Qianqian Hu[1*],

Heguang Wang[2],

Xiaotang Cui[3],

Bing Wang[4]

Product Design Interaction and Experience Based on Virtual Reality Technology

Journal of Electrical Systems

Abstract: - Artificial intelligence involves imitating human thought, consciousness, and other aspects. This is similar to having a device with human brain that can think also produce independently. However, like a human brain, it has a speed also memory advantage. The virtual reality interactive glove is built using a nine-axis kinetic sensor and an artificial intelligence deep learning (AIDL) procedure. In this research work, A Product Design Interaction and Experience on Virtual Reality Technology using Semi-Cycled Generative Adversarial Network (PDIE-VRT-SCGAN) is suggested. Initially, input gestures data are collected from Virtual Reality Experiences (VRE) dataset. The input gestures data is then pre-processed using Multi-Window Savitzky-Golay Filter (MWSGF) to decrease noises and escalation the overall excellence of the gestures data. In order to improving overall user engagement in product design interactions on virtual reality (VR) technology, the pre-processed gestures data are then fed into an adversarial network called a Semi-Cycled Generative Adversarial Network (SCGAN). In general, SCGAN does not express some adaption of optimization strategies for determining optimal parameters to promise exact to improving overall user engagement in product design interactions using VR technology. Therefore, FOX-inspired Optimization (FIO) is proposed to enhance weight parameter of SCGAN method, which precisely improving the user experience in product design interaction. The competence of the suggested PDIE-VRT-SCGAN method is evaluated using a number of performance criteria, including tracking accuracy, frame rate, latency, rendering time, error rate, and user error. The proposed PDIE-VRT-SCGAN method attains 22.36%, 25.42% and 18.17% higher tracking accuracy, 21.26%, 15.42% and 19.27% higher latency, 28.36%, 25.32% and 28.27% higher frame rate compared with existing methods, such as the Design also application of virtual reality interactive product software depend on artificial intelligence deep learning procedure (DVRI-PS-AI-DL), The virtual evaluation system used for product designing by virtual reality (VES-PD-VR), and Analysis of unsatisfying user experiences also unmet psychological requirements for virtual reality exergames by deep learning approach (AUUE-UP-VRE-DLA) respectively.

Keywords: *FOX-inspired Optimization, Interaction, Multi-Window Savitzky-Golay Filter Product Design, Semi-Cycled Generative Adversarial Network, Virtual Reality Technology.*

I. INTRODUCTION

Artificial intelligence involves imitating human thought, consciousness, and other aspects. This is similar to having a device with human brain that can think then produce independently. However, like the human brain, it has a speed also memory advantage. AI, like human body, is complex subject that encompasses mathematics, computer science, programming, information theory, cybernetics, biology, mechanical automation, psychology, and then philosophy. This diversity has led to a large number of researchers in the field [1, 2]. China's AI technology is still its early stages, with much advancement to come. Artificial intelligence has significantly impacted in daily lives, work, and studies. Examples include robots and artificial arms in factories. Artificial intelligence is a new science that studies then grows theories, methodologies, technologies, also utilization systems to mimic then enhance human brains [3, 4]. AI research encompasses multiple disciplines, including philosophy, cognitive science, mathematics, computer science, biology, psychology, and information theory [5-6]. As a result, both domestic and foreign research investigations continue. Wilson et al. proposed a plan system for a virtual reality (VR) co-operative classroom using DL algorithms. That debated the elements of VR-based DL method, the basic method construction technique, also DL path plan, given that a model situation for organizations and personnel involved in DL [7, 8]. First presented the DBN DL method then reviewed its computing properties. The assembly language converts arrangement purposes into assembler and evaluates program performance depend on instruction sets [9, 10]. The BDMISS system is evaluated in the context of the Hadoop ecosystem for sharing large data medical information resources. As the virtual reality business grows, key smart device manufacturers have introduced several interaction options. Virtual reality interactive gamepads currently offer an excellent user experience, but their shortcomings, such as awkward touch and insufficient simulated motions, hinder their ability to achieve high immersion [11, 12]. Virtual Reality (VR) technology

