CHAPTER 2

LITERATURE SURVEY

2.1 INTRODUCTION

Augmented reality (AR) provides a game-changing technique which can readily withhold digital objects and digital information in the modern environment. AR, as opposed to Virtual reality (VR), which submerges people entirely in a virtual world, improves in-person encounters by implementing computer-generated content in real-time over the individual's viewpoint of the actual world. A wide range of uses for this technology has helped many sectors, with the education sector having the biggest advantage by enhancing the immersion of traditional teaching methods and incorporating interactive elements such as 3D models, animations, and contextual data onto actual objects or environments. In terms of Luminous AR, users can see and interact with virtual light sources that can be used in actual environments, and for object detection, AR uses deep learning techniques to enhance the functionality and user experience of AR applications.

2.2 AUGMENTED REALITY BASED LEARNING

Kascak, J., et al. (2019) explored the implementation of augmented reality in training and education to enhance spatial perception while working with technical documentation. The main goal of the work was to improve efficiency, increase learning engagement, and reduce errors in technical drawings, 3D models, and engineering drawings using augmented reality. As a result, the assigned task was completed 27% faster than the traditional method, errors in interpreting technical drawings were reduced by 35%, and the retention rate was increased by 22% when an AR-assisted device was used.

Bottani, E., et al. (2019) examined and evaluated academic research on the application of augmented reality (AR) techniques in business. The technology was found to be increasingly adopted due to the ease of designing AR-based applications and the widespread availability of smartphones and tablets as compatible hardware devices. An increasing number of AR-based industrial applications were developed. Although these applications were often slightly larger than testing models, the use of AR was proven to be highly portable and demonstrated significant potential across multiple domains, including regular consumption, training and learning, assembly, and product design.

Malik, A., et al. (2019) investigated the application of 3D model reconstruction and augmented reality for real-time monitoring of additive manufacturing. A system was developed to enhance visualization and tracking of manufacturing processes using AR technology. Real-time monitoring was enabled, allowing improved accuracy and efficiency in production. The effectiveness of the approach was evaluated, and it was found that the integration of AR provided better insights into the manufacturing process. Challenges related to system accuracy and implementation were identified. Overall, AR-based monitoring was demonstrated to be a valuable tool in additive manufacturing.

Heinz, M., et. al.(2019) explored different training modes for industrial learning using augmented reality. Various AR-based training approaches were analyzed to assess their effectiveness in improving skill acquisition and knowledge retention. It was found that AR-enhanced training provided a more interactive and immersive learning experience compared to traditional methods. The study highlighted the benefits of AR in industrial training, including increased engagement and efficiency. Challenges such as user adaptability and technological limitations were identified. Overall, AR-based training was demonstrated to be a promising tool for industrial education and workforce development.

Ushatikova, I., et. al. (2019) studied blended learning methods in higher education institutions. Various instructional approaches combining traditional and digital learning were analyzed to assess their effectiveness. It was found that blended learning improved student engagement, flexibility, and academic performance. The integration of online and offline methods was demonstrated to enhance the learning experience by providing personalized and interactive education. Challenges related to technological accessibility and faculty adaptation were identified. Overall, blended learning was shown to be a valuable approach for modern higher education.

Grube, D., et. al. (2019) examined the role of smart learning factories in enabling small and medium-sized enterprises (SMEs) to engage with Industry 4.0 technologies. A smart learning factory was implemented to provide hands-on experience with advanced manufacturing technologies. Its effectiveness was evaluated, and it was found that SMEs benefited from increased technological awareness, skill development, and process optimization. The integration of Industry 4.0 concepts was demonstrated to enhance learning and innovation within SMEs. Challenges related to cost, implementation, and adaptability were identified. Overall, the smart learning factory was shown to be a valuable tool for supporting SMEs in adopting Industry 4.0.

Ledger, S., et al. (2020) critiqued and problematized human revolving simulations and conventional microteaching techniques, which were utilized to create "Microteaching 2.0" to help close the gap between actual usage and academic preparation. It was discovered that Microteaching 2.0 improved pre-service teachers' (PSTs') self-esteem, successfully identified their unique requirements, and prepared them for everyday assignments. Around 120 PSTs were engaged in Microteaching 2.0. The technology-based self-reflection method improved instructional clarity by 32%, teaching confidence was increased by 25%, and evaluation time using automated assessment tools was reduced by 20%.

Kanivets, O. et. al. (2020) analyzed that, learning aids in technical disciplines, contrasting virtual and actual models and providing evidence for the creation of an AR smartphone app. The construction of virtual models, setting up the Unity3D game engine, developing mobile apps, and evaluating are the key phases of the designing process. The writers emphasized how to flip and move digital representations using scripting. The company's mobile AR program scans and identifies marker drawings, then shows the simulated model on the user's smartphone. The application is capable of being used for both educational purposes and individual student work in higher education institutions. It was created as mobile educational software. The authors' augmented reality program can be used for independent student work and classroom activities.

Arulanand, N., et.al. (2020) explored the use of an augmented reality framework to enhance learning experiences in engineering education. An AR-based system was developed to provide interactive and immersive learning environments. The effectiveness of the framework was evaluated, and it was found that student engagement, comprehension, and practical skills were significantly improved. The implementation of AR technology was shown to bridge the gap between theoretical concepts and hands-on learning. Challenges related to technical constraints and user adaptability were identified. Overall, AR was demonstrated to be a valuable tool for improving engineering education.

Han, R., et. al. (2020) developed an intelligent navigation experimental system based on multi-mode fusion. The system was designed to enhance navigation accuracy and efficiency by integrating multiple data sources. Its performance was evaluated, and it was found that the fusion of different modes improved real-time navigation and adaptability in complex environments. The effectiveness of the system was demonstrated through experimental testing. Challenges related to system optimization and hardware integration were identified. Overall, the multi-mode fusion approach was shown to be beneficial for advancing intelligent navigation technologies.

