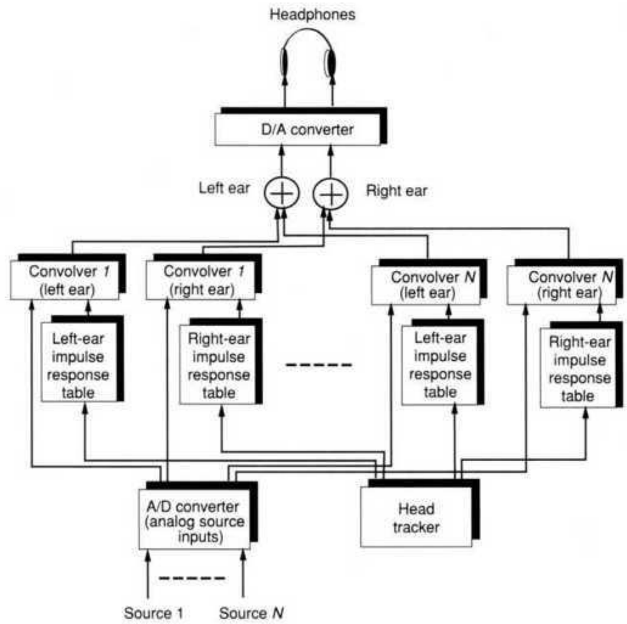

Figure 3.13. The generic Convolvotron block diagram.

Lately another age of reasonable PC three-dimensional sound cards has showed up. They use DSP chips to deal with sound system or 5.1-arranged sound and convolve it to yield genuine three-dimensional sound. As represented in Figure 3.13 [28], the PC amplifiers are put left and right of the screen, arranged corresponding with it and confronting the client. In a manner HRTFs can be recovered from the look-into table, knowing the surmised position of the client's head (confronting the PC), inside a "sweet spot" zone. It is subsequently conceivable to make the fantasy of a lot more ghost speakers encompassing the client and make viable azimuth confinement, as long as the client stays in the sweet spot zone.

In contrast to earphones, the amplifier based three-dimensional sound frameworks cannot confine the sound for every ear. Consequently, the sound $\boldsymbol{Y_{left}}$ arriving at the left ear is a combination of the sound coming from the relating amplifier $\boldsymbol{S_{left}}$ and the cross talk from the other amplifier$\boldsymbol{S_{right}}$. The circumstance is reflected for the correct ear. This cross-talk impact is communicated by

$$\begin{bmatrix} Y_{left} \\ Y_{right} \end{bmatrix} = \begin{bmatrix} H_{l,l} & H_{l,r} \\ H_{r,l} & H_{r,r} \end{bmatrix} \begin{bmatrix} S_{left} \\ S_{right} \end{bmatrix} \tag{3.5}$$

Where $\boldsymbol{H_{l,l}}$the HRTF between the left speaker and the left ear is, $\boldsymbol{H_{l,r}}$ is the HRTF between the correct amplifier and the left ear, etc. Here $\boldsymbol{Y_{left}}$ and $\boldsymbol{Y_{right}}$ are known (the yield of the convolving interaction), and the amplifier yield should be registered to guarantee cross-talk scratch-off. Numerically this implies modifying the grid in Condition to decide the obscure $\boldsymbol{S_{left}}$ and $\boldsymbol{S_{right}}$ that give appropriate three-dimensional prompts in spite of cross talk.

Haptic Feedback

The last classification of 1/0 gadgets talked about in this part are haptic interfaces. Named after the Greek term haptic (signifying, "touch"), they pass on significant sensorial data that assists clients with accomplishing material distinguishing proof of virtual articles in the climate and move these items to play out an undertaking see Figure 3.14. When added to the visual and three-dimensional sound input recently talked about, haptic criticism extraordinarily improves recreation authenticity. It becomes required any place the visual input is defiled (impeded items that should be controlled) or lacking completely (dim conditions).

Definition "Contact criticism passes on ongoing data on contact surface math, virtual article surface harshness, slippage, and temperature. It doesn't effectively oppose the client's contact movement and can't prevent the client from traveling through virtual surfaces".

Definition "Power criticism gives ongoing data on virtual article surface consistence, object weight, and latency. It effectively opposes the client's contact movement and can stop it (for huge input powers)".

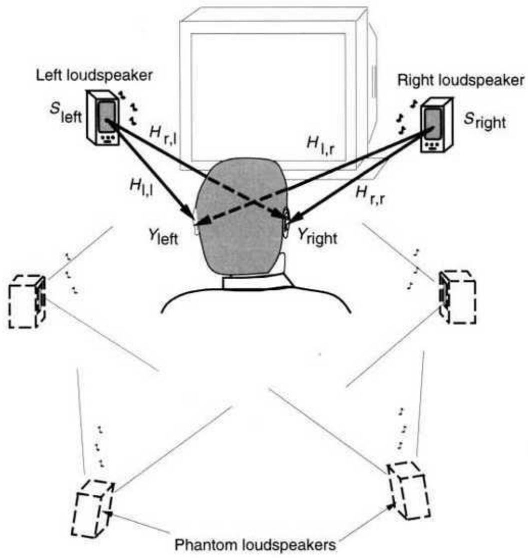

Figure 3.14. Speaker-based Three-Dimensional audio.

3.2.6. The Human Haptic System

Contribution to the human haptic framework is given by the detecting circle, while yield to the climate (for this situation the haptic interface) is intervened by the tangible engine control circle. The information are accumulated by a huge number of material, proprioceptive, and warm sensors, while the yield is powers and forces coming about because of strong effort. The framework is not adjusted, as in people see haptic a lot quicker than they can react [29].

3.2.7. Tactile Feedback Interfaces

The first category of haptic interfaces discussed here is tactile feedback devices for the hand. There are many ways in which skin tactile receptors can be stimulated, ranging from air bellows and jets, to electrical actuators producing vibration, to micro pin arrays, direct electrical stimulation, and functional neuromuscular stimulations. Electro tactile feedback provides electric pulses to the skin. Neuromuscular stimulation provides the signal directly to the user's primary cortex. Both techniques are considered by the authors to be risky and are not discussed here. Instead, we discuss commercially available interfaces for the hand that provide feedback and temperature feedback.

The Tactile Mouse

The computer mouse is a standard interface, serving as an open-loop navigation, pointing, and selecting device. By open-loop we mean that the information flow is unidirectional, being sent from the mouse to the computer (either as relative X. Y position increments or as button states). The interface loop is therefore closed through the vision and auditory channels (highlights of selected menu options and sounds confirming an action)[30].

The CyberTouch Glove

This is another haptic interface that gives vibrotactile analysis to the customer. The contraption is a CyberGlove retrofitted with six vibrotactile actuators (one on the back of each finger and one in the palm). Each actuator involves a plastic holder dwelling a DC electrical motor. The motor shaft has a lopsided mass, which produces vibrations when turned. Thus, by changing the speed of turn, it is plausible to change the vibration repeat some place in the scope of 0 and 125 Hz. Each actuator applies a little force of 1.2 N, which is felt by the skin mechanoreceptors and sensation receptors. During VR reproductions, the CyberGlove peruses the client's hand setup and sends the information to the host PC over a RS232 line. At whatever point the fingers or palm of the virtual hand collaborate with virtual items, the host PC sends orders important to enact the vibrotactile actuators. These signs are gotten by the actuator driver unit, which applies the relating flows utilizing D/A converters and operational enhancers. Along these lines, the criticism circle is shut haptic and the client feels the vibrations on the skin. The CyberTouch glove is generally reasonable for handy control assignments, where contact is at the fingertips, since it can give criticism to singular fingers. This is an unequivocal benefit over the iFeel mouse recently portrayed. Moreover, by energizing more than each actuator in turn it is feasible to produce complex material input designs with a generally light construction (5 oz.). At last, the CyberTouch glove fundamentally expands the client's opportunity of movement contrasted and the iFeel mouse, which necessitates that the client's hand be kept on the work area. This expanded usefulness includes some significant pitfalls [31].

3.3. Computing Architectures for VR

During a VR reproduction, it is difficult to anticipate every one of client's activities and store all comparing engineered world states in memory. In this manner, the virtual world is made (and erased) continuously. Human components examines propose a base rate at which the world pictures (or edges) ought to be introduced to the client. For smooth reproductions in any event 24 (the casing pace of films) or, better, 30 edges/sec should be shown. Consequently, the VR motor necessities to recomputed the virtual world each 33 ms! This cycle alone outcomes in a huge computational burden that should be taken care of in corresponding with different assignments (like 1/0 correspondence and capacity).

Low latency and fast graphics, haptics, and audio refresh rates require a VR engine that has a powerful computer architecture. These architectures are designed around a rendering pipeline, a concept that we discuss first. Subsequently this chapter details PC-based and workstation-based VR engines, with emphasis on graphics. Finally, we describe distributed VR architectures. These are simulation systems designed for a single user or systems, which make possible multiuser interaction in a single VR simulation. The discussion here concentrates on key concepts of what is a fast changing area of technology.

3.3.1. The Graphics Rendering Pipeline

Graphics rendering has three utilitarian stages. The primary stage is the application stage, which is done completely in programming by the CPU. It peruses the world math data set just as the client's info interceded by gadgets like mice, trackballs, trackers, or detecting gloves. Because of the client's info, the application stage may change the view to the reproduction or change the direction of virtual items (like a virtual hand). Other application stage assignments are examined later as a component of the haptics-delivering pipeline [32].

The application stage results are taken care of to the math stage, which can be executed either in programming or in equipment. This stage comprises of model changes (translation, rotation, scaling, etc., lighting calculations, scene projection, cutting, and planning. The lighting sub stage computes the surface shading dependent on the sort and number of reproduced light sources in the scene, the lighting model, the surface material properties, environmental impacts like mist, and so forth Due to lighting calculations, the scene will be concealed and accordingly look more reasonable.

Figure 3.15. The designs pipeline in OpenGL comprises of these five stages, in the new age of cards three of them, the vertex processor, the math processor and the piece processor are programmable. On the card utilized for this calculation (Geforce 7800 GTX), there is no programmable math shadier accessible Figure 3.16.

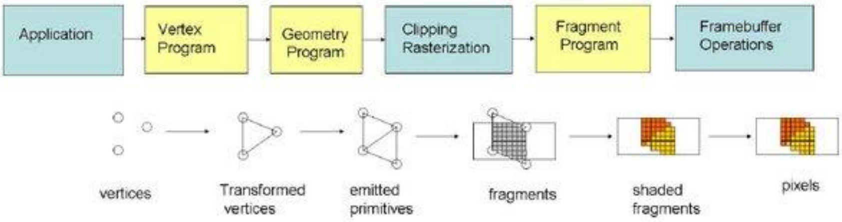

Figure 3.15. The designs pipeline in OpenGL comprises of these five stages.

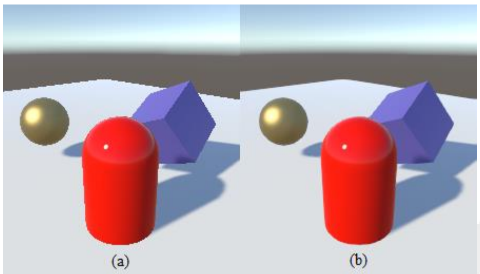

Figure 3.16. The effect of antialiasing on image quality: (a) Aliased polygons. (b) Anti-aliased polygons.

A Rendering Pipeline Example.

A model that executes the calculation and rasterizing stages in equipment is the HP Picture fx card [33]. The CPU output data are gotten by an interface chip, which at that point guides them to the math board and to the surface gas pedal. The least-busy GE on the geometry board starts working on the three-dimensional data and when done sends them back to the interface chip. Here they are converted from floating point to integer format necessary for the rasterizer. The two texture chips compute perspective-corrected textures, magnify the data, and pass them to the rasterizer, or store them in texture cache memory. The texture cache is reused for other objects, speeding up the pipeline. The RUs read data from the interface chip and from the texture chips, convert them to pixel format, and send them to the frame buffer. Finally, the video chip maps pixel colors to true colors (24-bit format), performs the D/A conversion, and does the video timing (synchronization).

Graphics Pipeline Bottlenecks.

The foregoing graphics pipeline discussion assumed an ideal case in which there is a perfect match between the output rate of one stage and the input rate of the following pipeline stage. In other words, the two FIFO buffers are never empty, which would correspond to a "starved" pipeline stage situation. In reality, one of the three stages will be the slowest, will operate at 100%, and will dictate the overall pipeline throughput. This is called the bottleneck stage and needs to be identified in order to improve efficiency.

3.3.2. The Haptics Rendering Pipeline

The foregoing discussion was limited to the graphics feedback channel. Modern VR simulation systems implement additional sensorial modalities, such as haptics, that need to meet similar real-time constraints. This can be implemented through a multistage haptics-rendering pipeline.

During the first stage of the haptics-rendering pipeline, the physical characteristics of the three-dimensional objects are loaded from the database. These include surface compliance, smoothness, weight, surface temperature, etc. The first stage of the pipeline also performs collision detection to determine which virtual objects collide, if any. Unlike the graphics pipeline, here only the colliding structures in the scene are passed down to subsequent pipeline stages.

