INNOVATING WITH AUGMENTED REALITY

APPLICATIONS IN EDUCATION AND INDUSTRY

Edited by
P. Kaliraj and T. Devi

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Preface

The world today has seen a massive change in manufacturing since the adoption of Industry 4.0, which comprises smart factories, cognitive computing, cloud computing, augmented reality (AR), Internet of Things, and cyber-physical systems. The industrial revolutions Industry 4.0 and Industry 5.0 are changing the world around us. Improved collaboration is seen between smart systems and humans, which merges the critical and cognitive thinking abilities of humans with highly accurate and fast industrial automation.

AR provides the experience of an augmented world to users by overlaying virtual information in the real world. AR is an interactive experience of a real-world environment where the objects in the real world are enhanced by computer-generated perceptual information, sometimes across multiple sensory modalities, including visual, auditory, haptic, somatosensory and olfactory. The advantage is that the user can be in touch with both the physical world and the virtual world and thus obtain real-time data and statistics.

The fourth and fifth industrial revolutions affect the roles that Indian universities and colleges prepare students for, and educational institutions are committed to helping produce the workforce for this new world and the student experience to match it. It is necessary to align higher education with Industry 4.0 through education on the tools of Industry 4.0. As a tool of Industry 4.0, students should be made familiar with AR and learn how to apply AR techniques in the domains they work. This book discusses AR and how it is used in specific application areas.

Bharathiar University has designed guidelines for Curriculum 4.0 and has prepared new syllabi for all subjects intertwining Industry 4.0 and 5.0 tools onto various disciplines, such as science, social science, arts, and education. The University has identified the gap in knowledge resources, such as books, course materials, interdisciplinary curricula, and innovative programs. To fill this gap and to prepare the future pillars of our globe to face the volatile, uncertain, complex, and ambiguous world, and to help the academic community, Bharathiar University has prepared guidelines for revising the syllabus, designing innovative faculty development programs, establishing connectivity to the real world for students, incubating creativity, and inculcating design thinking. Moreover, with the active participation of all stakeholders

under the esteemed leadership of the Honourable Vice-Chancellor, Prof. P. Kaliraj, interdisciplinary books are being edited for Education 4.0 and 5.0.

AR has many advantages, including increased engagement and interaction, enhanced innovation and responsiveness, easy accessibility to the smartphone market, and cost-effectiveness. This technology is found to have applications in almost all domains, such as medical training, retail, repair and maintenance of complex equipment such as car motors or MRI machines, interior design for architecture and construction, business logistics, virtual "walkabouts" for potential tourists, classroom education, laboratory practicals, and field service, to build deeper bonds between characters and the audience in the entertainment field, and to provide geolocation-enabled AR for public safety. This book in this context will uncover the details behind this technology, explore some of its application areas, and explore how this technology gets aligned with Education 4.0.

AR applications can provide a new level of interactive experiences and thus improved information. Companies are now leveraging this technology to provide their customers with the ability to experience their products' firsthand information and experience. Suppose typical apps on smartphones simply drove customers to the market. In that case, their counterpart AR apps allow users to visually experience the products by allowing them to deeply engage with the products as if they have already bought them. AR applications enable unique opportunities for immersive reality when sharing locations and places through social networks. AR applications can complement a standard curriculum by superimposing text, graphics, audio, and video into a student's real-time environment even in the educational domain. Thus, there are a lot of promising and exciting advantages when AR is brought to common use.

As per an estimate by Goldman Sachs, AR and virtual reality (VR) are expected to grow into a $95 billion market by 2025. There is a great need for educated individuals who have expertise in this domain. And with the demand for talented professionals more than doubling in the last few years, there are limitless opportunities for professionals who want to work on the cutting edge of AR application development. Universities and higher education institutions need to offer a prescribed set of courses for a major or specialization in AR, while those with dedicated AR programs may have unique approaches to the discipline. This will create graduates who are skilled in AR, and this book can help impart the concepts and knowledge of AR to graduates. This book provides a blend of the fundamentals and applications of AR with the description of its fundamentals, tools, challenges, and subfields of AR. This book on AR provides relevant theory and industrial applications of AR in various domains such as the beverage industry, education, gaming, and healthcare.

What's in the Book?

AR is the topic of discussion for this book, which comprises eight chapters. These chapters give exclusive understanding and exposure to the world of AR, with real-time examples and applications to provide a strong theoretical grip on this technology.

Starting with a discussion of a solid foundation for this technology, the chapters make available some application areas of this emerging domain. Due to the rapid advancements in technology, it is necessary that the future education system must prepare future graduates to be ready to work with the latest technologies by enabling them to learn virtually in augmented ways in varied platforms. By providing an illusion of physical objects, which takes the students to a new world of imagination, AR and VR create virtual and interactive environments for better learning and understanding. Hence, education is an application area that is dealt with in four chapters of this book. How gamification can be used in the teaching and learning process is covered in one chapter. Another application area dealt with in this section is the food and beverage industry with case studies on virtual 3D food, employee training, product–customer interaction, restaurant entertainment, restaurant tours, and product packaging.

One chapter familiarizes the reader with game development software, Unity, a real-time development platform for 2D and 3D AR and VR. A chapter on app development opens up details on the software, libraries, and techniques available for app development. The application of AR in the healthcare sector, medical education, and related gadgets and software are described in the last chapter.

Chapter 1, entitled *Augmented Reality,* provides an exclusive understanding and exposure to the world of AR with real-time examples and gives a solid theoretical grip on AR by providing a 360-degree view of the world of AR.