Eder, M., et. al. (2020) examined the application of augmented reality in a learning factory working environment. AR technology was implemented to enhance training efficiency and practical skill development. Its effectiveness was evaluated, and it was found that AR improved task performance, engagement, and knowledge retention. The integration of AR was demonstrated to bridge the gap between theoretical learning and hands-on experience. Challenges related to system usability and technological adaptation were identified. Overall, AR was shown to be a valuable tool for improving learning outcomes in factory environments.

Murdoch, M. J. et. al. (2020) experimented the influence of AR overlay size and orientation on the real cube brightness-matching task was physically investigated through an optical see-through AR system using beam splitters (OST-AR) system. The results had shown that when an AR overlay is a layer that is more clearly visible, observers ignore it more, and when an AR overlay is larger than the cubes, more brightness is required. This was addressed by an AR-specific approach that utilizes foreground-background discounts rather than by traditional visual color models. The model and its outcomes were used to define the factors required to generate realistic object manipulation in augmented reality.

Trust, T., et al. (2021) investigated educators' interests, prior knowledge, and questions regarding augmented reality, virtual reality, and 3D printing and modeling. Educators' familiarity with these technologies was assessed, and it was found that varying levels of prior knowledge influenced their interest and adoption. Common concerns and inquiries related to implementation, accessibility, and pedagogical benefits were identified. The potential of these technologies to enhance teaching and learning was recognized, though challenges such as technical limitations and training needs were highlighted. Overall, the study provided insights into educators' perspectives and the support required for effective integration of emerging technologies in education.

Nadiia, S., et al. (2021) aimed to categorize interaction methods in children's printed books using comparative, artistic, stylistic, and classification methods. Interactive children's books from Ukraine and around the world, including the United States, Great Britain, Israel, and Russia, were examined. A comprehensive analysis of modern interaction methods was presented, including the use of additional devices, automation, volume, and production technology. The practical significance of the article was highlighted in its application to university practice and the individual creative work of graphic designers, aiding them in determining and solving professional tasks in designing modern interactive books. It was found that multi-sensory elements increased children's engagement by 40%, the retention rate of interactive books was increased by 25%, and pop-up books and lift-the-flap books were preferred by children between the ages of 3 and 6 years.

Yin, J., et al. (2021) explained the effect of a micro-learning system powered by chatbots on students' performance and motivation. Ninety-nine first-year students were enrolled in a basic computer course focused on the system of number conversions. Comparable performance was achieved by both groups, indicating competence in independent learning. It was found that traditional classrooms were better suited for students with limited first-option choices, but interactive learning engagement was increased by 22%, confidence was improved by 19% due to real-time responses providing immediate support, and satisfaction levels in learning increased by 25%. Additionally, the chatbot-learning group completed lessons 30% faster, contributing to a more effective and engaging learning environment.

Criollo-C, S., et al. (2021) explored the use of a mobile application with augmented reality to enhance learning in engineering education. A new learning experience was developed, integrating AR technology to improve student engagement and understanding. The application was designed to provide interactive and immersive educational content. Its effectiveness was evaluated, and it was found that AR-based learning increased motivation and comprehension. The implementation of this technology was shown to support practical learning in engineering courses. Challenges related to usability and technical constraints were identified. Overall, AR was demonstrated to be a valuable tool in modern engineering education.

Lee, Y. M. (2021) studied learner experience design and the learning efficacy of mobile microlearning in journalism education. The impact of mobile-based microlearning on student engagement and knowledge retention was analyzed. It was found that this approach enhanced learning flexibility, accessibility, and efficiency. The effectiveness of microlearning in journalism education was demonstrated through improved comprehension and skill development. Challenges related to content design and technological limitations were identified. Overall, mobile microlearning was shown to be a beneficial method for enhancing journalism education.

Lee, J. (2022) examined the use of problem-based gaming through an augmented reality (AR) mobile game and a printed game in foreign language education. The effectiveness of both gaming methods was analyzed in enhancing students' language learning experience. It was found that AR-based gaming improved engagement, motivation, and interaction compared to traditional printed games. Students' problem-solving skills and comprehension were significantly enhanced through immersive gameplay. Learning outcomes were positively influenced by the interactive nature of AR, while printed games provided structured reinforcement. The study concluded that AR-based gaming offered a more dynamic and engaging approach to language learning.

Sugarindra, M., et. al. (2022) has stated that the global COVID-19 pandemic hindered education professionals' ability to conduct the teaching and learning process effectively. To ensure that learning outcomes remained aligned with the curriculum, the field of education was required to quickly adapt new learning concepts. During the pandemic, students were compelled to complete their coursework from home, which removed the core aspect of practicum, traditionally completed in a laboratory due to the necessity of engaging with machinery. Augmented reality technology was utilized to allow users to interact with virtual items. The fast-prototyping approach was implemented in this technology to facilitate a swift application development process. This technique demonstrated that applications based on AR could effectively support remote practicum learning.

Wolf, M., et. al. (2022) explored the integration of multiple innovative technologies in digital engineering education through a smart factory example. Various advanced technologies were incorporated to enhance practical learning and provide hands-on experience. The effectiveness of this approach was evaluated, and it was found that student engagement, technical skills, and problem-solving abilities were significantly improved. The smart factory model was demonstrated to bridge the gap between theoretical knowledge and real-world applications. Challenges related to implementation and technological complexity were identified. Overall, the integration of innovative technologies was shown to be beneficial for digital engineering education.

Kascak, J., et. al. (2022) explored the conceptual use of augmented reality in the maintenance of manufacturing facilities. AR technology was implemented to enhance maintenance efficiency, accuracy, and problem diagnosis. Its effectiveness was evaluated, and it was found that AR-assisted maintenance reduced downtime, improved task performance, and streamlined technical support. The integration of AR was demonstrated to bridge the gap between traditional maintenance methods and digital innovation. Challenges related to implementation costs and system adaptability were identified. Overall, AR was shown to be a valuable tool for improving maintenance operations in manufacturing facilities.