The second phase of the haptics delivering pipeline figures the crash powers, in view of different actual reenactment models. The easiest model depends on Hooke's law, where the contact power has a spring like reliance on the level of surface twisting. Different models include damping and grating powers and are more sensible, yet additionally more computationally escalated. The more item contacts and the more mind boggling the power concealing, the higher is the opportunity of the pipeline turning out to be power restricted.

3.3.3. PC Graphics Architecture

In 2010, Nvidia started an association with Audi to control their vehicles' dashboards. These Tegra GPUs were driving the vehicles' dashboard, offering expanded usefulness to vehicles' route and theater setups. Progressions in GPU innovation in vehicles has helped propel self-driving innovation. AMD's Radeon HD 6000 Arrangement cards were delivered in 2010-2011; AMD delivered their 6000M Arrangement discrete GPUs to be utilized in cell phones. The Kepler line of illustrations cards by Nvidia turned out in 2012 and were utilized in the Nvidia's 600 and 700 arrangement cards. An element in this new GPU microarchitecture included GPU support, an innovation that changes the clock-speed of a video card to increment or abatement it as per its force draw. The Kepler microarchitecture was produced on the 28 nm measure.

AMD disclosed the Radeon RX 6000 arrangement, its cutting edge RDNA 2 designs cards with help for equipment sped up beam following at an online occasion on October 28, 2020. The arrangement at first comprises of the RX 6800, RX 6800 XT and RX 6900 XT. The RX 6800 and 6800 XT dispatched on November 18, 2020, with the RX 6900 XT being delivered on December 8, 2020. The RX 6700 and RX 6700 XT variations, which depends on Navi 22 is required to dispatch in the principal half of 2021.

PC Graphics Accelerators

Graphics Accelerators loads up that were creating right now included equipment speed increase for large numbers of the picture blend tasks, equipment skillet and zoom, antialiasing, alpha channels for compositing, examine change, and so on The idea of adding a coprocessor to remove the illustrations tasks from the computer chip was instrumental in bringing complex designs pictures to the majority. The early casing cushions and the later gas pedal sheets related with them are presently encapsulated in the designs cards in the present PCs, for example, those made by NVIDIA, 3-Dlabs and ATI.

One way to deal with assuming greater liability from the computer chip was finished by the GeForce 256 from NVIDIA. Notwithstanding the delivering done by before age sheets, the GeForce 256 added change of the wireframe models from 3-D space to 2-D presentation space just as the work expected to process lighting. Since the two changes and delivering include huge gliding point science, these undertakings require an enormous preparing trouble by the computer processor. Since the illustrations processor does not need to adapt to large numbers of the undertakings expected of the computer chip, it very well may be intended to do those numerical assignments rapidly. 3dfx presented their GPU, the Voodoo in 1996. The Voodoo5 assumed control over another arrangement of undertakings from the central processor.

The Programming interface is a bunch of rules for composing capacity or subroutine calls that entrance capacities in a library. Projects that utilization these standards or capacities in their Programming interface calls can speak with any others that utilization the Programming interface, paying little mind to the others' particulars. Because of designs APIs, they gave admittance to the delivering equipment inserted in the illustrations card. Early APIs included GL, Phigs+, Phigs, and X. In 1992, SGI presented OpenGL, which turned into the most broadly utilized Programming interface in the business. Different methodologies were Direct3-D and seller explicit methodologies, similar to Quartz for the Mac and the Windows Programming interface [34].

PC Graphics Benchmarks

Our GPU benchmarks order positions all the current and past age designs cards by execution, including the entirety of the best illustrations cards. Regardless of whether it is messing around or doing very good quality innovative work like 4K video altering, your designs card normally assumes the greatest part in deciding exhibition, and surprisingly the best gaming computer chips play a subsequent job.

The accompanying table sorts everything exclusively by our exhibition based GPU gaming benchmarks. We have a different article that rundowns the best illustrations cards, which sees all components, including value, designs card power utilization, and generally speaking effectiveness. In this most recent release, we have refreshed the tables and diagrams with results from the recently dispatched GeForce RTX 3060 12GB and we are presently anticipating AMD's Radeon RX 6700 XT, which ought to show up in the not so distant future.

The appearance of NVIDIA's Ampere engineering and the GeForce RTX 3060, GeForce RTX 3060 Ti , GeForce RTX 3070, GeForce RTX 3080, and GeForce RTX 3090, 12GB stirred up the top portion of the GPU benchmark chain of command. AMD's Large Navi and the Radeon RX 6800 XT, RX 6800, and Radeon RX 6900 XT created a comparable commotion in rankings. As of now, seven of the ten best GPUs use either Ampere or RDNA2 and of the three past gen GPUs, two are Titan cards that don't actually tally [35].

3.4. Distributed VR Architectures

One advantage workstations had over PCs until recently was the UNIX operating system support for multiple displays. Although the Gloria III and the Fire GL2 have two graphics output ports (analog and digital), only one can be used at a given time. Furthermore, the PC operating system did not support two graphics cards working simultaneously on the motherboard [36]. Thus, a multi monitor display of the type would necessitate the use of five PCs, each feeding one monitor. Such multitier displays are becoming more frequent today for single users running applications ranging from military command and control, to mechanical design, to oil exploration. Large-volume displays, such as the CAVE or the tiled display walls, also require multiple views to be rendered by the VR engine. In order to do so, the VR engine needs to have several graphics pipelines working cooperatively to provide the visual feedback needed by the simulation [37].

Definition “A disseminated VR motor is one that utilizations at least two delivering pipelines. Such pipelines can perform designs or haptics calculations, and be situated on a solitary PC, on a few arranged PCs, or on various far off PCs incorporated in a solitary reproduction”.

4. METHODOLOGIES

4.1. Alternating Current AC Motors

The pivot of alternating current AC motor misuses the power created by the association between two magnetic fields rotating at a similar speed. There are two groupings of an AC motor: asynchronous motor and synchronous motor. An offbeat engine is all the more normally known as an induction motor.

Induction and synchronous motors have a similar stator arrangement for delivering the turning magnetic field. In any case, they have diverse rotor developments because of the distinction in their methods of producing the rotor magnetic field. In synchronous motors, regularly, the rotor magnetic field is created from the field twisting energized by a direct current (DC) power source. For little to medium-sized synchronous motors, permanent magnets are usually utilized for producing the rotor magnetic field. Then again, in Induction motors, the rotor magnetic field is delivered by an alternating current AC power. It is fascinating to take note of that this alternating current power is moved from a stator by electromagnetic induction.

Induction motors have a few benefits like basic development, unwavering quality, toughness, low upkeep, minimal effort, high velocity activity capacity, and the capacity to be worked by an immediate association with an alternating current power source. Then again, synchronous motors are better than induction motors in effectiveness, power thickness, dynamic reaction, and force factor.

In this part, we will consider the essential activity guideline and qualities of AC motors in more detail. We will start by analyzing the general type of motor, the induction motor.

4.1.1. Induction Motors

The crucial standard of induction motors was first shown by the trial known as Arago's Diskin1824. From this investigation, it was discovered that, when a magnet rotates along the edge of a copper plate (a nonmagnetic substance), the disk rotates toward the magnet at a more modest speed Figure 4.1. In 1832, Faraday showed that this wonder is because of the flows incited in the copper disk. The disclosure of this marvel at last prompted the improvement of the basic idea to fan enlistment engine. At the point when a magnet passes along the edge of a copper circle, an Electro Motive Force is prompted at the part in the plate that encounters a changing magnetic field. The initiated voltage makes a whirlpool current stream in the plate. Thus, since the current-conveying part is worked under the magnetic field of the magnet, a power (known as Lorentz power) is made on the current-conveying part. The heading of the power is equivalent to that of the magnet's development, and this power makes the copper disk to rotates alongside the magnet[38].

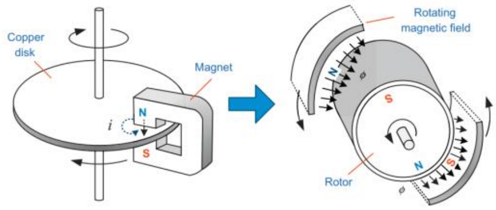

Figure 4.1. Arago's circle and the principal idea of an induction motor.

In an induction motor dependent on this major idea, such rotating magnet is acknowledged by a rotating magnetic field produced from three-stage stator windings associated with a three-stage AC power source. The rotor, at that point, follows this rotating attractive field.

Induction motors are most broadly utilized as universally useful engines in numerous modern applications on account of their ease and rough development. Generally, Induction motors had been associated straightforwardly to the line voltage of 60 or 50Hz and worked at an almost consistent speed. Nonetheless, as of late, factor speed drives have been made conceivable by power electronic converters like inverter, so induction motors are generally use racket numerous applications requiring speed control.

Structure

The construction of an ordinary acceptance engine is appeared in Figure 4.2. An induction motor has cylindrical stator and rotor configurations, which are isolated by a uniform outspread air hole. The stator and the rotor are comprised of an iron center, which has windings embedded inside. The iron center is certifiably not a solitary strong protuberance however comprises of a pile of protected overlays of silicon steel, generally with a thickness of about 0.30.5 mm to lessen swirl current misfortunes. The iron center is produced using a ferromagnetic material like steel, delicate iron, or different nickel combinations to deliver attractive transition productively and decrease hysteresis misfortunes.

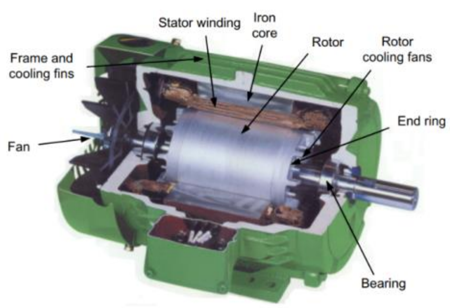

Figure 4.2. Design of a normal induction motor.

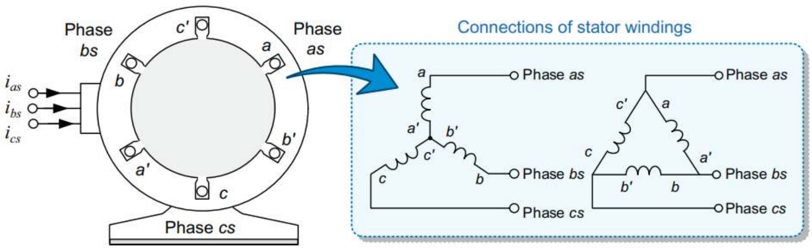

Figure 4.3. Stator windings.

Stator:

In an induction motor, just the stator windings are taken care of by the three-stage AC power supply. It ought to be noticed that the three-stage stator windings play out the jobs of both the armature and field windings of a DC engine[39]. These three-stage windings are set in the openings that are pivotally cut along the inward fringe of the iron center as demonstrated in Figure 4.3.

All turns in each winding are consistently circulated in the various openings spread around the fringe, with the end goal that the winding thickness can be sinusoidal as demonstrated in Figure 4.4. The motivation behind this plan is to build up a sinusoidal flux dispersion noticeable all around hole when flows move through them. This winding kind is called distributed winding. The appropriated winding arrangement builds the use of the iron center and lessens Magneto Motive Force (MMF) space music, bringing about a lower force swell contrasted with that of the concentrated twisting, in which all curls of the stage winding are put in one opening under a shaft.

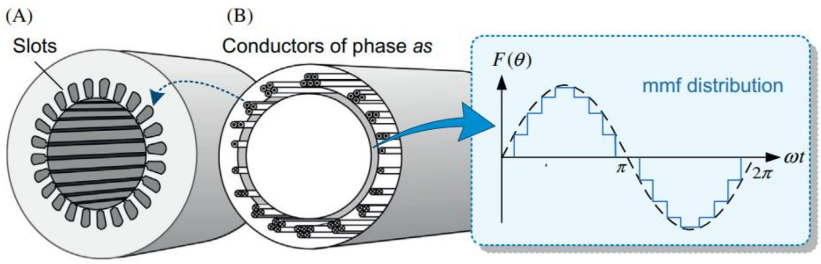

Figure 4.4. Stator phase winding. (a) Stator core. (b) Sinusoid ally distributed winding and MMF.

Rotor:

Like the stator, a rotor has a tube shaped iron center that comprises of silicon steel overlays. It ought to be noticed that the electric circuit windings or conductors in the iron center of the rotor is not taken care of by an outer force source however its flow streams by the induced EMF.

4.1.2. Synchronous Motors

The name synchronous motors stems from its trademark to build up the force just when the rotor works at the synchronous speed. Customarily, enormous measured synchronous machines have been for the most part utilized as generators. As motors, they have been utilized to improve the force factor in the force lattice by changing the field current, i.e., excitation. For this situation, they are called synchronous condensers. In little sizes, they have been frequently utilized in applications requiring a steady speed activity.

In any case, as of late, synchronous motors with a permanent magnet rotor are filling quickly being used for variable speed drives rather than DC motors. This is on the grounds that Permanent Magnet Synchronous Motors (PMSMs) have numerous benefits over different motors like high productivity, high force thickness, high unique reaction, and high force factor. Be that as it may, one hindrance is its greater expense in contrast with an induction motor.