[1*]Teaching Assistant, College of Art and Design, Zhengzhou University of Light Industry, Zhengzhou, Henan, China, 450000

[1*]Email: phdqianqianhu@gmail.com

[2]Lecturer, College of Cultural Heritage and Art Design, Zhengzhou University of Technology, Zhengzhou, Henan, China, 450000

[3]Lecturer, College of Art and Design, Zhengzhou University of Light Industry, Zhengzhou, Henan, China, 450000

[4]Lecturer, Rehabilitation Engineering College, Beijing Vocational College of Social Management (Training Center of the Ministry of Civil Affairs), Beijing, China, 102600

combines graphics processing, interaction between humans and machines, media, transmission via networks, sensing, and simulation. In some ways, this technology is an extension of the human body. Virtual reality technology enables users to communicate with the virtual environment [13, 14]. To facilitate interaction, either visualizes the online setting as an online setting or as a real-world environment. Current technology creates realistic virtual environments that are difficult to distinguish through the senses, leading to confusion with reality [15, 16]. VR technology is used to pretend product design and use environments, permitting evaluators to relate with the product in a accurate virtual atmosphere. Perceptual engineering theory is used to measure evaluators' perceptions and evaluate product design [17, 18]. VR is a computer system capable of making and feeling virtual worlds. It pretends human visual then auditory responses in natural setting. This article summarizes the panoramic roaming show platform, analyzes its design ideas then principles in product display design, and clarifies the benefits and factors influencing display design effect. The platform's promotion and application provide information and help. Adrian created a software platform for promoting and displaying tea products, utilizing panoramic camera technology and the panoramic roaming display platform's hardware [19, 20].

As the technology landscape changes rapidly, there is an increasing desire for novel approaches to product design, interaction, and user experience. Traditional approaches frequently fail to provide immersive, intuitive, and engaging experiences for users, resulting in restrictions in design exploration, feedback collecting, and decision-making. VR technology offers a viable answer to these difficulties by providing a simulated world in which customers can engage with things in a very realistic and engaging way. However, despite the potential benefits of VR technology in product design, there remain some significant concerns and challenges including User Interface Design, Immersion, Collaborative Design, Accessibility, Adoption, Data Security and Integration with Existing Workflows. These drawbacks in the existing approaches motivated to do this work.

The aim of this project was to enhance the product design and user experiences on virtual reality, this model based on the Virtual Reality Experiences with input gestures data and Semi-Cycled Generative Adversarial Network enhanced the FOX-inspired enhancement Procedure.

The main contribution of this research work is potted as follows,

- In this research work, PDIE-VRT-SCGAN is proposed.
- Applied an input gestures data are pre-processed using Multi-Window Savitzky-Golay Filter (MWSGF).
- Accelerating the gestures data and improving overall user engagement in product design interactions on virtual reality using the benefits of utilizing a SCGAN.
- The obtained results of proposed PDIE-VRT-SCGAN algorithm is comparing to the existing models such as DVRI-PS-AI-DL [21], VES-PD-VR [22], and AUUE-UP-VRE-DLA [23] methods respectively.

The remaining manuscript is structured as follows: Part 2 outlines the Literature Survey, Part 3 displays the future method, Part 4 presents the outcomes with discussions, and Part 5 concludes the script.

II. LITERATURE SURVEY

The literature presents a amount of research projects on deep learning- virtual reality based Product Design Interaction and Experience; this section evaluated some of the most recent studies.

Wang and Sun, [21] has presented Plan and application of VR communicating product software depend on AIDL procedure. This paper aimed to enhance the interaction capabilities of AI in VR environments. Here built a VR glove using a nine-axis inertial sensor and an AIDL system, based on extensive research into the collaborating needs of VR. AI deep learning techniques used contain KNN, SVM, Fuzzy, PNN, and then DTW models. Dynamic gesture gratitude requires real-time data forecasting to determine the minimum distance among two points, avoid graphs, and advance productivity. This involves building an absorbed graph structure, quickly retrieving the global optimal solution, then defining the gesture's starting point. It provides higher tracking accuracy and higher frame rate.