Chapter 2, entitled *Industry 4.0: Augmented and Virtual Reality in Education*, provides insight into the emerging technologies – AR and VR – that will create a virtual and interactive environment for better understanding in various sectors. The AR and VR technology thus provide an illusion of the presence of physical objects and take users to a new world of imagination. This chapter also discusses the basic concepts of AR and VR, types, hardware and software requirements, and applications of AR and VR technology in various areas, especially in education and industries.

Chapter 3, entitled *Augmented Reality Changing the Food and Beverage Industries*, discusses the revolution made by AR in the food and beverage industries. Applications of AR in various sectors of the industry that includes virtual 3D food, product–customer interaction, restaurant entertainment, employee training, restaurant tours, and food packaging are discussed. Also, technologies used and their impact on the industry are discussed. Finally, the chapter concludes with the future of food.

Chapter 4, entitled *Augmented Reality: A Boon for the Teaching and Learning Process*, enlightens how AR accelerates teaching and learning by using different applications of AR. It describes the history of AR, recent development of AR, elements of AR, place and benefits of AR, experiences in an AR classroom, role of AR in the teaching and learning process, the impact of AR, using AR for learners' development, applications of AR and the need for resources in the classroom, the future of AR in education, and three-dimensional learning models. Simplifying learning and teaching by using AR is clearly shown in this chapter.

Chapter 5, entitled *New Horizons for Learning: Augmented Reality in Education,* details AR technology and its educational potential. New technologies in education include smart classrooms for subject deliverance, webcast lectures, open educational resources (OER), video and interactive video tutorials, AR, virtual labs, VR, personalization, blended learning, individualized learning using portable devices, flipped learning, MOOCS, SPOC, mobile learning (M-learning), gamification, cloud-based learning, artificial intelligence, chat bots, Internet of Things, and big data, which are slowly finding their way into educational institutions. Fundamental techniques and methods are discussed in the context of education.

Chapter 6, entitled *Gamification for Education 5.0*, describes AR games that can change learning for students. Some of the popular tools for gamification for math programs, language learning, and classroom platforms that can be adapted to all platforms are detailed. The case studies of using gamification in school education for music, biology, mathematics, literacy, and vocabulary learning, and in higher education for information studies, computer science, computer organization and cloud computing, library, UML, mathematics, vocational courses, factory management, manufacturing training, software development, French language, and software engineering are given with the features used and the results. Finally, the effects of gamification on their satisfaction, cognitive load, and social problems are described.

Chapter 7, entitled *Augmented Reality Apps: A Developer's Perception,* describes a perception of a developer who is into creating applications that employ the use of newer emerging technology, AR. The chapter describes what AR is all about, differences between AR and VR, rules/constraints that need to be followed, libraries available for developers to develop applications, technical concepts associated with AR, use cases and, finally, a no-code approach for application development which can be installed on any smartphone independent of the operating system they are functioning on to understand what Augmented Reality actually means.

Chapter 8, entitled *Modernized Healthcare Using Augmented Reality*, details the applications of AR in healthcare and case studies on medical education, nurse training, dentistry, surgical visualization, and diagnostic imaging. Technologies that include gadgets and software packages behind augmented reality are described.

How to Use the Book

The method and purpose of using this book depend on the role that you play in an educational institution or an industry or depend on the focus of your interest. We propose five types of roles: student, software developer, teacher, member of Board of Studies, and researcher.

If you are a student: Students can use the book to get a basic understanding of augmented reality, its tools and applications. Students belonging to any of the arts, science, education, and social science disciplines will find useful information from chapters on *Augmented Reality* and *Industry 4.0: Augmented and Virtual Reality in Education*. This book will serve as a starting point for beginners. Students will benefit

from the chapters on applications of AR in education – teaching and learning, food and beverage industries, entertainment (gamification) and healthcare.

If you are a software or mobile app developer: Software or mobile app developers can use the book to get a basic understanding of AR, its tools and applications. Readers with a software development background will find useful information from the chapter on *Augmented Reality Apps: A Developer's Perception*. They will also benefit from the chapters on education – teaching and learning, gamification and healthcare.

If you are a teacher: The book is useful as a text for several different university and college-level undergraduate and postgraduate courses. A graduate course on augmented reality can use this book as a primary textbook. It is important to equip the learners with a basic understanding on AR as a tool of Industry 4.0. Chapters on *Augmented Reality* and *Industry 4.0: Augmented and Virtual Reality in Education* provide the fundamentals of AR. To teach the applications of AR in various sectors such as Education, Healthcare, Food and Beverages, teachers will find useful information from this book. A course on AR and its applications could also use the chapters in this book.

If you are a member of the Board of Studies: Innovating the education to align with Industry 4.0 requires that the curriculum be revisited. Universities are looking for methods of incorporating Industry 4.0 tools across various disciplines of Arts, Science, Education and Social Science. This book helps in incorporating AR across Science, Education and Entertainment. The book is useful while framing the syllabus for new courses that cut across AR and disciplines of Arts or Science Education. For example, syllabi for courses entitled augmented reality in science, augmented reality in education, or augmented reality in healthcare may be framed using the chapters in the book. Industry infusion into curriculum is given much importance by involving more industry experts – R&D managers, product development managers, and technical managers – as special invitees in the Board of Studies. Chapters given by industrial experts in this book will help infuse the application part of augmented reality into the curriculum.

If you are a researcher: A crucial area where innovation is required is the research work carried out by universities and institutions so that innovative, creative and valuable products and services are made available to society through translational research. This book can serve as a comprehensive reference guide for researchers in developing experimental AR applications and mobile apps. The chapters on *Augmented Reality Changing Food and Beverage Industries, Augmented Reality: A Boon for Teaching and Learning Process, New Horizons for Learning: Augmented Reality in Education, Gamification for Education 5.0, and Modernized Healthcare Using Augmented Reality* provide researchers, scholars, and students a base for research in the area of AR.