The design of the stator and rotor of a synchronous motor is shown Figure 4.5. A synchronous motor has a similar stator setup as an induction motor, however an alternate rotor structure. Not at all like induction motor, has a synchronous motor had free excitations for the stator and rotor windings.

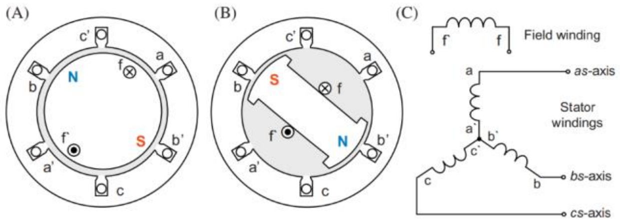

Figure 4.5. Stator and rotor structure of a synchronous motor types. (a) Cylindrical. (b) Salient pole. (c) Stator windings.

Cylindrical Rotor

Since the rotor winding with a DC excitation can be addressed as a straightforward R-L circuit without back-EMF, we need to examine an identical circuit for just the stator winding.

The stator windings of a synchronous motor are equivalent to those of induction motor. Accordingly, from Eq. (5.1), the stator voltage condition of a synchronous motor is given as

$$v_s = R_s i_s + \frac{d\lambda_s}{dt} \tag{5.1}$$

In any case, since the stator motion linkage of a synchronous motor is unique in relation to those of an induction motor, we need to analyze the stator flux linkageλ_s.

A synchronous motor has free excitations for the stator and rotor windings. Noticeable all around hole, these excitations produce two magnetic fields, which pivot at the synchronous speed as demonstrated in Figure 4.6. One is created by the stator twisting flows as in an induction motor, and the other is produced by the field winding current. In synchronous motors, the torque is created by the association of these two magnetic fields.

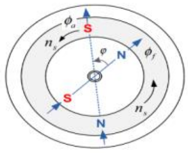

Figure 4.6. Rotating field flux of stator and rotor.

The rotating field flux $\emptyset_a$ created by the three-phase AC flows I_s streaming in the stator winding consists of the armature reaction flux $\emptyset_{ar}$ and the leakage flux $\emptyset_{al}$ as

$$\emptyset_a = \emptyset_{ar} + \emptyset_{al} \tag{5.2}$$

The armature response flux $\emptyset_{ar}$ relates to the charging flux in the induction motor. The field flux $\emptyset_f$ created in the field winding is likewise a rotating magnetic field rotating at the synchronous speed because the rotor itself rotates at the synchronous speed. Noticeable all around hole, there is a resultant of these two field fluxes as

$$\emptyset_s = \emptyset_f + \emptyset_{ar} \tag{5.3}$$

Thus, the flux linkage λ_s of the stator winding with an effective number of turns Ns will be communicated as

$$\lambda_s = N_s(\emptyset_f + \emptyset_{ar}) \tag{5.4}$$

In the stator winding, the voltage is induced by these two fluxes. The voltage E_f induced by the field flux $\emptyset_f$ is called the excitation voltage. The magnitude of the excitation voltage is proportional to the field current and the rotor speed.

The voltage Ear induced by the armature reaction flux $\emptyset_{ar}$ is called the armature reaction voltage.

Salient Pole Rotor

As we can find in Figure 4.7, a striking post simultaneous engine has a no uniform air hole because of the jutting rotor poles. In this kind of motor, the measure of the motion delivered by the stator current differs as per the situation of the rotor. A higher motion is produced along the shafts in contrast with between the posts because the hesitance of the motion way is low along the posts and high between the posts.

To think about the saliency of the rotor in a coordinated engine model, we need to characterize the d and q tomahawks as the accompanying. The d-axis is characterized as the pivot along the posts, which is likewise the course of the rotor transition created by the field winding. The hesitance of the d-axis way is low because of the little air hole, and consequently the inductance $L_d$of the d-axis is enormous. Then again, the q-axis is characterized as the hub between the poles, which is likewise the bearing of the excitation voltage. The hesitance of the q-axis way is enormous because of the huge air hole, thus the inductance L_q of the q-axis is small. Thus, L_d>L_q.

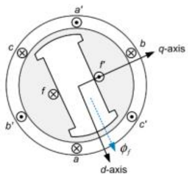

Figure 4.7. Salient pole rotor synchronous motor.

In order to consider the flux variation with the position of the rotor, it is more effective to analyze the saliency of the rotor by using the divided stator current into two components of the current I_d aligned with the d-axis and the current I_q aligned with the q-axis. Thus, the stator current I_s is expressed as

$$I_s = I_q - jI_d \tag{5.5}$$

Where$I_q = I_s \cos\varphi$, $I_q = I_s \sin\varphi$ and φ is the phase angle between I_q andI_a.

According to the d and q axes currents, the armature reaction flux $\emptyset_{ar}$ is also divided into two components: the d-axis flux $\emptyset_d$ produced by the d-axis current $I_d$and the q-axis flux $\emptyset_q$ by the q-axis currentI_d. The relation between $\emptyset_d$ and I_d is expressed by the d-axis armature reactanceX_{ad}, whereas the relation between $\emptyset_q$ and I_q is expressed by the q-axis armature reactanceX_{aq}. The d and q axes synchronous reactances are given by

$$X_d = X_{ad} + X_{al} \tag{5.6}$$

$$X_q = X_{aq} + X_{al} \tag{5.7}$$

Where X_{al} is the armature leakage reactance? The salient pole synchronous motor always$X_d > X_q$, normally$X_q = (0.5{\sim}0.8)X_d$.

Starting

Synchronous motors are innately not ready to self-start on an alternating current AC power source with the utility recurrence of 50 or 60 Hz, this is on the grounds that synchronous motors can build up a force just when running at the coordinated speed. Nevertheless, the coordinated speed for the utility recurrence is excessively quick for the rotor to synchronize for beginning as demonstrated in Figure 4.8.

Thusly, we need a few methods for turning over synchronous motors. When the rotor arrives at a speed near the coordinated speed (>95%) through some beginning methods, the field winding will be energized, so the motor secures in synchronization.

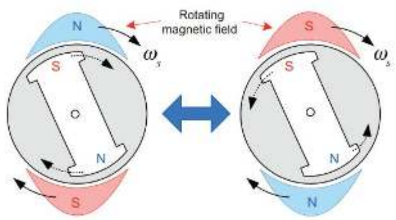

Figure 4.8. Synchronization in a synchronous motor.

There are a few procedures utilized to turn over a synchronous motor. As a basic technique, a different motor is utilized to drive the rotor to run near the coordinated speed. A subsequent strategy is to turn over the synchronous motor as an induction motor. For this situation, the rotor has an exceptional damping twisting for beginning, which is like the squirrel-confine game plans of an induction motor. At the point when the synchronous motor is turning over, the torque will be delivered by the incited current in the damping twisting, so it can begin as an induction motor. What's more, the damper winding has another capacity to help keeping the synchronous motor in synchronism.

4.2. Modeling of AC Motors

For a legitimate control of a motor, we need to examine its dynamic exhibition just as consistent state execution. This requires a mathematical model, which portrays the conduct of a motor. The motor model can be for the most part communicated by the voltage and torque conditions. The voltage condition for an engine essentially comprises of the accompanying segments: the voltage drop of the winding opposition R and the initiated voltage corresponding to the pace of progress over the long run of the winding transition linkage λ as

$$v(t) = Ri(t) + \frac{d\lambda(t)}{dt} = Ri(t) + \frac{d[L(\theta_r)i(t)]}{dt} \; (\theta_r = \omega_r t) \tag{5.8}$$

The flux linkage can be communicated as the result of inductance and current. For alternating current (AC) motors with windings in the stator and rotor, the shared inductance, which suggests the measure of flux connecting between the two windings, is a period changing boundary. This is on the grounds that that the shared inductance is an element of the rotor position because of the variety in the measure of connecting flux with the rotor position. Moreover, in remarkable post coordinated engines, even the self-inductance is an element of the rotor position because of the variety noticeable all around hole as indicated by the rotor position.

For instance, consider the enlistment motor in Figure 4.9, in which the stator windings are fixed while the rotor windings are pivoting with the rotor. Because of the development of the rotor, the precise position θ_r between the stator and rotor windings changes after some time with the exception of at a stop. Accordingly, regardless of whether flows thus, flux streaming in these two windings stay steady, the measure of the flux connecting these windings will shift after some time. These outcomes in the common inductance to become time shifting. Because of this time-changing inductance, the voltage conditions, which depict the conduct of AC motors, will be communicated by differential conditions with time-varying coefficients.

The investigation of such time-varying differential conditions will be genuinely overwhelming. Notwithstanding, by utilizing the *reference frame transformation*, which will be presented in this section, its intricacy can be essentially decreased. This is because the time- varying inductances can be wiped out in the voltage conditions by utilizing the reference outline change. When utilizing this change, the three stage abc factors are changed to dq factors in a symmetrical arrange framework. These dq symmetrical factors are important to utilize the vector control plot, which empowers a powerful force control of AC engines.

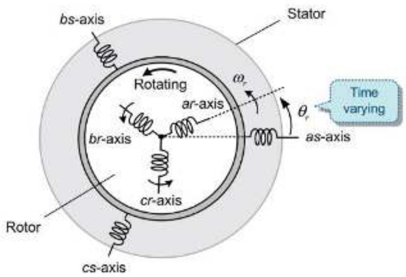

Figure 4.9. Angular position between stator and rotor windings.

4.2.1. Modeling of Permanent Magnet Synchronous Motor PMSM

The stator arrangement of a synchronous motor is equivalent to that of an induction motor. The stator windings are associated with a three-stage AC source to produce rotating magnetic field. Nonetheless, not at all like an induction motor having three-stage windings, the rotor of a synchronous motor has a field winding or a permanent magnet to create an attractive field flux on it. As of late, the magnetic field for synchronous motors has been created generally by utilizing a permanent magnet rather than a field winding.

Notwithstanding the electromagnetic torque created by the magnetic fields of the stator and rotor, synchronous motors with a remarkable rotor can abuse hesitance torque. Synchronous motors can be isolated into a few classes as per the proportion of electromagnet torque to reluctance torque as shown in Figure 4.10 [40].

We will restrict the extent of our investigation just to Permanent Magnet Synchronous Motors (PMSMs) with the exception of simultaneous hesitance motors, which just endeavor hesitance torque.

PMSMs offer numerous benefits over different motors. They have a higher productivity than induction motors in light of the fact that there are no copper misfortunes by the rotor. Moreover, they show a powerful thickness, high torque-to-volume proportions, and a quick unique reaction in view of the accessibility of practical incredible permanent magnet materials such as NdFeB

Other than these benefits, PMSMs with magnetic rotor saliency use hesitance torque just as magnet torque. Attributable to these appealing qualities, PMSMs are acquiring consideration for a wide assortment of private and mechanical drive applications, going from universally useful drives to superior drives.

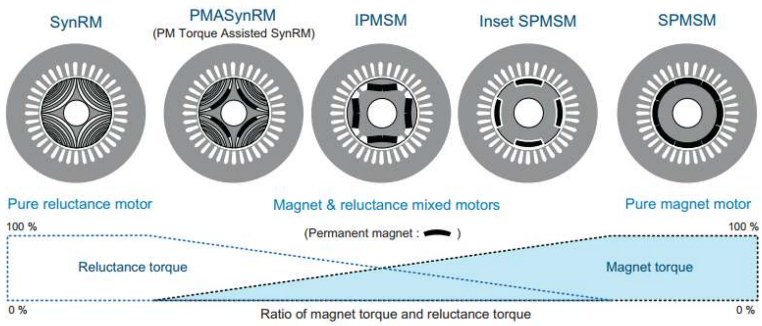

Figure 4.10. Several categories of synchronous motor.

Structure of PMSMs

Stator Structure:

A circulated winding has been commonly utilized as a three-stage stator-twisting setup to create a sinusoidal flux noticeable all around hole as demonstrated in Figure 4.11a. Nonetheless, as of late, a concentrated winding has been progressively utilized in PMSMs as demonstrated in Figure 4.11b.

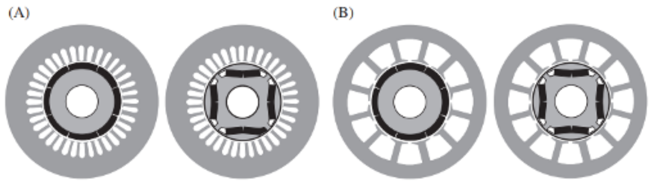

Figure 4.11. Different structures for the stator and rotor of PMSMs. (a) Distributed winding. (b) Concentrated winding.

Albeit a concentrated winding gives less sinusoidal magneto intention power dissemination contrasted with a circulated winding, this sort of winding can give a few benefits like high force thickness, high proficiency, short end turns, high opening fill factor, and low assembling costs by sectioned stator structures, low cogging torque, flux debilitating capacity, and adaptation to internal failure[41].

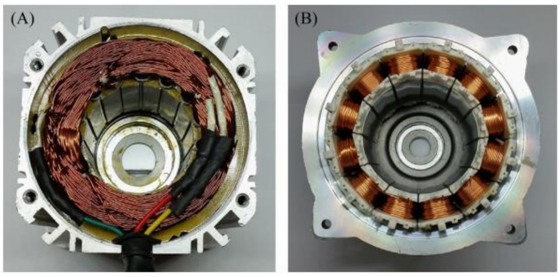

Figure 4.12. Comparison of distributed and concentrated windings. (a) Distributed winding (b) Concentrated winding.