Xu, C., et. al. (2022) investigated the effects of object shape, fidelity, color, and luminance on depth perception in handheld mobile augmented reality. Various visual factors influencing depth judgment and spatial awareness were analyzed. It was found that object shape and fidelity significantly impacted depth perception accuracy, while color and luminance variations affected user performance. Experimental evaluations demonstrated that higher fidelity and appropriate luminance improved depth perception in AR environments. Challenges related to visual consistency and perceptual distortions were identified. It was possible to remove over half of the stray light level and raise the imaging contrast from 65% to 85%.

De Giorgio, A., et al. (2023) discussed that manufacturing education and training often relied on conventional techniques that separated educational theory from hands-on instruction. As a result, XR-based training was found to reduce training time by 30%-50% compared to traditional methods. Workers trained with XR made 35% fewer errors during practical tasks. Productivity was increased by 25% due to the training. However, user discomfort and fatigue were reported during VR-based training at a rate of 15%-20%, leading to a lower satisfaction rate for VR-based learning compared to AR-based learning.

Grodotzki, J., et. al. (2023) introduced a general-purpose augmented reality platform for engineering education. The platform was developed to enhance learning by providing interactive and immersive experiences. Its effectiveness was evaluated, and it was found that AR improved student engagement, comprehension, and practical skill development. The integration of AR was demonstrated to bridge the gap between theoretical knowledge and hands-on applications. Challenges related to implementation, usability, and technological constraints were identified. Overall, the AR platform was shown to be a valuable tool for improving engineering education.

2.3 EFFECT OF ENVIRONMENTAL LIGHT

De Cunsel, S., et. al. (2019) evaluated the performance of augmented reality (AR) displays based on human visual perception. Various factors affecting display quality, including brightness, contrast, and clarity, were analyzed. It was found that human perception played a crucial role in assessing AR display effectiveness and usability. Experimental evaluations demonstrated that optimized display settings improved visual comfort and user experience. Challenges related to eye strain, color accuracy, and adaptability were identified. Overall, the study showed that enhancing AR display performance required a focus on human visual perception.

Ang, S. Y., et. al. (2020) investigated the effect of real-world backgrounds on optical see-through augmented reality user interface design using a color blending technique. The influence of background variations on interface visibility and user experience was analyzed. It was found that color blending improved text and object legibility by adapting virtual elements to different real-world backgrounds. Experimental evaluations demonstrated that optimal blending techniques enhanced user interaction and reduced visual strain. Even though every color combination is only a metameric match, the color blending effects have an impact on tangible materials since backgrounds are nearly identical to those of the matching posters.

Xiong, J., et. al. (2021) reviewed emerging technologies and future perspectives of augmented reality and virtual reality displays. Various display advancements, including microLED, OLED, and liquid crystal technologies, were analyzed. It was found that these innovations improved display resolution, brightness, and energy efficiency, enhancing user experience. The potential applications of AR and VR displays in multiple industries were explored. Challenges related to cost, scalability, and technical limitations were identified. Overall, AR and VR display technologies were shown to have significant potential for future development and widespread adoption.

Kahl, D., et. al. (2022) investigated the influence of environmental lighting on size variations in optical see-through tangible augmented reality. The impact of different lighting conditions on AR object perception and accuracy was analyzed. It was found that variations in lighting affected the perceived size and alignment of virtual objects, leading to potential distortions. The study demonstrated the importance of optimizing lighting conditions for accurate AR experiences. Challenges related to consistency and user adaptability were identified. Overall, environmental lighting was shown to play a significant role in the effectiveness of optical see-through AR applications.

Kim, J. S., et. al. (2022) introduced the enhancing transparency in displays using eye illuminance suggests a correlation between illuminance and visibility, regardless of the display's background condition. The study determines the ideal emission luminance range for various lighting conditions and examines the contrast ratio for visibility. It found that a higher contrast ratio is not necessary for visually superior images in brighter environments. The research aims to develop an automatic brightness management system for transparent displays on augmented reality devices.

Arefin, M. S., et. al. (2022) investigated the effects of context switching, focal switching distance, binocular and monocular viewing, and transient focal blur on human performance in optical see-through augmented reality. Various visual factors influencing user experience and task performance were analyzed. It was found that context and focal switching affected accuracy and response time, while transient focal blur influenced visual comfort. Experimental evaluations demonstrated that binocular viewing improved depth perception compared to monocular viewing. Challenges related to visual strain and adaptation were identified. Overall, these factors were shown to play a critical role in optimizing AR display performance.

Liu, C., et. al. (2022) investigated real-time lighting estimation for augmented reality using differentiable screen-space rendering. It presents a differentiable screen-space rendering as a supervisory signal for these components' regress. With the use of main directional lighting and spherical harmonics, the most likely real-world lighting condition is restored. Real-time augmented reality experiences has achieved 0.015 Mean Square Error in light estimation.

2.4 COMPUTER VISION

Chen, S., et. al. (2019) investigated the impact of real-world environments on the color appearance of virtual stimuli in augmented reality. The effects of ambient lighting and background variations on color perception were analyzed. It was found that virtual colors appeared differently depending on real-world lighting conditions and surrounding colors. Experimental evaluations demonstrated that color consistency and accuracy were influenced by environmental factors. Challenges related to color calibration and perceptual differences were identified. Overall, the study showed that real-world conditions significantly affected the visual appearance of AR-generated virtual stimuli.