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From Prof. P. Kaliraj

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I thank my wife Dr. Vanaja Kaliraj and family members for supporting me and being patient.

From Prof. T. Devi

I record my sincere thanks to **Prof. P. Kaliraj**, Hon'ble Vice-Chancellor of Bharathiar University, who identified the gap in the knowledge world when Professor searched for a book on Industry 4.0 and triggered the process of writing and editing books in the Industry 4.0 series. His continuous motivation during the lockdown period due to COVID-19, sensitization, and encouragement are unmatchable.

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*****

Editors

Prof. P. Kaliraj, Hon'ble Vice-Chancellor, Bharathiar University, a Visionary and an Eminent Leader leading big academic teams, has more than three decades of teaching and research experience. He has held various renowned positions, such as officiating Vice-Chancellor of Anna University, Head of Centre for Biotechnology of Anna University, Dean of Faculty at A C College of Technology, and Member of the Syndicate for two decades at Anna University. Professor Kaliraj had research collaborations with the National Institute of Health in Maryland, USA; Glasgow University in Scotland, UK; and University of Illinois in Rockford, USA. He received the University Grants Commission BSR Faculty Award and the Lifetime Achievement Award from the Biotechnology Research Society of India. **Forty-two scholars were gifted to receive the highest academic degree under his distinguished guidance**. His remarkable **patent in the area of Filariasis is a boon in healthcare** and saving the lives of mankind. He is a great motivator and very good at sensitizing the faculty, scholars, and students towards achieving academic excellence and institutional global ranking. Professor Kaliraj a recipient of the **Life Time Achievement Award and Sir J.C. Bose Memorial Award** for his Outstanding Contribution in Higher Education – Research. (email: vc@buc.edu.in, pkaliraj@gmail.com)

Prof. T. Devi Ph.D. (UK), Professor of Research and Evaluation, Professor and Head, Department of Computer Applications, Bharathiar University, focuses on state-of-art technology that industries adopt in order to make the students ready for the future world. She is a **Gold Medalist** (1981–1984) from University of Madras and a **Commonwealth Scholar** (1994–1998) for her **Ph.D. from University of Warwick, UK**. She has three decades of teaching and research experience from Bharathiar University, Indian Institute of Foreign Trade, New Delhi, and University of Warwick, UK. Professor Devi is good in team building and setting goals and achieving. Her research interests include integrated data modeling and frameworks, meta-modeling, computer-assisted concurrent engineering, and speech processing. Professor Devi visited the UK, Tanzania, and Singapore for academic collaborations. She has received various awards, including the **Commonwealth Scholarship and Best Alumni Award from PSGR Krishnammal College for Women (PSGRKCW), Proficiency award from PSG College of Technology and awards from Bharathiar University for serving for BU-NIRF, Curriculum 4.0, and Roadmap 2030 and guided 23 Ph.D. scholars**. (email: tdevi@buc.edu.in, tdevi5@gmail.com)

Contributors

A. Aravind
Department of Mechanical Engineering
Sree Vidyanikethan Engineering College
Tirupati, India

R. Balaji
Hardware enthusiast
Sri Ramakrishna Engineering College
Coimbatore, India

P. Bhanu Prasad
Advisor to R&D Centres
France, Germany, and India

V. Bhuvaneswari
Department of Computer Applications
Bharathiar University
Coimbatore, India

P. Janardhana Kumar Reddy
Department of Education
Bharathiar University
Coimbatore, India

D. Kalaivani
Department of Information Science and Engineering
New Horizon College of Engineering
Bengaluru, India

M. Lissa
Department of Computer Applications
Bharathiar University
Coimbatore, India

N. Padmaja
Sree Vidyanikethan Engineering College
Tirupati, India

Bhanu Prasad
Advisor to R&D Centres
France, Germany, and India

D. Ramya Chitra
Department of Computer Science
Bharathiar University
Coimbatore, India

P. Ranjit Jeba Thangaiah
Karunya Institute of Technology and Sciences
Coimbatore, India

B. Satish Kumar
Department of ECE
Sree Vidyanikethan Engineering College
Tirupati, India

G. Singaravelu
Department of Education
Bharathiar University
Coimbatore, India

N.S. Sukanya
Bharathiar University
Coimbatore, India

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Chapter 1

Augmented Reality

M. Lissa[1] and V. Bhuvaneswari[2]

[1]*Ph.D. Research Scholar, Department of Computer Applications, Bharathiar University, Coimbatore, India*

[2]*Associate Professor, Department of Computer Applications, Bharathiar University, Coimbatore, India*

Contents

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Objective

The main objective of this chapter is to focus on giving immense knowledge about emerged technology Augmented Reality, and it is essential to have a base knowledge about the technology before plunging into the field of experiencing. The chapter has five sections to give exclusive understanding and exposure to the world of Augmented Reality. It provides a 360-degree view of the world of AR and explains with real-time examples the variety of aspects that can be developed through Augmented Reality technology. It will provide a solid theoretical grip on the AR and a brief overview of the world of AR for underlying developments. The chapter also provides a holistic approach and concise overview of the realm of AR and how the world is being adopted by it day in and day out. AR cannot be categorized as a simple technology, but rather a combination of set of technological innovations.

1.1 Introduction to Augmented Reality

The chapter introduces Augmented Reality for the students and the people who are looking forward to learning more about emerging technologies this covers the core concepts which involve basics, features, advantages, tools, and technologies of Augmented Reality with real-time applications. The basic history and the term Augmented Reality is commonly abbreviated as AR, which emerged in the year 1992 by two airplane engineers of Boeing Thoman and David. The first experiment and goal are to create a display that can transform the physical world that is replacing the real world with digital reality. It needs more complex programmatical codes and big suspended machines, and mechanical arms to display (Craig, 2013).