Figure 4.12 thinks about the dispersed winding and amassed twisting in the stator of a PMSM. There are two primary kinds of a concentrated winding: single-layer winding design, where each space is involved by the curl sides of one stage, and double-layer winding setup, where each opening is involved similarly by the loop sides of two phases[42].

Rotor Structure

The rotor of PMSMs has a permanent magnet to create a magnetic field flux on it. The attributes of PMSMs like the force thickness, torque thickness, weight, and size may change as per the picked permanent magnet material. Nowadays, a neodymium magnet (otherwise called NdFeB) is the most generally utilized for PMSMs because of its brilliant magnetic qualities and ease. Despite the fact that we utilize similar permanent magnet material, numerous qualities of PMSMs are vigorously subject to rotor setups including the shape and game plan of the permanent magnets.

PMSMs can be partitioned into two kinds as per the bearing of the attractive motion created from the lasting magnets as demonstrated in Figure 4.13: radial-flux type and axial-flux type. In the radial-flux type, the rotor which is round and hollow fit as a fiddle pivots inside the stator and the magnetic flux crosses the air hole a spiral way. Then again, in the axial-flux type, the rotor which looks like a hotcake turns alongside the stator and the magnetic flux crosses the air hole in a hub bearing. Out of these two sorts, the radial-flux type is all the more generally utilized in numerous applications. The radial-flux type PMSMs can likewise be additionally arranged into two[43].

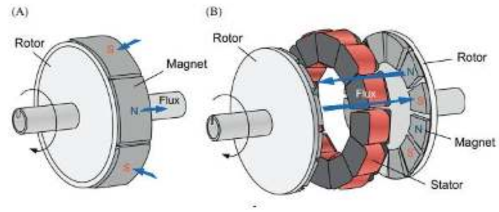

Figure 4.13. PMSM configuration. (a) Radial-flux type (b) Axial-flux type.

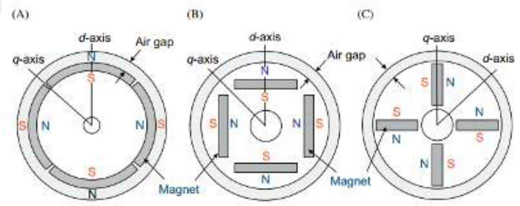

Figure 4.14. Rotor topologies of PMSMs (four-pole). (a) Surface mounted (b) Interior (parallel) (c) Interior (perpendicular).

Classes dependent on the situation of the permanent magnets as demonstrated in Figure 4.14a: surface- mounted permanent magnet synchronous motor (SPMSM) with magnets mounted on the outside of the rotor and Interior Permanent Magnet Synchronous Motor (IPMSM) with magnets covered inside the rotor iron center.

Concerning IPMSM, there are two geographies as indicated by the game plan of the permanent magnets: parallel topology, in which the magnetic posts are found corresponding to the periphery of the rotor as demonstrated in Figure 4.14b and perpendicular topology (likewise called spoke type), in which the magnetic poles are found oppositely to the boundary as demonstrated in Figure 4.14c.

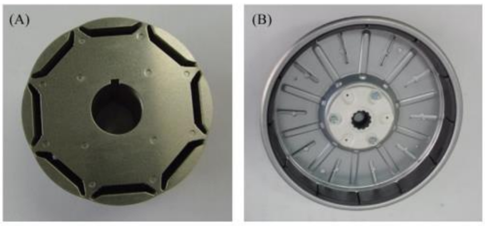

Figure 4.15. Rotor configurations of IPMSMs types. (a) Inner rotor. (b) outer rotor.

Material, for example, ferrite is utilized, the motor can show a high torque density. Notwithstanding, because of the flux concentration at the pole edges, there might be a high consonant mutilation noticeable all around hole flux density close to the post tips and in this way in the back-EMF profile. This likewise prompts a high wave in the created force.

The rotor can likewise be developed as an internal rotor type turning inside the stator windings or an external rotor type pivoting outside the stator windings as demonstrated in Figure 4.15. The inward rotor type has lower latency, and accordingly, brings about a snappy speed reaction.

Model of PMSMs

For a parallel topology IPMSM, the q-axis inductance is higher than the d-axis inductance because of the magnets placed along with the d-axis. Although the rotor of an IPMSM is cylindrical in shape, we will express it as a magnetic equivalent salient rotor as shown in Figure 4.16 to simplify the analysis of the IPMSM.

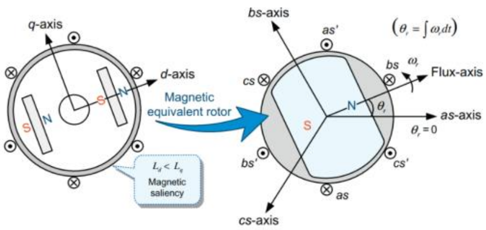

Figure 4.16. Rotor and its equivalent of an IPMSM.

As a PMSM has no rotor circuits, we can consider only the voltage equations for the stator windings. The stator windings of a synchronous motor are the same as those of an induction motor. Thus the stator voltage equations will be

$$v_{abcs} = R_s i_{abcs} + \frac{d\lambda_{abcs}}{dt} \tag{5.9}$$

Where $v_{abcs} = [v_{as} v_{bs} v_{cs}]^T$, $i_{abcs} = [i_{as} i_{bs} i_{cs}]^T$, $\lambda_{abcs} = [\lambda_{as} \lambda_{bs} \lambda_{cs}]^T$.

Since a synchronous motor has a different rotor configuration from that of an induction motor, the components of the flux linkage of the stator windings are different.

The flux linkage of an IPMSM has the following four components: the flux linkages due to the stator currents and the flux linkage due to the permanent magnet as

$$\lambda_{as} = \lambda_{asas} + \lambda_{asbs} + \lambda_{ascs} + \phi_{asf} \tag{5.10}$$

$$\lambda_{bs} = \lambda_{bsas} + \lambda_{bsbs} + \lambda_{bscs} + \phi_{bsf} \tag{5.11}$$

$$\lambda_{cs} = \lambda_{csas} + \lambda_{csbs} + \lambda_{cscs} + \phi_{csf} \tag{5.12}$$

These flux linkages can be expressed as the product of the related current and inductance as

$$\lambda_{as} = L_{asas} i_{as} + L_{asbs} i_{bs} + L_{ascs} i_{cs} + L_{asf} i_f \tag{5.13}$$

$$\lambda_{bs} = L_{bsas} i_{as} + L_{bsbs} i_{bs} + L_{bscs} i_{cs} + L_{bsf} i_f \tag{5.14}$$

$$\lambda_{cs} = L_{csas} i_{as} + L_{csbs} i_{bs} + L_{cscs} i_{cs} + L_{csf} i_f \tag{5.15}$$

Here, the flux linkages $\phi_{asf}, \phi_{bsf}, \phi_{csf}$ due to the permanent magnet are expressed as the product of the equivalent field current I_f and the related inductance $L_{asf}, L_{bsf}, L_{csf}$.

Now, we will determine the stator inductances of

$$L_s = \begin{bmatrix} L_{asas} & L_{asbs} & L_{ascs} \\ L_{bsas} & L_{bsbs} & L_{bscs} \\ L_{csas} & L_{csbs} & L_{cscs} \end{bmatrix} \tag{5.16}$$

As can be seen in Section 4.1.1, the stator inductances consist of the self-inductances of the stator windings and the mutual inductances between the stator windings. Furthermore, the stator self-inductances $L_{asas}, L_{bsbs}, L_{cscs}$ consist of the leakage inductance and the magnetizing inductance.

The self-inductance of an IPMSM, unlike an induction motor, may be different depending on the angular position of the rotor because the effective air gap may vary with the position of the rotor. Consider an example of the phase as winding. In this case, the self-inductance becomes the maximum value at the rotor positions of both 90° and 270° (the smallest reluctance position), where the flux produced by the phase as current becomes the maximum value. This, in turn, makes the flux linking its own winding to become the maximum value. On the other hand, the self-inductance becomes the minimum value at the rotor positions of both 0° and 180° (the largest reluctance position).

4.3. Modeling of VR

The I/O inputs and VR motors introduced in the past parts can be viewed as the empowering equipment for VR reproductions. Another significant angle is the demonstrating of the virtual world. This implies first the planning of 1/0 inputs with the reproduction scene. For instance, a detecting glove may control a virtual hand, or a HMD tracker may set the reproduction see. VR interface planning expects adjustment to the client's attributes just as 1/0 correspondence coding. These assignments are typically settled by business tool stash, which will be examined in the following section.

The subsequent stage following 1/0 input planning is the advancement of item data sets for populating the virtual world. This implies demonstrating object shape, appearance, kinematic requirements, wise conduct, and actual qualities (weight, idleness, hardness, and so on) At last, to keep a constant connection with the recreation, the model should be enhanced during the model administration step. Figure 4.17 shows the different parts of VR displaying examined in this section. We center around the basic science and the connection to the delivering pipeline introduced in Section 5.

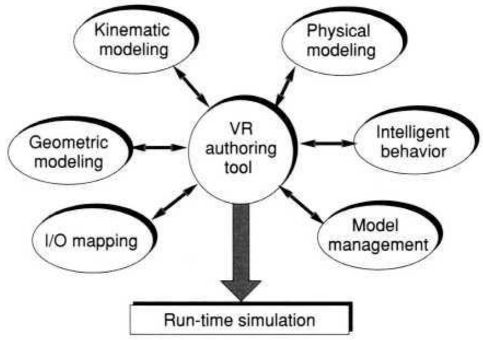

Figure 4.17. The VR modeling cycle.

4.3.1. Geometric Modeling (Virtual Object Shape)

Geometric modeling describes the shape of virtual objects (Splines, vertices, triangles, and polygons) just as their appearance (surface illumination, surface texture, and color).

The shape of virtual objects is determined by their three-dimensional surface, which can be described in several ways. The vast majority of virtual objects have their surface composed of triangle meshes. Triangle meshes are preferred because they use shared vertices and are faster to render. As illustrated in Figure 4.18a, the vertices of shared edges are the same for adjacent triangles. An example is the pair (X_1, Y_1, Z_1) and (X_2, Y_2, Z_2), which is shared between triangle 1 and triangle 2. This means that the model using triangle meshes will need less memory to be stored and will be loaded faster by the application stage of the rendering pipeline. Furthermore, as discussed in previous chapter, certain architectures are optimized to process triangle meshes (through MIMD parallelism) and render them faster than surfaces described by independent polygons. Finally, triangle meshes are well suited for geometric transformations and level-of-detail optimization.

For all their advantages, triangle meshes are not well suited for representing objects with highly curved and bumpy surfaces. The more intricate the detail needed in the curved surface, the more triangles are needed in order to model such objects. An alternate way of shape representation is to use parametric surfaces, as illustrated in Figure 4.18b. A parametric spline is represented by the points $\boldsymbol{X(t)}, \boldsymbol{Y(t)}\ and\ \boldsymbol{Z(t)}$, as given by

$$X(t) = a_x t^3 + b_x t^2 + c_x t + d_x \tag{7.1}$$

$$Y(t) = a_y t^3 + b_y t^2 + c_y t + d_y \tag{7.2}$$

$$Z(t) = a_z t^3 + b_z t^2 + c_z t + d_z \tag{7.3}$$

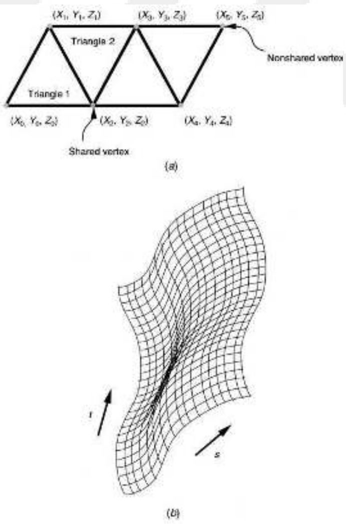

Figure 4.18. The object shape description. (a) Using a triangle mesh; (b) Using a parametric surface.

Where t is a parameter with values between 0 and 1, and a, b, and c are constant coefficients. Parametric surfaces are extensions of splines obtained by introducing second parameters also between 0 and 1. Thus points on a parametric surface are given by coordinates $x(s,t), y(s,t), and\ z(s,t)$ [44]. Since parametric surfaces are represented by functions of higher order than the linear functions describing a polygon, they use less storage and provide increased surface smoothness. Parametric surfaces are at a disadvantage when it comes to surface deformation. Whereas the shape of a polygonal surface can easily be changed by direct vertex manipulation, parametric surfaces do not allow that. Their shape can only be changed by changing the position of control points, which are located outside the surface itself.

There are several methods by which object surfaces can be constructed. These involve the use of a toolkit editor, importing CAD files, using a 3-D digitizer, scanning the object with a 3-D scanner, or purchasing models from existing databases.