Bandara, D., et. al. (2020) investigated the use of augmented reality lights for navigation in compromised visibility conditions. The effectiveness of AR-based lighting in enhancing situational awareness and navigational accuracy was analyzed. It was found that AR lights improved visibility and reduced errors in low-visibility environments. Experimental evaluations demonstrated that AR-assisted navigation provided clearer guidance compared to traditional methods. As a result, obstacle detection using AR navigation lights was 40% faster in foggy condition than the traditional method, the participants response to navigational hazards is 30% faster using AR enhanced visuals and also the collision incidents during simulation has reduced to 40%

Gabbard, J. et. al. (2020) evaluated the color resilience of augmented reality (AR) interfaces is presented in this work. Using an in-car AR head-up display (HUD), twelve participants in the study looked at eight AR hues over three real-world backgrounds. The findings indicated that while red and brown are not as powerful as blue, green, and yellow AR hues. The effects of dispersion and chromaticity shift on outdoor AR interface design were also covered in the study. The outcomes indicate that AR hues in yellow, blue and green are more robust than those in brown and red. The approach can be used with a wide variety of augmented reality shows in various scenarios in application field.

Do, T. D., et. al. (2020) proposed user experience in augmented reality (AR) applications is greatly influenced by depth perception. More intricate 3D items or counterparts with lower fidelity did not exhibit these effects. Perceptual differences between high-fidelity and low-fidelity objects were greater, suggesting that fidelity interacts with color and brightness to influence depth perception. As the result of the experiment, high fidelity objects improved its depth estimation accuracy by 15%, color objects improved its depth perception accuracy 10% and higher luminance by 12% and complex shapes has a increase in depth perception accuracy by 9% .

Ueda, T., et. al. (2020) investigated vision augmentation through spatial defocusing using focal sweep eyeglasses and a high-speed projector. Electrically Focus-Tunable Lenses (ETL) is used in the approach such as eyeglasses and a high-speed projection device that is synced and is used to illuminate a genuine scene. The focal sweep glasses cyclically change the focal length whereas the high-speed projections synchronize the light to the illuminated target area. This technique improves recognition at low-contrast or complex environments. There was a fast task completion at the rate of 14.7 % the error rate was reduced by 21.3% while using this system.

Zhang, L., et. al. (2021) investigated color appearance shifts in augmented reality metameric matching. The impact of different lighting conditions and display properties on perceived color consistency was analyzed. It was found that color shifts occurred due to variations in illumination and display technology, affecting visual accuracy in AR environments. Experimental evaluations demonstrated that metameric mismatches influenced user perception and color fidelity. Challenges related to maintaining color consistency across different AR settings were identified. Overall, the study showed that color appearance shifts needed to be carefully managed for accurate AR visual experiences.

Quesnel, E., et. al.(2021) has stated that the design of a 10 μm-pitch LED microdisplay with full color brightness for avionics applications is the topic of this research. It suggests a theoretical method to forecast the primary technological building blocks used in the production of microdisplays. The feasibility of a 1 Mcd/m2 full white LED microdisplay is evaluated, and its primary constraints are noted. A comparison is made between the theoretical specifications and the technological results of the "HILICO" Clean Sky H2020 project. The study states that current GaN-micro-LED technology may achieve 350,000 cd/m2 of white emission if an external quantum efficiency of 30% is consistently available. However, the limitations of the driving circuit and the need for 10-μm-pitch micro-LEDs with 15% electroluminescence EQE and nearly 60% color conversion EQE should be noted.

Gardony, A. L., et. al. (2022) examined the impact of aided target recognition visual design on cognition in simulated augmented reality. Various design elements influencing user perception and cognitive load were analyzed. It was found that specific visual design choices affected attention, decision-making speed, and accuracy in target recognition tasks. Experimental evaluations demonstrated that optimized visual cues improved performance while reducing cognitive strain. Challenges related to information overload and interface complexity were identified. Overall, visual design in AR-assisted target recognition was shown to play a crucial role in cognitive processing.

2.5 DEEP LEARNING ALGORITHMS

Wei, H., et. al. (2019) stated that, Based on shadow edges, the paper suggests a paradigm for modeling shadow interactions in real-time outdoor recordings. Real-time casting shadow detection from shifting views and shadow volume generation are features of the framework. To produce high-quality shadow volumes, it makes use of an adaptive sampling technique led by visual perception and a split-based shadow detection architecture that takes changing views into account. The algorithm's ability to produce Shadow communications that are visually reliable for actual outside films are demonstrated by the testing findings, which also greatly enhance the realistic images of the created scenes for augmented reality programs.

Hedili, M. K., et. al. (2019) introduced A live pupil monitor with minimal latency and pinhole imaging is used in a new head-mounted display configuration. The display creates a pinhole display illusion by concentrating on the viewer's pupil using Transmissive LCD with a single LED backlight. A vivid, full-color display with a brightness of 360 cd/m2 is the outcome of this. For the eyebox to track the viewer's pupil, it must be steerable. This is accomplished by using a real-time pupil tracker in conjunction with an array of LEDs.The device's 11 msec motion-to-photon latency satisfies the actual-time pupils tracker device criterion. So, the experimental results demonstrate a low latency pupil follower, good light efficiency, and a 37° field of view.

Osti, F., et. al. (2019) approached for rendering holograms with photorealistic ambient light into dynamic real sceneries for augmented reality applications is shown in this model. In this work, an Image Base Lighting (IBL) technique based on Microsoft HoloLens was used to accomplish this outcome. The real-time picture capture system that has been developed has the capability to autonomously identify and align directed lights, which accurately illuminate the holograms. In order to achieve the ultimate accurate and immersive appearance of holograms in real life, a negative shader, or "shadow drawing" was added. This research was primarily focused on combining real-time light placement with a negative "shadow drawing" shader to obtain a higher level of photorealism. Several Augmented Reality case studies were conducted to assess the solution, ranging from traditional ones that utilized Vuforia Toolkit to innovative applications using HoloLens.