Today there is no longer a need for heavy machines instead of the independent hardware referred to as standalone headsets or head-mounted display. In short, it is called an HMD this is also an AR content delivery system first introduced by the Microsoft Hololens, it is a wireless and rechargeable battery present within a frame. On the other side, the smartphone development industry contributed to AR's growth because the components used for AR are the same for mobile devices. Also, AR is created using face and rear camera on smartphones by holding it up the screen can display digital objects and information integrated within the real world. Now the smartphone itself can act as a portal to a new world's experience and knowledge.

AR begins with the most powerful and broadly applicable matters, as was the Internet itself. It is self – an evident and eventual conclusion reached when anyone, achieving upon a basic level of comprehension, spends a few moments considering the limitless potential that augmented reality promises. Spatial and interactive were AR builds on what has come before and takes connectedness to new places and it is a medium that allows you to interact with digital data visually and spatially that is utterly seamless with your environment and everyday life.

1.1.1 Definition and Augmented Reality Characteristics

The technology involved in Augmented Reality can project 3D models directly or insert, fuse, and overlay digital and virtual information in the real-world environment. AR can be leveraged to recognize things and see things and get instantaneous information via a Smartphone. In AR, the images generated by the computer are superimposed on the physical world which changes the perception of reality. AR projects a real-world environment by adding sounds, videos, or graphics to it that helps to experience an automated tour with audio Augmented Reality (Bederson, 1995).

The characteristics that define Augmented Reality are related to interactive concepts which include combining the real and virtual world, the virtual environment created with the AR experience is interactive. The real images and virtual images are combined and can be seen at the same time. 3D objects appear in a fixed space where it is spatially registered AR, it also makes simple interaction.

Focuses on the main three characteristics

a. Integration with a real-world environment
b. Real-time integration
c. Alignment in the 3D model to embed in the focused area

1.1.2 Difference between Augmented Reality and Virtual Reality

Virtual reality is defined as the use of computer technology to create a simulated environment, it makes the users immerse into the environment and interact with the 3D worlds. Virtual Reality simulates the various senses like vision, touch, hearings, a smell which transforms to experience the artificial world. It creates an artificial environment to experience the 3D world on the other phase augmented reality helps to simulate the artificial objects in the real environment. A brief comparison of Augmented Reality and Virtual Reality is explained as shown in Table 1.1.

1.1.3 Current Industry Landscape

AR technologies produce a digital immersive user experience across various industry verticals like Gaming, Entertainment, Media, Aerospace, Healthcare,

Table 1.1 Augmented Reality vs. Virtual Reality

Augmented Reality	*Virtual Reality*
The digital elements can be added to the actual environment by using Augmented Reality (AR) (Hubspot, 2018)	The user can interact with the virtual world which does not exist and get an immersive experience with the use of Virtual Reality (VR) (Hubspot, 2018)
Augmented Reality is a live direct or indirect view of a physical world environment whose elements are augmented by computer-generated or extracted real-world sensory (Geospatial, 2018)	The real world fits with virtual objects with Virtual Reality used in headsets, sometimes in combination with physical space (Geospatial, 2018)
AR supplements the world with digital objects of any sort, Airplane pilot helmets that display data within the pilot's view as they fly are AR headsets (Geospatial, 2018)	Multi projected environments to generate realistic images, VR devices are Facebook's Oculus, Samsung's gear or Google Cardboard are all VR devices (Geospatial, 2018)

Education, Manufacturing, Retail, and others. The key market players are Alphabet (Google Inc.), DAQRI, Facebook, HTC, Magic Leap, Inc., Microsoft Corporation, Osterhout Design Group, Samsung Electronics Co., Ltd, Sony, Wikitude (Prnewswire, 2020). As per the statistics (Tech Jury, 2019) of finance, online reviews for the business world population are access to AR technology via Facebook, Snapchat, and many graphic software solutions that adapt to this technology by applying AR elements for realistic rendering (Financesonline.com, 2020). More than twenty industry giants make AR products for consumers to benefit in the part of product demonstrations, workplace training, and workplace safety (Tech Jury, 2019). Among all the technology giants, main market players for AR gains competitiveness to increase the sales of AR smart glasses, and they are dominant market players Google LLC (Alphabet INC.), Seiko Epson Corporation, Vuzik Corporation, RealWear Inc., Toshiba Corporation, and Vuforia (Mordorintelligence.co., 2020). The statistics of International Data Corporation (IDC) for the global market of the Information technology industry is categorized into four divisions as software, Device and Infrastructure, Business services, Emerging technologies, Telecommunication services (Azuma, 1997). A part of this division is to focus on emerging technologies that show 46 percent as per the survey (Olsson & Salo, 2011) of the share is sourced among the global market it is significantly higher than other global regions. The industry invests in software services mainly to provide a robust infrastructure and platform by enabling devices communication through the service of software so it paves the way for emerging technologies that drive the growth of global revenue. The automobile industry widely uses this technology for designing and structuring the body of the vehicle it is estimated that automotive companies depict the immense pockets of investment. As part of emerging technological growth drivers, Augmented Reality is one of the other technology sectors. The Industry landscape rapidly changes with the digital transformation, which provides new skills and values to apply in modern business and society with technology.

1.1.3.1 AR Today

The current state of AR applications transforms the smartphone's use in different views by using a marker that is connected with digital animation or the phone pinpoints the location with the help of GPS, the real-time experience happens with the augmentation and within the context of the environment. Technology plays a major role in marketing medium, a popular giant in the industry called IKEA created an AR application designed the catalog which populates the three-dimensional model in various pages with a camera in the application to visualize the product.