Using a Toolkit Editor

All graphics programming languages allow 3-D polygonal object shape to be created from scratch. The programming toolkit layer that creates an authoring tool then exploits such capability. Text-based specification of vertex coordinates and connectivity is necessary to create the shape, and normal need to be specified if smooth shading is desired. The process is based on trial and-error iterations and requires an amount of time inversely proportional to the programmer's skill. This approach is prohibitively expensive if the virtual scene has extremely complex models, requiring a significant amount of person-hours to develop.

Importing CAD Files

An alternate way to create 3-D objects is to use a CAD program, such as AutoCAD or 3-D Studio. These programs are the de facto standard in mechanical and architectural design. Thus, preexisting models of mechanical assemblies or buildings can be reused to populate the virtual world. Alternatively, the user can interactively create the object's model. Various moving objects within the house, such as the front door or a ceiling fan, need to be animated separately in the VR simulation. Therefore, they have to be created and saved under separate files (because there is no standard way to keep objects separate in the AutoCAD DXF file format) show in Figure 4.19. Once the AutoCAD object files are saved, they need to be reformed into formats compatible with the particular VR toolkit used to run the real-time simulation.

Creating Surfaces with a 3-D Digitizer

This approach is taken when a given virtual object used by the simulation is not part of an existing database. One solution is to use a 3-D digitizer, such as the Immersion MicroScribe 3-D mechanical arm with a modeling toolkit such as form Z[45]. The process of digitizing a clay model of the object starts with calibration of the MicroScribe. This is done by selecting three points in space and mapping them with three points on the computer screen selected using a mouse. This process establishes the distance scaling as well as the orientation of the model in relation to the virtual space. The user needs to trace a mesh on the real object surface and select desired vertices by pressing the MicroScribe pedal. Symmetrical objects have the advantage that the manual digitization process needs to be done only for half of their surface. The other (symmetrical) half is obtained by mirroring the data already input in the computer and subsequently stitching the two halves. The form Z allows an increase in object level of detail by automatically subdividing surface patches. This process creates finer contours without requiring additional vertices to be digitized by the user.

Another 3-D digitizer is the HyperSpace produced by Mira Imaging Inc. Unlike the form-Z, the HyperSpace digitizer has a Polhemus stylus, which is used to get 3-D point information. The stylus has a miniature 3-D tracker receiver and can be used with two emitters for increased accuracy. The user places the stylus on the model surface (such as a statue) to obtain its wireframe vertices. The vertex (x, y, z) coordinates are stored when the user presses the built-in pushbutton in the stylus to initiate the data acquisition. A built-in editor later allows line segments and polygons to be repositioned along any axis. Points within line segments and points connecting polygons may be fit to Bezier curves and reshaped.

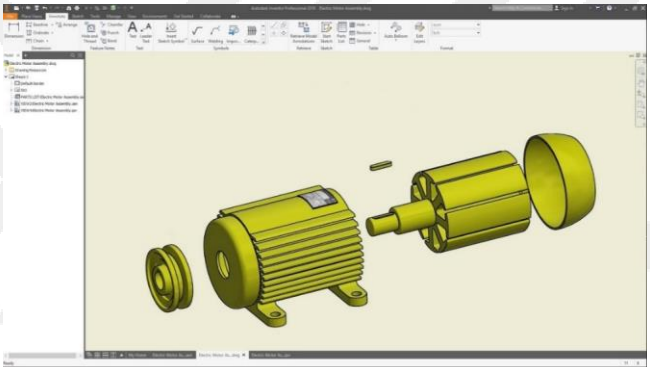

Figure 4.19. A virtual AC Motor created with AutoCAD.

Creating Surfaces with a 3-D Scanner

This represents a faster way to build 3-D models, especially for large objects. These scanners have a digital camera laser assembly, which measures the distance to an object through triangulation. The distance is obtained based on the known geometry of the camera-laser assembly (distance and angle) and the image information of the reflected laser beam. The 3-D scanner's advantages over the 3-D digitizers (Figure 4.20) previously discussed are noncontact measurement and the ability to get substantially more measurement points in a given amount of time.

An example of a handheld 3-D scanner that works up to about 0.7 in away is the Polhemus FastScan [46]. It consists of a laser and two miniature monochrome cameras integrated in a rigid structure that holds a FastTrack receiver. The tracker source is placed close to the object being scanned, such that the orientation and position of the laser beam on the object surface are known. Since the scanning speed is limited (50 lines/sec), motion of the object being scanned will introduce errors. In such cases a second receiver is attached to the object that could inadvertently move during scanning (such as a human face) in order to compensate for these errors.

The accuracy of triangulation-based scanning is degraded rapidly with distance to the object surface. This is due to the digital camera's inability to distinguish between adjacent dots when the object is too distant. Furthermore, if the laser beam is not properly focused, it can spread to a cross-section diameter of 12 cm at 100 m away. This degrades the triangulation results even more. An alternative is to supplement laser data with radar time-of-flight data to determine range. This is the approach taken by the Cyra Technologies Cyrax 2500 laser scanner, used for modeling large and distant objects [47]. The scanner has a single-point accuracy of 6 mm at a range of 50 m and a maximum range of 100 m. Thus, practically any size objects, from battleships to buildings, can be scanned.

Figure 4.20. Creating a model with a three-dimensional digitizer.

Whether scanning is done at short or at long range, the data are in the form of a cloud of dots, each having (x, y, z, color) information. These data need to be first processed before they can be stored as a polygonal or spline-based model. Some scanner drivers perform this data conversion. Alternately, third-party conversion software can be utilized. Depicts the stages of such processing performed by the Wrap software. The second stage is polygonal decimation, in order to reduce the model complexity by as much as 95%. Finally, the polygonal model is converted to a NURBS parametric surface format for improved appearance. Some scanners use their camera to take photo images of the scanned object see in Figure 4.21. Such images are then converted to textures and pasted over the object surface to increase realism.

Figure 4.21. Hand-held portable 3-D scanners for CAD users.

Using Online 3-D Object Databases.

This involves purchasing already created 3-D models from various commercial databases. Such models usually have three levels of detail, low (L), medium (M), and high (H), according to the number of polygons in the model (Figure 4.22). An example the reader is familiar with is the Viewpoint. The need to have several models of the same object relates to level-of-detail model management techniques discussed at the end of this chapter. Each model comes with two data files, one containing vertex coordinates and the other for vertex connectivity. It is then possible to use the local graphics library to transform these numbers into a wireframe or a shaded model of that object. Purchasing 3-D models is fast, but can be expensive.

Table 4.1 summarizes the various methods for modeling 3-D object geometry discussed in this chapter.

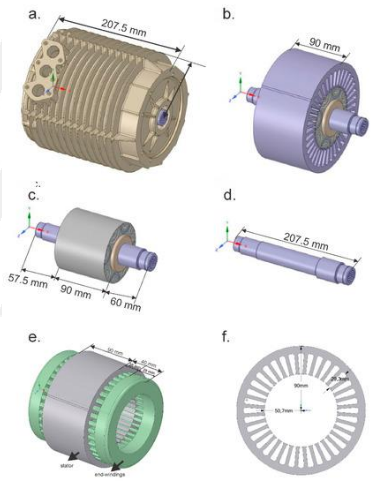

Figure 4.22. The 3-D geometry of the Interior Permanent Pagnet IPM motor.

Table 4.1. Methods for Modeling 3-D Object Geometry.

Method	Feature	Source
Toolkit editors	Tedious, requires skill	OpenGL, Starbase, PHIGS
CAD Programs	Interactive, existing technology	AutoCAD (Autodesk), 3-D Studio, etc.
3-D Digitizers	Interactive, allows custom models	Autodesys Inc., Mira Imaging, Polhemus Inc., etc.
3-D Scanners	Fast multipoint acquisition, large objects	Polhemus Inc., Cyra Technologies, etc
Commercial 3-D Database	Level of detail, Static model, Connectivity, and Vertex list	Viewpoint, etc.

4.3.2. Kinematics Modeling

The next step in virtual world modeling, following the setting of object shape and appearance, is kinematics modeling. This decides the area of three-dimensional articles regarding a world arrangement of directions just as their movement in the virtual world. A further part of kinematics displaying is the manner in which the world is seen, in particular the movement of a virtual camera. Object kinematics is administered by ParentChild hierarchical relations, with the movement of a parent object influencing that of its child. At last, the camera picture should be changed and projected in the Two-D presentation window to give visual input to the client.

Object Position

We have seen that object surface modeling uses (x, y, and z) vertex coordinates expressed in an object system of coordinates. This system of coordinates is attached to the object, usually at its center of gravity, and oriented along the object axes of symmetry. When the object moves in the virtual world, its system of coordinates moves with it. Therefore, the position and orientation of object vertices in the object system of coordinates remain invariant, regardless of the object position in the scene. This is true as long as the object surface does not deform or is not cut.

Figure 4.23 shows an example of a virtual prism that we will call object 1. It has an attached Cartesian system of coordinates (i1, j1, k1). The system of coordinates has its origin at the object's center of gravity and overlaps the prism's three axes of symmetry. The absolute position of object 1 is referenced to a fixed system of coordinates called the world system of coordinates (is, jw, kμ,). The transformation between object 1's system of coordinates and the world system of coordinates is given by.

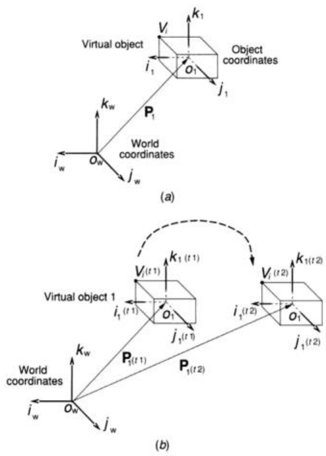

Figure 4.23. Virtual object's position (a) Static object; (b) Translating object.

Viewing the Three-Dimensional World

The backwards of the matrix T-globa1 is the view change. It addresses the position and direction of the camera arrangement of directions in the (fixed) world arrangement of directions. The camera system of coordinates in OpenGL is left-handed, unlike the other Cartesian system of coordinates associated with model transforms[48]. The camera is oriented such that it is looking in the positive z direction, with the $y - axis$ pointing upward and the$x - axis$ to the right, as seen in Figure 4.24.

Mapping the virtual objects to camera coordinates; (the so-called eye space) is the first task in the geometry stage of the rendering pipeline. Lighting (previously discussed), perspective projection, clipping, and screen mapping follow this. These geometry sub stages are discussed next.

The designs pipeline is not worried about the whole of the virtual world; rather it measures just what the camera sees. This addresses a volume of room called a frustrum, which is a bit of a pyramid lined up with the camera arrangement of directions. As delineated in Figure 4.25a, the tip of the frustrum is at the beginning of the camera arrangement of directions, likewise called the center of projection. Lines from the focal point of projection to the three-dimensional article vertices converge the survey plane to frame the item's viewpoint projection. The size of the projection is contrarily relative to the separation from the item to the focal point of projection. The frustrum pyramid is additionally characterized by a close and a far square shape. The square shape measurements are given by the boundaries (1, r, b, t, n, f), which decide how huge the survey point is and at what distance objects are seen.

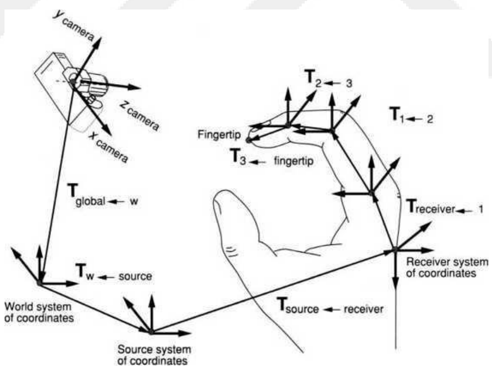

Figure 4.24. The hierarchical structure of a virtual hand as seen by a virtual camera.

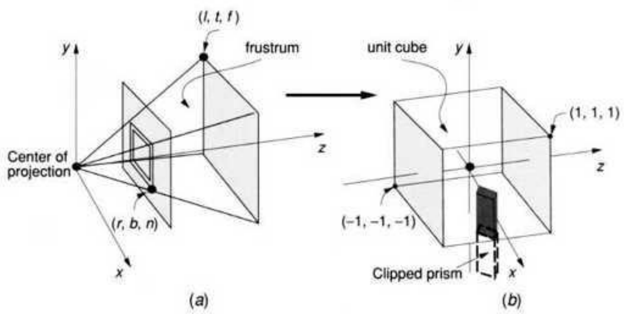

Figure 4.25. Viewing the three-dimensional World. (a) The frustrum (b) The canonical view model.

To optimize processing, the geometry stage of the graphics pipeline maps the frustrum to a canonical view volume. This is a unit cube with corners at (-1, -1, -1) and (1, 1, 1), as illustrated in Figure 4.25b. The mapping is done by the following projection matrix:

$$Protection = \begin{bmatrix} \frac{2n}{r-l} & 0 & 0 & 0 \\ 0 & \frac{2n}{t-b} & 0 & 0 \\ \frac{r+l}{r-l} & \frac{t+b}{t-b} & -\frac{f+n}{f-n} & -1 \\ 0 & 0 & -\frac{2fn}{f-n} & 0 \end{bmatrix} \quad (7.4)$$

Once the three-dimensional objects are projected into the canonical cube, their coordinates are normalized, which helps in the Z-buffering process. Objects with higher z values are further away, and should not be rendered if occluded by objects with smaller z.