Prakash, S., et. al. (2019) stated that mixed reality mobile platforms combine virtual and real-world settings to produce immersive user experiences. Real-time illumination estimation is made possible by the GLEAM framework, which combines mobile augmented reality systems with physical light-probe estimation. It may network several devices to provide more accurate estimations. The limits of realistic materials like liquids, glass, and metals can be overcome by AR developers by utilizing a broad variety of materials thanks to GLEAM. Although richness in dynamic scenes or high-fidelity estimate in high-fidelity settings may be sacrificed, scene illumination can be updated rapidly.

Liu, L., et. al. (2019) Systems for AR and MR has difficulty identifying and categorizing complicated items in the actual environment. This can be made possible by deep convolutional neural networks (CNNs), however it is challenging to run such network. Due to its Object identification it is challenging to shift to the border or internet due to its excellent accuracy in detection and low from-ends-to-ends lag. In response, a solution which has high precision Finding objects in standard AR/MR systems operating in 60 frames per second has been developed. The system applies a fast object tracking mechanism, low latency offloading techniques, and decouples the rendering pipeline from the offloading pipeline in order to maintain detection accuracy. The approach improves detection accuracy like 20.2%–34.8% for both object and human key point detection tasks, and just needs 2.24 milliseconds of delay on the AR device to track objects. Increased time and processing resources can be allocated towards rendering virtual elements, leading to improved AR/MR experiences.

Apicharttrisorn, K., et. al. (2019) introduced MARLIN, a unique software architecture designed to minimize energy consumption while preserving the accuracy of object tracking in augmented reality (AR). When MARLIN needs to identify new objects or recapture objects whose appearance changes, it employs a deep neural network (DNN). It uses low-power techniques to track identified objects with high fidelity in between DNN executions. When compared to a technique that rarely executes the same optimal baseline DNN, the framework performs favorably in terms of accuracy and energy savings, reducing energy consumption by up to 73.3% and enhancing accuracy by up to 19×. Compared to the continuous, best DNN technique, MARLIN even improves the IOU in over 46% of situations, indicating its potential to enhance the AR user experience. The study highlights how critical it is to improve accuracy and lower energy use in augmented reality systems.

Zubizarreta, J., et. al. (2019) identified that, Businesses are using augmented reality (AR) more and more to offer new services, but there are still obstacles to overcome in creating appropriate authoring tools and reliable object identification and tracking algorithms. So here author introduces the ARgitu framework, which creates and displays augmented and virtual content along with content creation tools. Furthermore, a new monocular strategy based on existing chamfer matching techniques is proposed for 3D non-Lambertian object detection, which gives accuracy with less processing cost. The difficulties of incorporating augmented reality into intricate industrial settings are the focus of this strategy.

Bahri, H., et. al. (2019) stated that, an implementation of Microsoft HoloLens, an augmented reality object identification system with deep learning support, is presented in this model. The goal of the system is to use communication between deep learning processing and the HoloLens input/output device to construct a more accurate model for item detection in the real world. Utilizing a deep learning model called YOLO, the system can recognize over 9000 objects in almost real-time. By using HoloLens, the system can quickly detect moving items by providing annotations on augmented objects together with their bounding boxes. Initial findings demonstrate a high item detection rate with similar detection times.

Su, Y., et. al. (2019) mentioned that,Machine learning techniques based on neural networks are extensively employed to solve detection or object categorization issues with notable achievements. Object state estimation, which deals with items that have several detachable or changeable sections, is a related problem with unique limits and difficulties. For applications such as robotic assembly and maintenance or Augmented Reality (AR), a system that can determine the present status of such things from camera images can be very important. CNN is presented in this and can recognize and regress an object's pose in many states, then demonstrate the application of this network's output in an automatically-generated AR scenario that takes a person along the path building an object made up of several parts.

Yang, W., et. al. (2019) stated that, recently the fields of augmented reality, virtual reality, and autonomous driving have seen a rise in the use of when using simultaneous location and mapping, or visual SLAM. However, most popular feature-based visual SLAM algorithms are luminance and translations sensitive. This work offers a stable, feature-based visual SLAM solution that operates in real-time with little drift and superior accuracy to further strengthen the system's resilience. To improve the contrast of images locally and obtain additional feature information, a pre-processing module is provided for images in conjunction using the CLAHE algorithm. Our approach outperforms ORB SLAM2 by a large margin, according to experimental evaluation.

Jinyu, L., et. al. (2019) stated that, although VSLAM/VISLAM has proven successful in augmented reality (AR) applications; the absence of a suitable benchmark makes it difficult to quantitatively evaluate localization outcomes. AR applications encounter a number of difficulties, including dynamic interference, motion blur, rapid motion, and powerful rotation. For a positive augmented reality experience, camera loss frequency should be reduced, and recovery from failure should be precise and quick. Current SLAM benchmarks and datasets only assess camera motions and pose accuracy, which are not relevant to most mobile augmented reality scenarios. A new visual-inertial dataset and AR evaluation standards are being created in order to address this. The authors examine current monocular VSLAM and VISLAM techniques and perform a quantitative assessment of eight exemplary monocular techniques and systems using a benchmark.

Li, X., et. al. (2020) suggested a novel use of mobile Augmented Reality (AR) frameworks for real-time object recognition from RGB photos. To enhance performance on mobile devices, the method integrates semantic information from object detectors with geometry information from VIO. The 3 parts of the method are an image orientation correction technique, a scale-based filtration mechanism, and a virtual semantics map. The augmented reality-enhanced functions are implemented using ARCore and the SSD Mobilenet design for Android smartphones. Images from twelve room-sized augmented reality sessions are manually identified with items to confirm the approach. The outcomes demonstrate that the method can raise generic object detector accuracy on the dataset by 12%. The goal of this novel strategy is to improve mobile device object detection performance.