As it seems to be revolutionary, real-world applications create heads up applications for pilots, and the great pioneer among the car brands BMW uses the features of augmented reality by displaying information such as speed, navigation

and injects it from the console on the dashboard on the glass which can be viewed only who drives the car. Various types of applications are developed today like Projection-based AR which projects it with synthetic lights as in the hologram of Microsoft, Superimposition-based AR replaces it with the virtual item. Augmented Reality emerged as a key driver of the technological economy because of AR headsets, Smart glasses, and AR applications as per the global economy prediction this makes a big impact in the field of education and across the broad. In the Health field, students practicing medicine broadly make use of AR headsets to experience and delve into the human body with digital 3D models. E-Commerce uses more to advertise and demonstrate the products to the user's choice by customizing the colors and features using AR applications. Architect modelers and constructors make use of Augmented Reality to visualize the final product in the period of creation, engineers use AR headsets to visualize the city layouts and involve a geospatial relationship. In today's business environment, the AR technology paves the way for the return of investment largely in logistics, including transportation, warehouses, and route optimization. The warehouses workers wear smart AR glasses that provide the shortest path to pick the item from different places for shipping.

1.2 How Augmented Reality Works with Technology

1.2.1 Augmented Reality Functionality

The augmented reality functionality allows the user to control applications through real-world interactions, computers generate the output which is overlaid upon the real-world objects. On integrating AR functionality into the environment set of function blocks are grouped to sense the real-world objects, with the physical interactions, the AR functions observe the information about the physical world. It starts to capture the data of individual objects such as position, angle of rotation, camera distance. The output of the reality is mixed with physical objects as getting the input of the device camera and processed in the background which follows the position of the track and preserves the screen with the user interface.

By combining these simple interactions over the device sensors Augmented reality shows an overlaid layer on the physical object. These blocks are integrated with the AR functionalities for user interaction in real-world objects to the virtual cloud for ease, as shown in Figure 1.1.

1.2.1.1 Features of AR Technological Components

The technological components are found based on two systems one is server-side and the other is content provider where the virtual information is stored, this information can be projected on various devices like portable smartphones, head-mounted displays,

Figure 1.1 Printed, Black strip blocks on the clock, Overlaid timer upon the clock.

and glasses. A part of the content is made into small components and stored in various preferred machines the content provider server will act as a storage service that stores different data formats in the form of graphics, text, images, videos, and geographic information. It can be interactive with the device through protocol services to individual clients with various communication protocols like video protocol and network protocol. As in the part of the client-side, it works with the main component software framework, a part has units in which they require software in terms of firmware, an operating system that is supported by AR (Satyanarayanan, 2015).

The other component in the technology is the application browser to serve as detecting and tracking through recognition units uses camera API. The flow of technological components moves to the process of rendering that provides visualization which uses the computer graphical API and video components. The visualization is shown through the other important component User Interface that shows various gestures, voice, user interactions and gives the virtual touch feel of the objects with the technique called haptic. AR components feature connect in process of recognition unit which communicates through protocol services where the stored data from the content provider service taken to the other part of rendering process using graphics interface with this result the user feedback is been pushed to through the user interface and helps the user to feel the augmentation with the rendered visualization and virtual information produced from the devices for the physical environment.

1.2.1.2 The Methods to View Object with AR Feature Detection

Feature detection is needed to display virtual content or to place an object in some location in the real world first and foremost the device should detect that object and to put the character it is necessary to decide the proper area to place for that this feature detection is used. This technology is robust it means users move around without fixing at a location to view the virtual object in the real world so this technology is the speed in processing to give effective and accurate information. From the user's view if an object under a different position, a different angle

the device will detect the same object in the same way for this feature detection is required (Drews, P, et.al., 2011). IPD is used for feature descriptors. The feature detection influences various factors like environment, changes in viewpoints, image scale, resolution, and lighting. A particular image is taken and using sample regions, interest point is detected and shown in circular or square regions, the scale determines the size of the regions in the image. This has different feature detection methods by considering the local image region gradients (Lowe, 2004), (Bay, Ess, Tuytelaars, & Van Gool, 2008, Juan et al., 2009). The other methods are identified using point-pair pixel intensity comparisons.

1.2.2 Feature Extraction Technologies Used in AR (Augmented Reality)

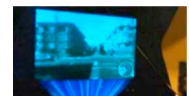
AR feature extraction starts with image acquisition, in such a way the interest points are detected and the feature extraction is done. To achieve feature extraction there is the various process to have proceeded with Grayscale Image Generation (GIG) – When AR device captures the image it is converted to a grayscale image for robustness, Integral Image Generation (IIG) – (Parmar & Desai, 2019). From grayscale image it is converted to an integral image this process of building it to enable the summation calculation over the sub-region images, Response Map Generation (RMG) – The image interest points are detected using the determinants of the image matrix to obtain this scale- space is required for that response map generation is used, Interest Point Detection (IPD) – On generating response map it can be accessed as interest point, Orientation Assignment (OA) – The detected IP provides image rotation by assigning it to the orientation process and Descriptor Detection (DD) – This descriptor identifies the IP uniquely and compares the descriptor with the data in the database and checks the qualification as invariability from noise, scale, rotation for this process descriptor detection is used. There are different kinds of descriptors available: Corner, Blob, and Region. Blob detection LoG (Laplacian of Gaussian), Hessian Matrix (H) second-order derivative, Laplacian trace of H is a process of detecting blobs in an image that has constant image properties all the points in a blob are considered to be similar to each other. These image properties that is brightness, color are used in the comparison process to surrounding regions. It also carries typical feature extraction techniques Haar feature (Messom & Barczak, 2009), HOG (Histogram of Oriented Gradient) (Jia & Zhang, 2009.