The last stage of geometry processing is screen mapping. This stage translates and scales the (x, y) vertex coordinates of the objects inside the cube to the dimensions of a 2-D display window. If the window is rectangular, the scaling will be no uniform. The vertex z coordinate is not affected by screen mapping, as it is sent directly to the Z-buffer.

4.3.3. Environmental Modeling

The subsequent stage in virtual world demonstrating, following math and kinematics, is the incorporation of the item's actual attributes. These incorporate weight, idleness, surface unpleasantness, consistence (hard or soft), misshaping mode (flexible or plastic), and so on These highlights, along with object conduct, carry more authenticity to the virtual world model. The calculation load needed by actual demonstrating is doled out to the haptics-delivering pipeline. Subsequently, our conversation of actual demonstrating follows the phases of this haptic texturing, force mapping, force smoothing, force calculation, namely collision detection, and pipeline.

Collision Detection

The principal phase of haptic delivering (and in this manner actual displaying) is impact discovery, which decides if (at least two) objects are in contact with one another. This can be viewed as a type of haptic cutout since the haptics-delivering pipeline measures just articles that impact.

Impact discovery can be grouped into estimated and accurate [49]. Surmised crash location, likewise called bouncing box impact identification, utilizes three-dimensional degrees (jumping boxes), as outlined in Figure 4.26.

Bouncing boxes are grouped into arranged and hub adjusted. A situated jumping box (OBB) is a crystal lined up with the item's significant tomahawks and which changes direction progressively as the article turns. A pivot adjusted jumping box (AABB) is a bouncing box lined up with the world arrangement of directions. An uncommon instance of an AABB is a fixed-size block, which can oblige any direction of the three-dimensional item it encases. Fixed-size bouncing boxes are computationally quicker than variable-size jumping boxes, yet in addition will in general be bigger than these are[50].

Definition "A bounding box is a prism which encloses all the vertices of a given three-dimensional object".

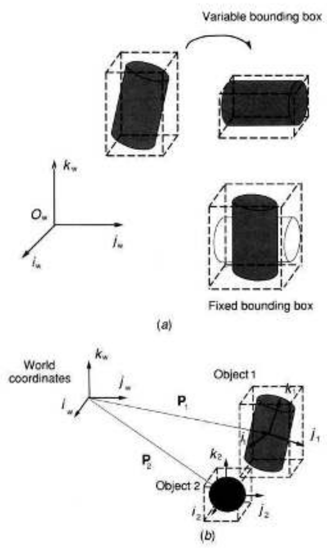

Figure 4.26. Bounding-box collision detection. (a) Types of axis-aligned bounding boxes; (b) Checking for collision.

5. PROGRAMMING WITH UNITY

In this chapter showed how to model the geometry, appearance, physical, and behavior properties of virtual objects as well as their parent-child object hierarchy. It also described ways to manage the resulting world (or universe) in order to reduce the frame rendering time. These are the basic components of programming, or authoring, a virtual environment.

Definition "An authoring environment is an Application Programming Interface (API)-based method of creating a virtual world. A run-time environment subsequently allows the user's real-time interaction with the authored world".

Building Virtual Reality with Unity and Steam VR

In 2017, we stood at the gates of a new technological landscape. As we looked out at the virtual real estate trying to figure out just how and what to build there, it was obvious there is a lot to discover. In the virtual world, there are no politics or borders to what we can experience and what we can build for others to experience. Just as early filmmakers had to find out how to tell their stories up on the cinema screen, we are only just beginning to explore the grammar of virtual reality (VR). Even the very basics of interfaces: how our fellow cybercasts interact with the virtual world, is still undecided [51]. Technology will keep moving. We will never stop learning.

Designing and Developing for VR

If you already have a project design document, or plans on how you intend to implement all of the interactivity in your virtual world, there is a very good chance that the final working systems will end up quite different from those original ideas. Testing and iteration are going to be at the very center of your production process and what feels right will triumph over anything that may have seemed right on paper.

With VR development, the best preparation you can do is pure prototyping: prototyping interactions, movement systems, and the scales of your environments prototype everything until it feels right.

5.1. Getting set up for Unity SteamVR development

In this chapter, the author assumes that you have already set up your virtual reality (VR) hardware as per the manufacturer's setup instructions.

5.1.1. Installing SteamVR

Once your hardware is set up, you need to download the required software. You will need both the Steam client software and the additional SteamVR download for all of the examples in this research. All the examples are targeted for SteamVR, and they use the SteamVR SDK for Unity.

One of the biggest advantages of using SteamVR is the cross-platform compatibility between headsets, but there are many more advantages like the SteamVR Interaction system, which we will be looking at throughout this research.

5.1.2. Install SteamVR

Once you have an account set up and the Steam client software running, you need to download and install SteamVR. Find this as a separate download within the Steam client, in the Library > Tools section. Right click on SteamVR and click Install Project.

5.1.3. Start SteamVR

Once SteamVR has downloaded and installed, open Steam and you should see a little VR icon in the top right of the window. Click the VR icon to start SteamVR. After a short time, the SteamVR status window should appear see Figure 5.1. You will need to turn on your controllers, too, if you have not already.

The SteamVR status window Figure 5.1 shows connected devices as well as their status. Everything shown in the SteamVR window should be green. Otherwise, if there are any problems with your headset, tracking or controllers, a colored icon or text-based message will let you know about the problem right away. The SteamVR status window will also inform you about any required firmware updates.

Figure 5.1. The SteamVR Window.

5.1.4. Setting up a Unity project for SteamVR

Unity is free to download and one of the easiest project engines to use. The Unity editor Figure 5.2 is where you create, configure, and bring to life all your graphics, sounds, music, and other elements that go to make up your virtual world. We focused primarily on using SteamVR as the Software Development Kit (SDK). SteamVR is free, with the added advantage of being easy-to-use and supporting just about anything compatible with Open Source VR (OSVR) like the HTC Vive or Valve Index headsets or Oculus Go.

To use SteamVR as a developer, as discussed earlier in this chapter, you need the Steam client software and SteamVR running. In Unity, you also need the SteamVR SDK imported into your projects. Before we get to that, for the benefit of readers who have not tried Unity before, there will be a quick crash course into the basic interface of the editor. If you know about Unity and you have already used it, feel free to skip ahead to the "Creating a New Unity Project" section to get started with our first project itself.

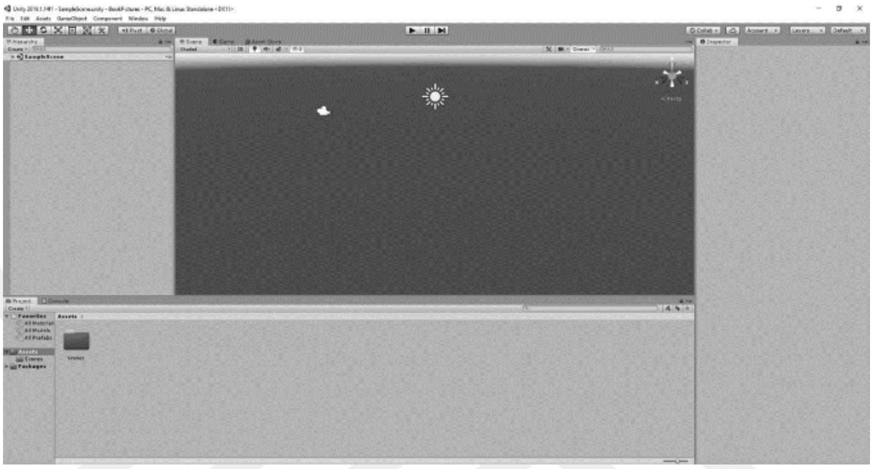

Figure 5.2. The Unity editor in its default layout.

5.1.5. Downloading Unity to make a new project

If you have not already downloaded Unity, you can grab it from the Unity website at https://unity3d.com/get-unity/download.

Downloading the SteamVR SDK for Unity

The required files to use SteamVR with Unity can be downloaded from Valve's SteamVR Github page (https://github.com/ValveSoftware/steamvr_unity_plugin/releases) or the Unity Asset Store. The Unity Asset Store is a shop where you can purchase and download all kinds of useful assets and scripts for your projects. Products on the Asset Store include scripts, 3-D models, full projects, textures, and graphics, and more. The store is provided by Unity and you can get to it from right inside the Unity editor. Open the Asset Store inside Unity by accessing the menu Window > Asset Store Figure 5.3. The search field runs across the top of the Asset Store page that appears in the main editor window. Type SteamVR into the search window and press enter on the keyboard. After a short time, the search results should appear.

Click on either the SteamVR graphic or the name "SteamVR Plugin." In the top right of the product description you will find the Download button Figure 5.4. Click on Download and then let Unity download it.

When the download has finished, the button will change to Import. Click the Import button. Unity will start importing SteamVR. Before the files are copied over into your project, a small window will appear prompting you to look at the files contained in the package. On an empty project, the extra step may seem pointless to check that it is OK to import the files.

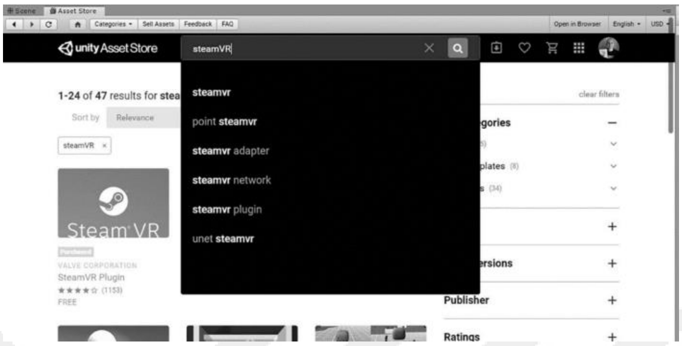

Figure 5.3. The Asset Store search results, showing the SteamVR Plugin.

Figure 5.4. The SteamVR Plugin asset store product description.

5.2. The SteamVR interaction system

We look at the Steam Virtual Reality (SteamVR) interaction system and find out how it can rapidly increase development time by supplying mechanisms for common VR interactions. The SteamVR interaction system is the same one seen in the Valve VR title The Lab, which includes a whole bunch of code to interact with switches, pick up and drop objects, teleportation, and more.

5.2.1. Add Teleportation

Look to the Project browser window and find ProjectFile > Prefabs. Inside that Prefabs folder, find the Teleporting prefab and drag it over into the Hierarchy to add it to the Scene Figure 5.5. Click on the Teleporting GameObject you just added to the Scene and check out the Teleport Component in the Inspector. From the sound it makes when to teleport to the colors of the pointers and highlights, it is very customizable! The default settings are all we need for now, though.

Below the Teleport Component, there is a Teleport Arc Component. This, again, is a highly customizable Component that will display that nice arc out from the controller to the potential teleportation destination.

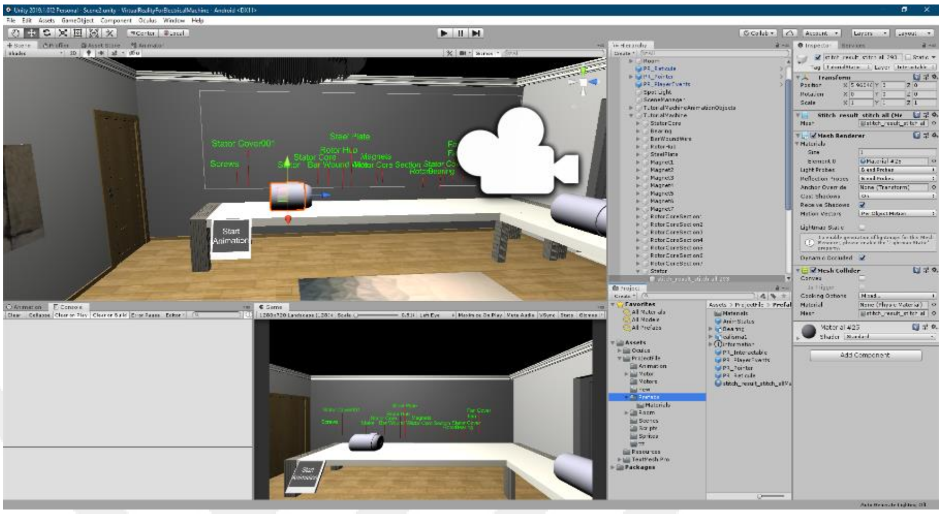

Figure 5.5. The Teleporting prefab.

5.2.2. Picking Up and Moving Objects

Let us throw things around! In this section, we will make a sphere object and add a Component that will allow us to use the controllers to pick it up, drop it, or simply throw it away!

Right click in the Hierarchy and choose 3-D Object > Sphere. Now select the new sphere in the Hierarchy. Drag it into a place where you will be able to pick it up in VR. For example, I used the position [52]:

X: 5.9

Y: 0.78

Z: 0.9

As mentioned earlier, all objects utilizing the Intractable Component need a collider to tell when the controllers are trying to interact with them. Unity primitives, like the sphere, already have a collider attached so there is no additional work to do there. Instead, we can just go ahead and add the Moveable Component.