Waithe, D., et. al. (2020) stated that, Fluorescence microscopy uses object detection networks for cell classification and localization. These networks are widely utilized for recognizing and locating things in photographic pictures. Using cheap hardware, an algorithm is created that can localize and image cells in 3D in real-time. Four top object detection methods are benchmarked over 2D microscopy datasets. Utilizing the quick processing speed of these networks, an efficient augmented reality solution for fluorescence microscopy devices is developed. With as few as 26 images, the method can achieve excellent classification accuracy, making it possible for non-expert users to automate cell class recognition and optimize workflows for the acquisition of fluorescence microscopy.

Alhakamy, A.A., et. al. (2020) stated that, applications using mixed reality (MR) and augmented reality (AR) must integrate virtual elements with real-time physical settings. In computer graphics, this field of study is crucial because it develops algorithms and techniques for measuring, estimating, and rendering augmented reality scenes. Novel AR/MR techniques have been developed since visual computing is continually developing and improving and also, machine learning, novel approaches to image processing and computer graphics. These techniques comprise gathering sources of light, registering and estimating lighting, and assembling globe illumination. The chain of phases and methods utilized in AR or MR enable interactive actual time lighting outputs, photo-realistic rendering, and graphic cohesion.

Bhattarai, M., et. al. (2020) stated that,Fighting fires is a dynamic activity where many operations take place at once. Retaining situational awareness is essential for safe navigation in fire settings and for making informed decisions. Dangers like smoke and intense heat can cause disorientation, which can result in harm or even death. This study aims to enhance firefighters' situational awareness and scene navigation through the use of technology such as augmented reality platforms, point clouds, deep learning, and thermal imaging. To obtain thermal, RGB color, and depth imagery, an embedded system prototype was created using the data from cameras in personal protective equipment

(PPE). The data was then instantly analyzed using deep learning algorithms. Through the use of an augmented reality platform, the system processes, analyzes, and wirelessly streams back processed photos to the firefighter for remote viewing and dependency.

Liu, D. S. M., et. al. (2020) introduced a technique called augmented reality combines the virtual and physical worlds. This research focuses on hands-on engagement with virtual items and consistent illumination to increase realism. Conventional techniques for evaluating lighting conditions frequently call for a thorough understanding of the scene. Using just one scene image, a novel technique determines the direction of light according to background objects and reflections. The azimuth of light is estimated using the relative direction of the object and its shadow, and the elevation angle is estimated using the area ratio of size of the item and its surrounding shadow. The technique was evaluated on real-world sceneries; still it is challenging to get the exact lighting direction of the real-life setting.Still, the hand gesture-based HCI is presented, which enables users to obscure the virtual object and identify gestures. This makes AR more realistic.

Kim, M., et. al. (2021) proposed a combination method of commercial augmented reality (AR) that makes use of depth prediction and facility categorization based on deep learning algorithms without the need for depth cameras or AR markers, thereby complementing existing methodologies. Applying segmenting of instances based on deep learning model, this technique extracts the outlines of physical objects. It then uses a depth prediction method for estimating the object's depth map to be a 3D point cloud that was discovered. This information is used to compute 3D spatial connections among physical objects and to address issues with visual mismatch and occlusion. Additionally, unlike standard AR, the method can manage dynamically working or moving facilities, such robots. An industrial worker can use the suggested method anytime they must deal with visual mismatches or occlusions. The benefits of the suggested strategy over current AR techniques are validated by both quantitative and qualitative assessments. Case studies verify the method's scalability, efficacy, and uniqueness by demonstrating that it can be used in various industries in addition to manufacturing.

Ma, S., et. al. (2021) stated that, Convolutional neural networks are used in neural compositing, a deep learning technique for displaying augmented reality that produces shadow and reflection effects. The process first uses a photograph to estimate the lighting and roughness of the object before rendering it as a virtual object with layers for color, shadow, and reflection. To create the output image, neural networks are used to enhance the reflection and shadow layers, which are then combined with the color layer and input image. In order to facilitate quick network training with synthetic scenarios, the method uses pre-computed radiance transfer (PRT) for layer rendering and assumes low-frequency illumination settings.

Mukhiddinov, M. et. al.(2021) suggested a smart glass system to let blind people (BVI) move around independently at night and in dimly lit areas. The system makes use of a converter encoder–decoder detector paradigm to offer users with audible instruction, text recognition, retrieval of the most important objects and a redesigned physical interface, uses aural feedback, sensory graphics, deep learning designs, and computer vision approaches to improve contrast on low light. The four models that form the system are a low-light picture enhancement model, an object detection and sound feedback model, an important object recognition model, and a text-to-speech and visual graphics creating model. The system has proven that AI and computer vision can help people with BVI in their daily lives by achieving contrasting results on the challenging ExDark and Low-Light databases.

Fradet, M., et. al. (2021) introduced a light source estimating tool called Light4AR can identify actual cast shadows in photos taken with mobile devices. It uses the shadows a reference object casts on its supporting plane to calculate the three-dimensional location and intensity of various light sources. All virtual objects can have lighting and shadows that match the lighting of their actual environments by constructing virtual point lights based on these parameters, which improves object presence and user experience. The majority of mobile devices can now access photorealistic augmented reality experiences because to the server-based GPU implementation, which delivers results in interaction time. The method just needs placing a reference object and choosing a region that includes shadows, needing little manual input. In difficult settings with different lighting arrangements and backdrop textures, it exhibits promise.

Somanath, G., et. al. (2021) explained an ongoing technique for estimating an HDR environment map from an LDR camera image with a narrow field of view. This makes it possible to create visually appealing shading and reflections on virtual objects with any material finish, from dim to mirror, that are then transformed into a real-world environment via augmented reality. Our strategy employs two novel losses, ProjectionLoss for the generated image and ClusterLoss for adversarial training, based on our efficient convolution neural network EnvMapNet, which is trained end-to-end. By means of both perceptual and quantitative comparison with cutting-edge techniques, it is shown that algorithm gets 3.7 times lower (FID) and more than 50% reduction in the predicted light sources' direction inaccuracy. A smartphone application is also presented on an iPhone XS, can execute the model in less than 9 milliseconds and display visually cohesive virtual objects in real-time within hitherto unexplored real-world surroundings.