1.3 Hardare Components to Power Augmented Reality

1.3.1 The Hardware Needed to View AR Content

AR content is viewed with the help of various devices, some of them which include like Screens, glasses, handheld devices, mobile phones, head-mounted displays.

Table 1.2 Augmented Reality Hardware Devices

Augmented Reality Hardware	*Augmented Reality Devices*
Mobile Devices	
Holographic Displays	
Smart Glasses	
Immersed Head-Mounted Displays	

It involves technologies like SLAM (Simultaneous Localizing and Mapping) and Depth tracking that calculated the distance to the objects using sensors. The hardware components collect data with cameras and sensors to send data about the interaction of users for processing . It scans the surroundings and the device locates the physical objects to generate three-dimensional models to adapt the virtual layer with the detected physical environment. It can use a common smartphone to do the process and capture pictures or videos. This involves the technologies and detects the object (Thinkmobiles, 2017).

AR devices eventually should act like little computers, modern smartphones already do. In the same manner, they require a CPU, a GPS, flash memory, RAM, Bluetooth/Wi-Fi to be able to measure speed, angle, direction, orientation in space, and so on. The data collected from the sensor projects the digital content onto a surface or projects on AR headsets it shows the results of processing. Some AR devices assist the human eye to view the virtual images and mirrors are included to perform a proper image alignment (Thinkmobiles, 2017).

The core components required to power AR for developing applications and to set up the environment in AR can be divided into two different categories as software and hardware (Table 1.2).

1.3.2 Hardware Requirements

a. Sensors
b. A Camera
c. Accelerometer

d. Gyroscope
e. Digital Compass
f. GPS (Sensing and tracking system), CPU
g. Display Screen, Smart Phones
h. A Network infrastructure
i. A Marker

1.3.3 Augmented Reality Devices

1.3.3.1 Software Requirements

a. A Content Service Provider
b. Web Services

An application or program running locally depends on various factors. The process of development has to assure placing additional reality to the end-user. To meet up this the hardware requirement and software requirements are needed to appear in the AR application to view and feel the augmentation. Technology helps that helps to define and detect the location to place the objects and includes all the hardware components to process. To present the augmented reality information software requirements involve giving the user 3D rendered model from rendering engine and animation gesture detection. Finally, the application program running locally presents the virtual content through the user interface to attain these software components that are used (Solutions, 2019). With these components, to provide augmentation experience there are tools available for environment and gadgets, this is covered with the common name called software development kit. The main feature of SDK gives visual information to the users with object interaction and supports any platform services it includes multi-target detection that is virtual buttons (Solutions, 2019).

1.3.3.2 AR Assets and ARCore Features

The hardware components find inside the smartphones or gadgets powers the augmented reality with the help of AR Assets that gives a real feel to the users. A digital asset is defined as an animated 3D model that binds with the real-world objects to experience the Augmented Reality which can also be benefitted in the business by demonstrating or advertising the product by allowing the customers to interact with the digital assets created like their products. Example: Items of furniture appear in the real environment which provides an option to decide to choose a better before the time of purchase. In this way, the creation of an asset is more important which provides interactiveness and engages the users with good satisfaction. It strives the user or consumers to use and interact with the digital representation. ARCore is a powerful tool for developers which gives a unique feature like cloud anchors which

functions with cross-platform to experience in the different mobile operating system, Augmented faces functions with facial tracking by meshing 3D models without a depth sensor and environmental HDR focus on lighting extension from the real world onto virtual objects to make digital objects appear.

1.3.3.2.1 How the User Feels Real with Mobile Devices

To experience the real world and to give the user, the immersion in the objects which are not present in the real environment. Among the hardware requirements above mentioned it uses the assets to give the sense of realism and to start with the accelerometer the acceleration measures the change in velocity as to say mathematically speed divided by time, so the acceleration gives either static or dynamic that is motion or vibration state. Gyroscope works with the orientation feature it maintains in making the objects rotate and ensures the assets bind onto correctly. A camera gives the live feed of the real-world environment to overlay the virtual content and ARCore is more capable of using Google pixels which depends on machine learning, computer vision, and image processing to produce denser image quality for geolocation tagging. With this connection to enable the location-based augmented reality Magnetometer component of hardware is used and gives the direction where with this component it automatically knows which direction is north and it equates with the physical orientation to rotate the device. GPS receiver gets the time information from Global Navigation Satellite which provides geolocation here mobile devices act as a receiver, to enable location-based AR application uses ARCore.

1.3.3.2.2 AR Assets

The key point for AR creator is to focus on objects behavior when embedding the real environment and virtual layer simultaneously here placing the assets and positioning to one point when the devices or users are in motion is more important to makes stay the object where it is already to be positioned this kind is known as placing the assets. Next, it should be able to scale and size which has to incorporate with a placed object.

If there are more than one virtual content or object in the same environment, devices overlay both the content one above the other so it breaks the sense of immersion to the user to avoid this kind, a technique called occlusion is used where it makes understand the hardware about the presence of objects and the relative distance of it. In this way, the technique hides the unwanted object and views the required content to give the real feel with the AR application. With this alone the real experience cannot be given, the virtual object response is required according to the pattern for this color, shadows, and lightning is essential if the object is moved and shadow needs to move accordingly as happens in real-life for these effect shadow assets are used. The other important asset is solid augmented where the AR

creator must be aware that virtual objects should not overlay on the real-world objects, for this solid augmented asset is used and context awareness on digital object fidelity, smoothness, and functionality. The context-awareness needs to be maintained by both hardware and software by tracking the anchored virtual object present in the environment and understanding its size and shape individually.