5.3. Environment and Building a Main Menu

We look at how to build a main menu Scene. As well as building the User Interface (UI), we look at three methods for interacting with UI in virtual reality (VR) and scripting the behaviors to correctly load another Scene when the Start Game button is activated.

5.3.1. Tutorial Machine Table

Click the table (Tutorial Machine), when you click the start button (Start Animation) (Figure 5.6a), the motor parts will be separated (Figure 5.6b). Display the motor part name when clicking on the part (Figure 5.6c).

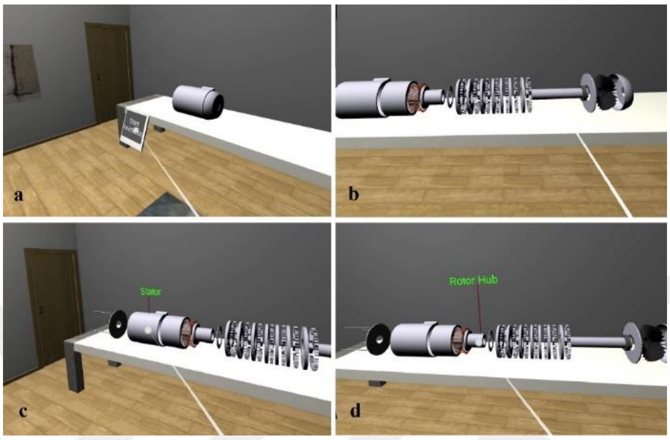

Figure 5.6. The main menu to start project (Tutorial Machine) (a) Start button (b) Sperate part. (c) Select stator. (d) Select rotor hub.

5.3.2. Assembly Machine Table

Click the table (Assembly Machine), when you click on the cell of the table (6- Bearing) Figure 5.7a, the motor bearing part will be separated, and the engine part name will be displayed.

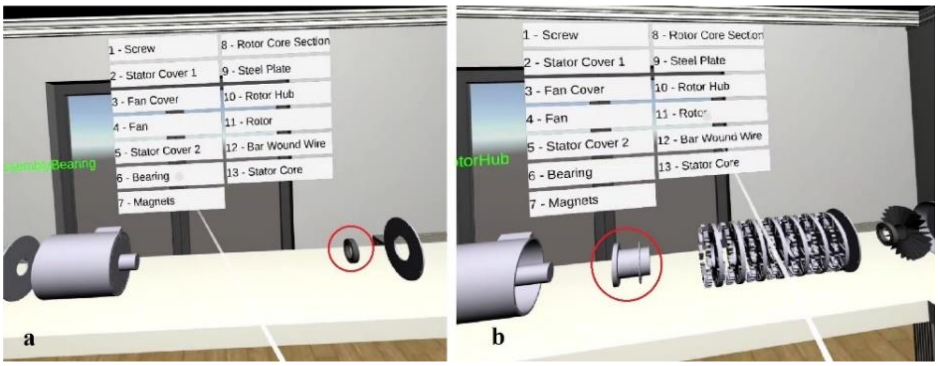

Figure 5.7. The part separated (Assembly Machine). (a) (6- Bearing). (b) (10- Rotor Hub).

5.3.3. Maintenance Machine Table

The last step, click the table (Maintenance Machine) you can allow the user to assemble a part when the part is assembled into the appropriate system according to the (First in Last out FILO) algorithm (Figure 5.8).

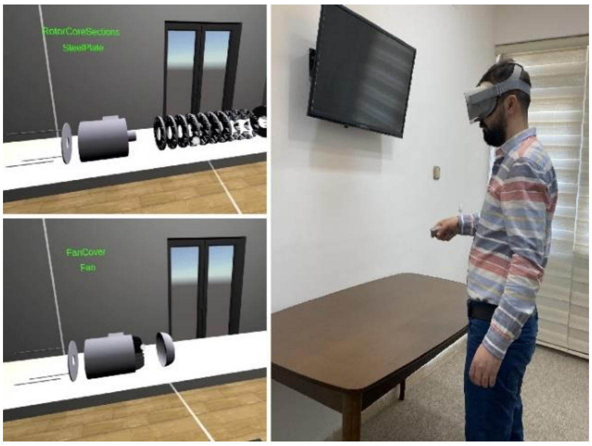

Figure 5.8. User in the testing process the assembled part (Maintenance Machine).

5.3.4. "THAT’S NOT THE NEXT PIECE!"

The last advance in the structure of the Virtual Reality for Electrical Machine is transforming the game into an instructional exercise is finished by scripting just as by carrying out show remark. In programming, it permits the client to acknowledge when mistakes happened by executing the remark show "THAT’S NOT THE NEXT PIECE!" When some unacceptable part is held or not permitting the client to gather a section when the part is not collected in the right request, every development order is enacted when the past advance is finished accurately right.

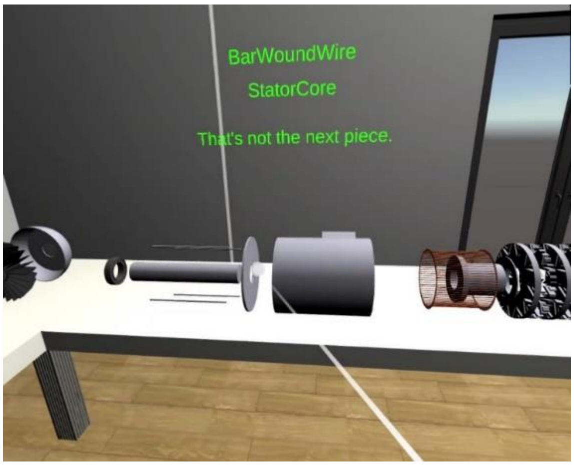

Figure 5.9. Display comment when wrongly assembled part.

The instructional exercise project likewise incorporates the scripting of the motor dismantling activity instructional exercise .19 which permits the client to see how the motor is dismantled. At that point, the client can genuinely choose the parts, which show their names Figure 5.9. This shows the client the parts, their area inside the motor and their names.

5.4. Programming

When every one of the articles have colliders and actual qualities, their conduct identified with the client can be customized. The vast majority of the actual conduct that identifies with cooperation with the client just as developments must be modified utilizing scripting. As Unity states on their site:

"Programming is quite basic defining games. In fact, even the slightest requirements of the game difficult contents, to respond to user interference and harmony occasions in constant, interaction occurs when they have to. Then, the contents can be used to create graphic effects, and control the actual behavior of the objects".

Unity takes into account two Java and C # programming dialects. C # was used to implement the project (Virtual Reality for Electrical machine). Software engineers can pick among C# and Java relying upon experience or inclination since both have a similar functionality. A portion of the capacities that were modified utilizing C# in Unity for the Electrical Machine situation includes:

- The robotized generation of the gathering and dismantling of a motor, that fills in as an instructional exercise.
- The association between the clients that permits snatching parts in the climate like pieces of the motor for dismantle and collect.
- The connection of the client and the apparatuses, the association among devices and parts.
- The framework that permits the motor to be just amass and dismantle in the right request.

Through the Unity creator window Figure 5.10, we can observe which motor the customer needs to disassemble. In the right side of the window, we can see a portion of the devices that this particular GameObjects has. This complex content allows the customer to extract each piece separately to the motor and collect just as it is disassembled. Content window consists of a few factors. Unity makes these factors into content and really shows them to see behavior and examine programming as it occurs continuously.

The total scrip in C# is given underneath for instance:

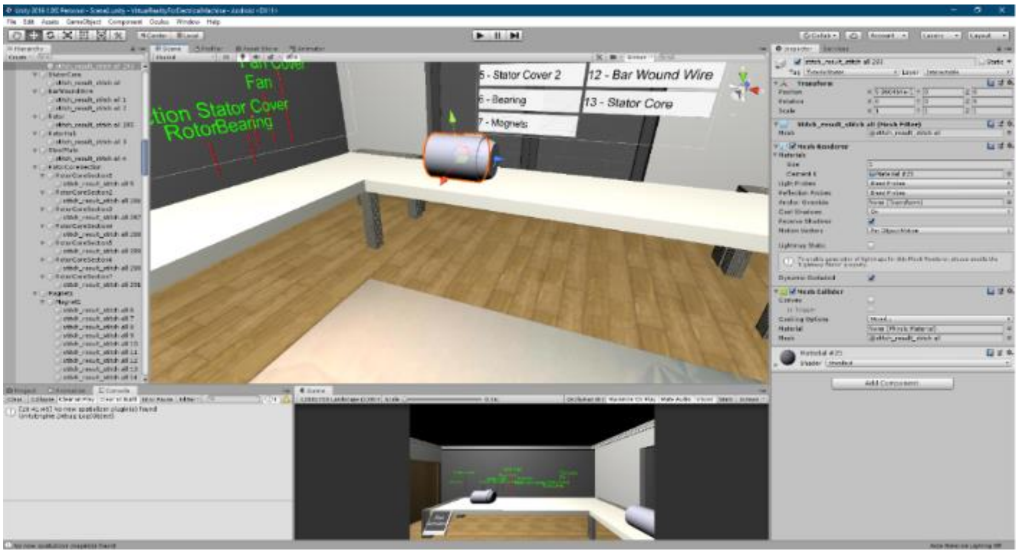

Figure 5.10. The complete scripts.

Part of Programing

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.UI;
public class Interactable : MonoBehaviour
{    private int tagState = 0;
    private int movingState = 0;
    private string maintenanceTag = "";
    Vector3 downPos = Vector3.zero;
    [Header("Standart Objects")]
    public GameObject m_Reticule;
    public GameObject m_PlayerObject;
    [Header("Tutorial Table Objects")]
    [Tooltip("1-Screw  2-StatorCover1  3-StatorCover2  4-Stator  5-StatorCore  6-
BarWoundWire 7-RotorHub 8-SteelPlate 9-Magnets 10-RotorCoreSection 11-Rotor 12-Fan 13-
FanCover 14-Bearing")]
    public GameObject[] m_Description;
    public Animator m_TutorialAnimator;
    public GameObject[] m_AnimationObjects;
    [Header("Assembly Table Objects")]
    [Tooltip("1-Screw 2-StatorCover1 3-StatorCover2 4-Stator 12-BarWoundWire 13-
StatorCore 7-RotorHub 8-SteelPlate 9-Magnets 10-RotorCoreSection 11-Rotor 12-Fan 13-
FanCover 14-Bearing")]
    public Animator[] m_AssemblyAnimator;
    public Text m_WarningTextAssembly;
    [Header("Maintenance Table Objects")]
    [Tooltip("1-StatorCore  2-BarWoundWire  3-Rotor  4-RotorHub  5-SteelPlate  6-
RotorCoreSection 7-Magnets 8-Bearing 9-StatorCover2 10-Fan 11-FanCover 12-StatorCover1 13-
Screw")]
    public GameObject[] m_MaintenanceMachine;
    public GameObject[] m_MaintenanceMachineSub;
    public Text m_ThisPiece;
    public Text m_NextPiece;
    public Text m_WarningTextMaintenance;
    float[] maintenancePosFloat;
    float[] maintenancePosPlus;
    float[] maintenancePosSour;
    private void Start()
    {   maintenancePosFloat = new float[m_MaintenanceMachine.Length];
        maintenancePosPlus = new float[m_MaintenanceMachine.Length];
        maintenancePosSour = new float[m_MaintenanceMachine.Length];
        tagState = 0;
        DescriptionInactive();
        maintenancePosition();     }
        downPos = m_Reticule.transform.position;
```