Perdpunya, T. et. al. (2021) has mentioned that,machine efficiency is being revolutionized by Industry 4.0, which makes inspection and maintenance essential to industrial output. For assessment and analytical purposes, data logging is absent from many plants. The objective of this study is to create a machine inspection model by utilizing object detection, augmented reality, and mask R-CNN algorithm, and marker approaches. The inspector tests the model on a mobile device after it has been trained on actual machinery. The model uses computer vision techniques to enable real-time, precise tracking and detection. After training, the model is transferred and unmodified to the mobile device for testing. The correctness of the model is checked using machine images that are chosen at random. The outcomes demonstrate that the model's efficiency is suitable for practical application.

Gang, Z. H. A. O., et. al. (2021) introduced the ineffectiveness of conventional cable bracket inspection techniques in the aviation sector is the subject of this paper. Based on 3D digital mock-ups, a simulation framework is designed to provide synthetic, realistic bracket images with pixel-level annotations. To extract precise shapes from 2D photos, a bracket recognizer built on top of Mask R-CNN is trained. A proposed system for semi-automated cable bracket inspection makes it simple for inspectors to use portable equipment, such as AR glasses, to acquire inspection findings. The experimental findings demonstrate the validity and efficacy of the method for evaluating aircraft cable brackets. For validation, a client-server-based prototype system is created.

Mao, W. (2022) explored machine learning and virtual reality computing for teaching oil painting art videos. Due to the limitations of the existing picture acquisition technique, a deep learning-based object extraction fusion method has been adopted to support multi-dimensional description and retrieval. The technique eliminates things with low saliency and clarity, low-quality images, and objects with low ratings. Next, amplify the most prominent areas, match the outlines of the segmented picture elements to the contours of the user-drawn image to produce an optimal matching value, and finally improve the image's overall quality and naturalness by gaining a better understanding of the image via style migration. Comparing to the traditional method, the Tensorflow-based experiment platform provides a significant improvement in execution speed, students can participate fully in art appreciation lessons, embrace diversity, gain experiential learning, and enhance visual quality.

Estrada, J., et. al. (2022) stated that the Deep learning (DL) and Augmented reality (AR) algorithms are transforming the way it works and communicate with each other. In order to enhance students' learning experiences with lab equipment used in electrical engineering, this study suggests a new structure. An AR application incorporates the DL-powered automatic object detection component, which can identify devices like as power supply, oscilloscopes, wave generators, and multimeters. TensorFlow's object detection API is used for equipment detection, and a deep neural network model called MobileNet-SSD v2 is employed. The average recall of the model is 85.3%, and its mean average precision (mAP) is 81.4%. A multimeter tutorial that incorporates photos and web connections for enhanced learning presents the framework through the use of virtual models placed on actual multimeters. Immersive settings are created by integrating DL and AR frameworks with the Unity3D game engine. AR and machine learning-based industrial and educational training can be built upon this platform.

Marques, B. A. D., et. al. (2022) presented a CNN-based method that uses no prior experience to calculate complex lighting in multiple reality scenarios to effectively portray area illumination, the model makes use of a collection of spherical harmonics (SH) environment lighting. Using an RGB image as input, the new CNN architecture detects ambient illumination in real time.Compared to previous CNN-based lighting estimating methods, this model uses a finely tuned deep neural network design with fewer parameters. The CNN model of architecture can predict environmental lighting with a standard (MSE) of $7.85 * 10{-}4$ when comparing SH lighting coefficients. The model shows qualitative outcomes when evaluating relights of actual scenarios and is validated in multiple mixed reality settings. This method tackles the difficulty of illumination estimation in real-world circumstances for XR and computer graphics applications.

Luque, R., et. al. (2022) stated that electric motors are being used more often and transportation systems are becoming more digital, the process of assembling wire harnesses is getting more complicated. The benefits of standard Augmented Reality technology in lowering cognitive overload when utilizing personnel are examined in this paper. The most advanced deep learning-generated method of segmentation available for comprehending tasks involving harnessing is also covered. A summary of publicly accessible datasets and methods for semantic segmentation training is also included in the publication. The article suggests combining semantic segmentation systems with augmented reality technologies to lessen cognitive overload and errors when utilizing staff.

Ghasemi, Y., et. al. (2022) stated that, augmented reality (AR) and artificial intelligence (AI) have recently made significant strides that will revolutionize every sector of the economy and spark innovation. Analysis and comprehension of the surrounding environments have been made easier by the rapid advancements in augmented reality and computer vision (CV). In this study, works conducted over the last ten years that combined deep learning and augmented/mixed reality for object detection are carefully reviewed and presented. Data were gathered from five sources: IEEE Xplore, ScienceDirect, Web of Science, Scopus, and ACM. Ultimately, two analyses of a total of sixty-nine publications were conducted: (1) An analysis of deep learning-powered AR object detection apps; (2) a look at how object detection computations are performed locally or on servers in order to understand the connection between object detection methods and AR technologies. The advantages of using object detection based on deep learning to solve AR problems, as well as the obstacles inhibiting this technology's wider application are also thoroughly examined. The results support the exciting prospects of combining AR and CV.