1.3.3.2.3 ARCore

ARCore achieves optimal realism using both the hardware and software parts of AR. The environmental information is scanned, recognized, segmented, and analyzed, these processes are involved for tracking. ARCore mainly does motion-tracking this uses the SLAM technology. This process collects the hardware data information to create an environment understanding for rendering augmentation by detecting the feature points to set appropriate anchors. The process used in AR is known as COM (Concurrent Odometry and Mapping), it tells the smartphone about the located space in the environment this is called feature points. The awareness is created with inertia data of feature points and also the smartphone movement information using ARCore. The smartphone position can be determined with the use of a gyroscope which gives the present angle of the device and the accelerometer gives the speed of the phone now ARCore determines the position of the phone and finds the assets to be placed. To detect the flat surface ARCore software uses the hardware component information together of gyroscope and accelerometer to create context-awareness. The environment light is estimated by scanning the image pixels which determines the average incoming light that helps to decide and set the incoming light which is used by ARCore. The ARCore makes the user feel real by providing the shadows and lighting by matching it to the environment in games. If the motion tracking fails or drifts, when the device position is not reflected with the actual environment anchors can be used by setting it up with the static digital object or plane. In a specific location if the anchor is placed when the user places the device it holds the object accurately and detects the feature points to provide the virtual object in the static position to stay visible and placed consistently in the environment. Likewise, ARCore software uses a cluster of filter points to appear on the surface to determine the boundary of the plane and make the information to be viewed in the AR application. To rest the virtual information on a flat surface, the same information produced by ARCore from the boundary can also be used (Cammeron, 2018).

1.3.4 Real-World Uses of Augmented Reality

The AR applications work on the live feed of the camera into the digital content which is likely embedded into the use of real-world scenarios. Some of the examples are the entertainment and gaming field making good use of AR. As an example, the famous AR game Pokemon GO. With the use of augmented reality

hardware devices, many medical students are trained with the technology wearing the AR headsets to practice medical training and integrates with various platforms to perform invasive surgeries.

Mechanical Engineers: The methods of AR help the engineers to learn the service and maintenance in real-time with the AR glasses and learns the live guides, getting an idea of improving the efficacy of technical machine repairs and speed up services for customers. These are some of the real-world use cases with AR technologies.

1.3.5 The Advantages of Various AR UI (User Interface) Types

1. AR application gives real-world training to make it easier and process new concepts for students, this makes improvisation of education in clarity learning and helps to acquire skills with capabilities.
2. Visualizing 3D objects created by merging the virtual objects with the real world helps to provide digital information and detailed insights.
3. AR offers guidance to enhance customer services. For example, AR glasses used by sales professionals to help customers to buy cosmetics enhance the aesthetics.
4. AR headsets play a major role by adding a video of the car as a virtual layer into the existing environment to evaluate and estimate the cost of the damaged car to fix it. This kind helps the insurance worker to process the claims precisely and it changes the way of business operations easier.
5. The advantage of using Augmented Reality application is that gives additional information about the surroundings of the product present in the real-time which makes user retrieve valuable information with its characteristics.
6. The user also gets benefited from a unique function that adds up value for the buying process on creating interaction with consumers on a merchant site.
7. AR creates a drive-in business growth and many AR application have emerged to reach the audience with new services as software industries turn towards AR application development to exchange information and explore the technological advancements for business developments.
8. The significant benefit is visualizing and thinking in a three-dimensional view so it made a revolution in the field of advertising and marketing.

The transformation takes place in the real world with the incredible features of AR when it is demonstrated to assist, entertain, and educate people.

1.4 Augmented Reality Business Applications

Augmented reality has made a huge impact on creating business values in broader ways which help organizations around the globe to become a product of themselves and improve the performance across the value chain. There are various business

areas where the augmented technology paves the way to shape business activities to digitize the products on rebuilding and improvising the existing products.

1.4.1 AR Today: Smart Phone vs. Standalone

In today's world, AR is made possible with smartphones which act as a portal giving information and experience to the new world. The rapid growth of the AR industry is mainly because of the contribution from the side of mobile devices, all the features which are required for an AR application are needed for mobile as hardware components: gyroscope, accelerometer, high-resolution displays. The smartphone itself creates AR with front and rear-facing cameras, with this integrated information and the digital objects, are displayed in mobile devices.

1.4.2 AR for Weather Prediction

Weather forecasting to give graphics, digital effects to forecast the weather information is challenging for the forecaster. The basic element previously used were setting Chroma key projecting blue or green screen behind with a graphic feed from a computer. The technology effectively helps the forecaster to interact with the graphics and to broadcast visual interests this seems to be an AR-type presentation for forecasting the weather. Augmented Reality for weather forecasting is because it gives visualization in a four-dimensional view and adds inherent value for the forecaster ease to hold the attention of the audience through live interaction with dynamic 3D images of storms and atmospheric events. It is also useful in enabling travel conditions information to the audience by integrating traffic data into an on-air presentation that assists to provide real visual content. The advanced AR technology is used for displaying live radar, storm timing feature, rainfall totals, and flooding impact in a virtual set, many companies work on this part using the technology for weather prediction through this it helps the captivate viewers to hold their attention.

1.4.3 AR for Market Prediction

Augmented reality contributes to gaming, sports, entertainment, and education, as it is the base of strong consumers the market prediction technology, predicts the growth of the Augmented Reality market by finding information about a product, real-time stock, and sales information. Finally resulted that the vast majority of growth is been raised and reaches 85 percent in global market size.

The main key growth is in the area of health, manufacturing, and retail sectors it is been derived from the compound annual growth rate.