```
            switch (tagState)
            {
                case 3:
                    switch (maintenanceTag)
                    {   case "MaintenanceScrew":
                            maintenanceControl(12);
                            break;
                        case "MaintenanceStatorCover1":
                            maintenanceControl(11);
                            break;
                        case "MaintenanceFanCover":
                            maintenanceControl(10);
                            break;
                        case "MaintenanceFan":
                            maintenanceControl(9);
                            break;
                        case "MaintenanceStatorCover2":
                            maintenanceControl(8);
                            break;
                        case "MaintenanceBearing":
                            maintenanceControl(7);
                            break;
                        case "MaintenanceMagnets":
                            maintenanceControl(6);
                            break;
                        case "MaintenanceRotorCoreSection":
                            maintenanceControl(5);
                            break;
                        case "MaintenanceSteelPlate":
                            maintenanceControl(4);
                            break;
                        case "MaintenanceRotorHub":
                            maintenanceControl(3);
                            break;
                        case "MaintenanceRotor":
                            maintenanceControl(2);
                            break;
                        case "MaintenanceBarWoundWire":
                            maintenanceControl(1);
                            break;
                        case "MaintenanceStatorCore":
                            maintenanceControl(0);
                            break;      }
                    break;
            }
        }
```

5.4.1. Instructional Exercise Creation

The last advance in the production of the Virtual Reality for Electrical Machine is transforming the game into an instructional exercise. This is finished by scripting just as by carrying out voice orders. The scripting takes into account the student to acknowledge when missteps have been made by carrying out various tones to parts when some unacceptable part is gotten or by not permitting the learner to gather a section when the part is not being amassed organized appropriately. The instructional exercise creation likewise incorporates the scripting of the engine dismantling liveliness instructional exercise Figure 5.11 which considers the learner to see how the engine is dismantled. At that point, the learner can truly contact the parts, which show their names Figure 5.12. This shows the learner the parts, their area inside the engine and their names.

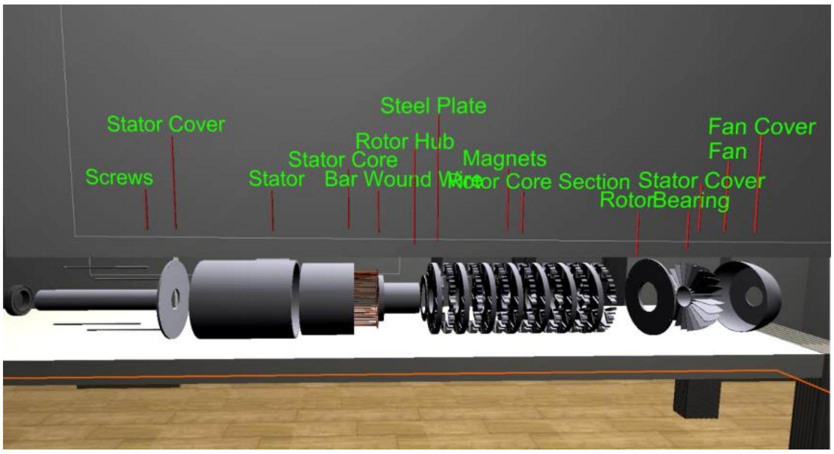

Figure 5.11. The components of Motor.

Figure 5.12. The stator core of Motor.

5.4.2. Unity GUI

Essentially, anything that you can make with the regular Unity GUI system is up for grabs in VR. The system we will be using here will just hook into Unity's existing systems to do the actual UI work, leaving SteamVR to deal with detecting when the controller is trying to interact by using scripts provided as part of the SteamVR library.

5.5. Unity Engine Polish and Optimizing Unity for VR

A difficult part of virtual reality (VR) development is cramming everything into the simulation without destroying performance. VR calls for your graphics hardware to do more than it was originally intended for certainly, more than rendering a single image to a 2-D screen. For VR, two images need to be rendered one for each eye. The images are updated faster than many common monitors will even display at. At its current level, the quality of experience we strive to achieve is pushing the limits of the hardware we have, and it is important to optimize our work as much as possible. Keeping the frame rate high, responding quickly to input and providing smooth, intuitive interfaces are the key to providing a comfortable nausea-free VR experience for your users. It can sometimes be difficult to achieve, but Unity provides some tools to help make it happen, and with a little caution, it is possible to deliver high-end experiences.

5.5.1. CPU vs. GPU

Although the graphics hardware needs to work hard to be able to render VR at a good, steady frame rate, you also need to keep an eye on how hard the computer's processor is working. The CPU takes care of most of the code-based processing like game logic, whereas the GPU works with rendering or, in some cases, physics simulation. If the CPU is working too hard, we call it CPU bound. If the GPU works too hard, it is GPU bound. By using the profiler, you can find out which one it is.

5.5.2. Profiler Modes

Along the top of the Profiler (ignoring Add Profiler button for now, but we will get to that further down) are some of the modes the profiler can operate in Figure 5.13:

Record: Start or stop performance data recording. Performance will be profiled whenever this button is checked and the Profile window is active.

Deep Profile: The profile will record many different aspects of the simulation, but if you wanted to get in-depth and have the editor record levels from all scripts and objects, you will need to enable Deep Profiling.

Profile Editor: Tis toggles whether or not to include the Unity editor in the performance data recording.

Editor: Tis is used for remote profiling, where you can choose the IP address of a Player to profile. Allocation Call stacks: Clears the Profiler window of all recorded performance data.

Clear: Clears the Profiler window of all recorded performance data.

Clear on Play: Whenever this is checked, Unity will clear the Profiler window of all recorded performance data whenever you press the editor's Play button.

Load: Loads profiling data from a (previously saved) binary file. It can also be appended to any existing data by holding down Shift on the keyboard when you click this Load button.

Save: Saves profiling data to a binary file. Tis can be useful to use for comparison after you have made changes to your work to make it perform differently.

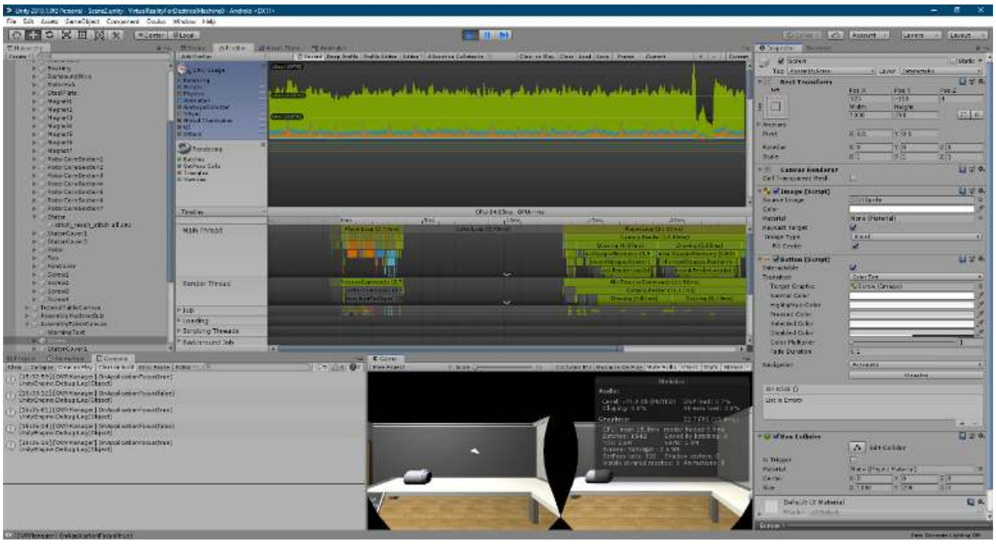

Figure 5.13. The Profiler.

Different Profilers

In the Profiler window, down the left-hand side of the graphs are the active profilers. In the top left of the Profiler window is a button Add Profiler. You can choose what gets profiled and focus on areas that might need attention or choose to profile a multitude of different aspects. Unity does offer a wide range of profilers:

CPU

GPU

Rendering

Memory

Audio

Video

Physics and Physics 2-D

Network Messages and Operations

UI and UI Details

Global Illumination

6. RESULTS AND DISCUSSION

Chapter 2 presented a number of input devices, ranging from trackers to trackballs, 3-D probes, and sensing gloves. These devices are all aimed at capturing the user's input in real time and transmitting it to the host computer running the simulation. These interfaces are key to the interactivity component of the VR three I's continuum. The simulation response to the user's input is conveyed through output interfaces, which are the subject of the chapter 3.

Chapter 3 introduced VR-specific output devices, designed to provide graphics, auditory, and haptic feedback to the user. These interfaces vary in complexity from the Olympus HMD to CAVEs, from PC 3-D sound cards to the HURON 3-D audio workstation, and from tactile mice to the CyberForce. Many systems currently in the research and development stages have necessarily been left out. The discussion here was instead aimed primarily at familiarizing the student with the various principles, capabilities, and design tradeoffs of current commercial VR output interfaces. The source of the real-time feedback mediated by these interfaces is the computer (or group of computers) running the VR simulation.

The real-time requirement of virtual reality simulations demands powerful graphics hardware and multiprocessor, or multicomputer, task distribution. This chapter analyzed the basic rendering pipeline for graphics and haptics and described various computing platforms that implement it. The discussion was dominated by PC-based systems, from single-pipe to multipipe and clusters, as they form the vast majority of today's VR engines. Of particular interest are architectures that support large-volume displays, or side-by-side tiled displays, where synchronization of the multiple graphics pipelines involved is crucial. Finally, this chapter discussed networked virtual environments that allow two or more remote users to interact with a shared virtual environment. Such distributed architectures are the foundation that allows multiuser VR applications to exist. The software tasks performed by the rendering pipeline are described in the next chapter, which focuses on VR modeling.

Next introduced the various aspects involved in virtual object modeling. These include geometrical modeling, kinematic modeling (defining parent-child hierarchies), physical modeling, and object intelligent behavior. The limited computational power available and the desire for simulation realism require management of model size and complexity, including level of detail and cell segmentation. Several of these features are included in software toolkits designed specifically for VR programming.

Finally introduced a number of VR toolkits designed to help programmers in system integration and application development. These are extremely useful tools and can cut programming time substantially. Commercial packages, support a large variety of high-end 1/0 devices, allowing advanced graphics and networking for multiuser simulations. Noncommercial toolkits, support less expensive I/O devices and have slower graphics. They are, however, useful for proof-of-concept in initial research stages as well as for teaching students the fundamentals of virtual reality. C# performance has been improving in recent releases and is becoming a powerful VR programming tool, with excellent marketing potential (free). Special-purpose toolkits.

7. CONCLUSIONS

The general target of this paper was to make a Computer generated Virtual Reality for Electrical Machine which was reasonable and with the capacities of preparing an individual to play out a particular strategy in more secure manner with no requirements that ordinary preparing techniques have now daily. The entirety of the goals of this paper where met. Initially, a mechanical support measure was recognized. This cycle met all the necessities, for the production of a fruitful preparing apparatus. The interaction was completely perceived, and the apparatuses expected to play out the mechanical upkeep, overall, where recognized. The authenticity of the situation was accomplished and even outperformed assumptions utilizing surfaces, mood articles, lightning and then some. The climate ends up being more secure without the utilization of any actual hardware, which likewise permits the situation to be accessible consistently. The conduct of the Virtual Situation was modified utilizing C#; the conduct gives both usefulness and authenticity to the virtual preparing situation. The production of an instructional exercise to prepare an individual the correct request of a mechanical support technique was accomplished utilizing a 3-venture measure. The initial step was the instructional exercise movement that showed the client an activity of the cycle, with the various strides of a dismantling and the parts names. The subsequent advance, permitting the client to perform said measure with the utilization of actual communication through Oculus Go select regulators that allowed the client to get, choose and work devices just as segments effortlessly. The third step was to execute a voice-guided instructional exercise that manages the client through the preparation gave the two guidelines and criticism.

This situation has demonstrated to be an extraordinary instrument for instruction just as for modern preparing, as an additional apparatus. All through the paper might be various gatherings of understudies, educators, and modern staff got the opportunity to use the virtual situation. The input acquired from the wide assortment of gatherings at various levels was positive. This situation was appeared at three changed secondary school enrolling occasions and one school-selecting occasion where it was consistently the main fascination for understudies just as educators.

Virtual Reality has been being used for quite a while for gaming purposes, because of the gaming market being a 100 billion dollar industry as per the 2017 worldwide games market report. This has caused various organizations to put a large number of dollars into this innovation. Gaming innovation, as seen with this paper, can be utilized for instructive just as mechanical preparing objectives, giving Computer game advancements a more life-important reason. This paper showed that a sensible preparing situation could be made. Such a situation takes into account an individual to learn in a more proficient manner. This preparation situation does not have the limitations of gear accessibility, spending limitations and wellbeing issues. This virtual situation demonstrates that we can prepare more individuals at a lower cost and in a more secure manner with the utilization of existing augmented simulation advances.

If you have been playing along with the projects in this thesis, you will have gone right from setting up the hardware and downloading software all the way through to spraying bugs. I like to think that this thesis has what you need to get up and running with development using SteamVR, whether that is taking just a few pieces or taking it all. One of the reasons I chose to use SteamVR libraries over other specific hardware-provided systems is the flexibility it offers and quality of the software, giving you the widest possible audience and widest number of devices at the lowest cost. Using the SteamVR system means that we only need to manage a single codebase for multiple devices and device types. SteamVR makes for a feature-rich, wide-reaching ecosystem already geared up for solid, social experiences.

Now that we have reached the end of this thesis, I hope that you can venture out there to bring your VR ideas to life on your next adventure. The virtual space is a place without rules, which makes it the perfect place to get a little crazy and try something different. The rules and conventions we have established in videogames and simulations are there to be built upon or completely rewritten for VR. Do not think for a second that the conventional approach is the best or only way to do something. In the virtual world, it is all unknown. If something feels natural, regardless of what it is or how silly it seems: you should pursue it and see where it goes. A simple crazy idea you have today could become a conventional approach in the future.

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CURRICULUM VITAE

Nechirvan Salman IBRAHIM

[redacted]

[redacted]

[redacted].

RESEARCH EXPERIENCES

- ✓ Laboratory Instruments you use, such as test systems etc. you know
- ✓ Computer Programming languages available (C-C++, MATLAP, LABVIEW, vb.)
- ✓ Computer programs you can use (CAT/CAM, PROTEUS, CALCULUS, vb.)

WORK EXPERIENCE

[redacted]).

ACADEMIC ACTIVITIES

Paper:

1. **“Virtual Reality for Electrical Machine”. Published by the International Journal of Scientific Research and Management for publication in the "Volume 9 Issue 5 [May 2021]".**

Projects:

2. **Virtual Reality for Electrical Machine.**
3. **Remote Control for Desktop Using C# Programing.**
4. **Athan App. For Muslim prayer times.**
5. **Database. For (market, coffee, shop, etc.)**