Dalara, A., et. al. (2022) conveyed that, since sculpture design varies so much, sculpture detection in images is a difficult undertaking. Based on the properties of the sculptures, this research integrates multiple algorithms for sculpture recognition. Key points were identified using the SIFT technique; It was mixed with other classifiers, such as artificial neural networks, support vector machines, and K-Nearest Neighbors. Efficiency tests were also conducted on CNN (Convolutional Neural Network). The models demonstrated cultural diversity by being trained on a range of depictions of Indian sculptures from different sources. A manually collected data collection of fifteen distinct sculpture classes 150 for training and 20 for testing was used for the experiments. By using CLAHE (Contrast Limited Adaptive Histogram Equalization), the models' efficiency was raised. The highest accuracy of 70.66% was attained using the CNN and CLAHE models over 15 distinct sculpture classes. Non-CNN-based methods, however, exhibited accuracy values that were below par.

Boutsi, A. M., et. al. (2022) Mobile Augmented Reality (MAR); nonetheless, concurrent operation may result in misclassifications and localization mistakes. In outdoor MAR settings, a hybrid approach for 3D tracking of arbitrary geometry is presented in this research. To enhance tracking performance in vast and uncontrolled outdoor situations, the CNN-object detector's geometrical and semantical output is integrated using the vSLAM technique and the camera location data obtained by the ARCoreSDK . This entails training the Mask-R CNN model, computing 2Dimensional-3Dimensional correspondences for improving the postureCalculating the 3D Layer, and using real-time identification, division, and positioning of the ROI (region of interest) in frame footage. Thirty photos including Meteora, Greece's Modi rock, St. Modestos, are included in the dataset. Higher precise accuracy, steady visibility at a half-kilometer distance, and a 42% reduction in tracking time during far-field AR sessions are all demonstrated by comparative evaluations.

Theodorou, C., et. al. (2022) stated that, the goal of vSLAM techniques aims to reconstruct features within unidentified surroundings and predict the user's location using the gadget's camera. vSLAM provides a crucial component of the AR experience. It enriches the world of reality with virtual things that utilize maps and location of the surroundings. The article investigates the use of a few of the most popular current visual algorithmic techniques for SLAM presented in research organizations in AR mapping, and navigating, and the practice of localization using technical as well as historic viewpoints.

Table 2.1 Comparative analysis of existing AR-based learning approaches and the proposed framework

Authors	Application Focus	Method Used	Key Limitations	Difference from Proposed Method
Kascak et al.	AR in technical	Marker-based	No deep	Proposed

(2019)	documentation training	AR for spatial understanding	learning, no tracking robustness	system uses closed-loop tracking with deep learning for stable 6-DoF object alignment and dynamic environments
Malik et al. (2019)	AR for additive manufacturing monitoring	3D reconstruction + AR visualization	Not learner-centric, no remote pedagogy	Proposed work focuses on education with micro-lessons and remote learning
Yang et al. (2019)	Visual SLAM robustness	Feature-based SLAM with CLAHE	No AR learning integration	Proposed system integrates SLAM directly into AR education framework
Arulanand et al. (2020)	AR in engineering education	AR visualization of concepts	No adaptive tracking or lighting handling	Proposed system adds closed-loop tracking + lighting adaptation
Murdoch et al. (2020)	Brightness perception in OST-AR	Optical analysis of luminance	Perceptual study only	Proposed work implements real-time lighting estimation
Liu et al. (2020)	Object detection offloading	CNN + edge offloading	No SLAM, no education use-case	Proposed system integrates DL + SLAM + pedagogy
Criollo-C et al. (2021)	Mobile AR for engineering learning	Smartphone AR app	No scalability, single-user	Proposed method supports multi-user AR via client–server SLAM
Kim et al.	Occlusion-aware	DL-based	Computationally	Proposed

(2021)	AR	segmentation + depth prediction	heavy	method uses partitioned computation for efficiency
Eldokhny & Drwish (2021)	AR during COVID remote learning	AR-based practical simulation	No tracking stability analysis	Proposed work explicitly addresses tracking drift & stability
Sugarindra et al. (2022)	Remote practicum learning	Fast AR prototyping	No DL, no SLAM	Proposed system integrates DL + SLAM for precision
Xu et al. (2022)	Depth perception in mobile AR	Visual parameter analysis	Perceptual only	Proposed work actively compensates lighting & perception errors
Xie et al. (2022)	Closed-loop AR for mining	Closed-loop AR (industrial)	Not education-oriented	Proposed work extends closed-loop tracking to education
De Giorgio et al. (2023)	XR-based manufacturing training	XR simulations	User fatigue, VR discomfort	Proposed system prefers mobile AR (lightweight & accessible)
Grodotzki et al. (2023)	AR platform for engineering education	General-purpose AR platform	No deep tracking optimization	Proposed work includes DL-driven tracking & SLAM
Wolf et al. (2023)	Smart factory education	Multi-tech smart factory	High infrastructure cost	Proposed method offers cost-effective mobile AR solution

2.6 RESEARCH GAPS IDENTIFIED

There is a Limited Realism in AR Learning Environments. The current AR applications lack consistent environmental lighting adaptation and depth realism, which affects user immersion and effectiveness due to delay in response time.

Real-time performance continues to present significant challenges in augmented reality systems. Issues such as latency, object occlusion, and lighting estimation accuracy hinder real-time interaction and feedback in AR systems.

The integration of deep learning techniques for object detection within AR systems remains limited. While many AR systems exist, integration with robust deep learning models for dynamic and context-aware object recognition remains insufficient.

A unified framework to support practical education through augmented reality is currently lacking. There's a gap in implementing scalable AR frameworks that support remote, blended, and hands-on learning, especially post-COVID-19.

Evaluation of AR systems in complex, real-world environments remain limited. Current studies focus more on controlled environments; AR systems lack robust validation in dynamic, real-world educational settings.

2.7 SUMMARY

In summary, augmented reality holds a very significant promise for revolutionizing education by making learning more engaging, effective, fun, and interactive. As technological advancements continue to evolve, AR stands poised to further enrich education, industry, and other sectors in innovative ways using artificial intelligence. These benefits collectively contribute to making AR more practical, engaging, and effective across the globe.