1.4.3.1 AR for Business Models

Augmented Reality is so effective in the business models on developing various models in different domains like architecture which is benefitted by the

archaeological information and gives plans for the rebuilding of ruins, arts and performance provides some useful assistance on using the technology by giving musical notes and services for sound coordination's. In terms of Education, students are given customized assistance for complex subjects by interactive computer simulation of concepts to experience and explore them (Kurubacak, G., Altinpulluk, H., n.d., 2017). In Medical Science and Engineering, it guides the doctors and nurses to follow the procedure and support in the right way by providing services like health scan of patients and robotic surgery support, then this technology also used by military defense operations and serves as assistance for providing situational awareness.

The techniques using Augmented Reality to identify the movement of each player in sports and entertainment. It enables the commercial value for every domain by the advertisements overlaid in real-time onto the user's view. Navigational information and guidance of historical events are displayed so it is used in tourism and sightseeing likewise the same information can also be displayed on automobile windshields to prevent accidents by giving specific attention to the drivers. The domain of AR provides platforms with toolboxes and custom services for application development also industry-specific developments and self-services it tests with content management tools.

1.4.3.2 Market Analysis of the AR Market (Market Size Forecast)

The forecast of market share for AR, focusing on a head-mounted display and all other components grow significantly in the future. The major type of services in the market for Augmented Reality devices are video games, video entertainment, and health care in all other applications it has a rapid growth. The forecast of the market size in 2025 says slow improvisation in user experiences in technology usage, seamlessly mobility supports a lot with the display, safety, and privacy. The head-mounted display is more popular and the system behaves and operates sufficiently well. Extensible mobility evolves the market size of AR in 2025 to become a generic computing platform.

1.4.4 AR for Smart Cities

The technology overlays digital content in the real world. As the emergence of AR engines like ARCore and many other usage and access to technology is been increased in the market. Due to the extensive availability of network connectivity and smart devices around the environment surrounding augmented reality plays a major role in powering its feature into smart cities. Some of the features like navigation services, live tracking, intelligent road work assistance, and much more make AR explored in all the domains as it provides public services on managing and controlling street lights, parking, etc. in a single platform. AR can be experienced with simulating the city services and collecting the data readings from the smart devices and environmental sensors which are embedded into the mobile devices to provide data based on location.

1.5 Tools Available for Augmented Reality and Recognition

Augmented Reality has many tools available to create digitally enhanced features for warfare emergent programs that prevails from serious conditions. The possibilities of AR technology are limitless on integrating the tools into devices. Various software tools can incorporate into the applications to create AR-based featured applications.

1.5.1 Software Tools: AR with Tools like Google Poly and Unity

- **Poly**

An online library is used by the people to browse and remix the 3D assets or 3D models, the asset can be created by any model developing platforms or tools like a block that generates a file it can be uploaded into the poly library and direct object file also can be uploaded. It is an Application Programming Interface (API), with this it contains thousands of assets and it can be accessed freely for the developers to browse, search, view, and add create applications.

- **Software Development Kit (SDK)**

AR application can be developed in Java using high-level 3D frameworks it offers a library for android it will integrate for AR experience which combines with ARCore API for rendering, plugins can be used to import and preview the assets directly in Android Studio.

- **Creation of Sceneform**

Scene form is a plugin used for developing three-dimensional applications without working with complex APIs like OpenGL. To create Sceneform using Android Studio adds the plugin from preferences:

Android Studio > Preferences > Plugins > Browse Repositories > Google Sceneform tools (Beta)

After adding the plugin automatically all the assets are imported and the source file is created into the project, this contains three supported files they are

1. The object file (obj) – It is a file format that contains three-dimensional coordination of an object.
2. Filmbox file (fbX) – It is used as interoperability for creating digital content.
3. GL Transmission Format (glTF) – It stores information about 3D models in JSON format.

Now Sceneform will convert the source file into a.sfb format that is runtime optimized format and this will be added to the.apk file. Right-click on the model imported and an import wizard dialog box opens just click the finish button the asset will be imported. The plugin will add the imported asset to the Gradle file to create a new runtime optimized format. By this render views the asset through sfb file viewer without deploying into the mobile it shows like WYSIWYG (What You See Is What You Get) on the phone screen. Using Sceneform SDK an android AR application is been created.

- **Unity**

A popular cross-platform game engine has a great visual interface for creating both 3D and 2D objects and interactive applications, video games, AR contents, Films, and many other projects. It contains many tools to create objects and environments. Unity can be used with ARCore and can import the objects from poly to incorporate into the developing applications this gives the unique experience exclusively unity platform is used to create AR content. The toolkit is used in unity and import assets at edit time and run time. To run on mobile devices it relies on ARCore and ARKit.

1.5.1.1 AR Technological Software Approaches

Augmented Reality can be carried out with the main technology called Simultaneous Localizing and Mapping. This technology is used significantly in AR applications and it is applicable for no prior reference points. In SLAM, as the machine or device to understand the visual content collected data from a sensor that is recognized as a reference point, it helps the machine to differentiate between the objects around the surrounding like roads, walls, and floors. But with this technology, the SLAM does not require any prior reference points instead it has the capability of localizing the virtual object without any prior map or GPS signal it navigates through space (Mayekar, 2018). SLAM uses some algorithms to map the objects that simultaneously localize to find the location of physical objects and fits with the preexisting device layout and framework of the environment. It is done possibly only with the mathematical and statistical algorithms where SLAM largely makes use.

In the initial state, the measurement leads to uncertainty and it is solved with the method by factoring in noise. Among all the algorithms this technology exclusively uses the Kalman filter to predict the position and find the unknown variables of 3D objects whereas the same algorithm is also used by Google for its self-driving cars. It is an autonomous technology that creates the map of its surroundings, augmentation is done with the existing Google maps upon these algorithms come into the play to find the different probabilities of outcomes.

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