Wang and Liu, [22] has presented A virtual estimation system for creation planning using VR. This research paper offered an estimation method for virtual creation design that uses a VR-aided technique to address the difficulties. The suggested strategy is intended to provide a quick also low-cost mechanism for examining and analyzing product thoughts. It employs a creation presentation method for specialists to analyze plans and enables specialists to examine product programs by evaluation directories. The analytic technique is created on evaluations of user involvements, which are classified in three types: behavior layer experience, sensor layer experience, and reflection layer experience. The evaluation index construction is created by a ordered inference method. It provides lower frame rate and lower tracking accuracy.

Zhang, et.al, [23] have presented Analysis of indecisive user experiences and unmet emotional needs for VR exergames using DL approach. In this paper, applied a deep learning method to uncover disappointing experiences buried in online evaluations of VR exergames, as well as to identify user unfulfilled psychological requirements using self-determination theory. This study use convolutional neural networks for language categorization (textCNN) to categorize online reviews with unsatisfactory experiences. The term frequency-inverse document frequency (TF-IDF) algorithm is used to remove keywords as of each set of classified appraisals. The top ten terms in each set of reviews represent significant areas of unmet psychological needs. It provides lower latency and higher rendering time.

Ipsita, et.al, [24] have presented The Plan of Virtual Prototype System for writing Interactive VR Surroundings from Real-World Scans. This paper presents VRFromX, a scheme workflow architecture that makes the virtual content formation process accessible to DUs nevertheless of programming services or knowledge. VRFromX is in-place content creation procedure in VR that allows workers to select areas of interest in skimmed point clouds or plan in mid-air with a brush tool to obtain virtual methods and then assign behavioural possessions to those objects. Using a joining use case, then evaluated VRFromX's usability with twenty DUs, Twelve of whom were new to VR programming. It provides lower rendering time and lower tracking accuracy.

Chu, et.al, [25] have presented Virtual Footwear Try-On in Augmented Truth Using DL methods. In this paper to predict the six degrees of liberty position of a human foot from a color photograph using DL methods. Then provide a training data collection made up of artificial and real foot photos that are routinely labeled. Three models based on convolutional neural networks (CNN) (deep object pose estimation (DOPE), DOPE2, then Just Only Look Once (YOLO)-6D) are skilled on the data collection to forecast the foot pose in real time. Customization is a growing trend in the fashion product business that reflects individual lives. Previous research investigated the concept of virtual footwear try-on in augmented reality (AR) utilizing a depth camera. It provides lower error rate and higher rendering time.

Mu, et.al, [26] have presented User attention then behaviour in VR art meeting. In this paper, with the widespread availability of consumer virtual reality (VR) headsets and creative tools, satisfied makers are testing with new procedures of interactive spectators engagement through absorbing media. Considerate user consideration and conduct in a simulated world can substantially aid original processes in VR. It created an intangible VR painting and a testing system to analyze spectators art interactions using eye gaze then movement tracking. DL methods are used to investigate the relationships among social data and the spectators background. The project brought new integrated approaches for visualizing user care for content authors. It provides lower user error and higher error rate.

Choi, et.al, [27] have presented Applications of virtual reality in industrial industries: historical studies, current conclusions, and prospective paths. In this paper, VR is employed in product growth procedures in manufacturing organizations as useful tool for achieving rapid merging of knowledge and administrative through conception and knowledge. The research and analysis focused on virtual reality's use in manufacturing. For this, a study map was built created on a VR technology classification and new product development process, and the articles researched were placed on map before bibliometric studies were performed. Trends in previous and current research were studied. It provides higher tracking accuracy and higher rendering time.

III. PROPOSED METHODOLOGY

In this sector, A Product Design Interaction and Experience on Virtual Reality Technology using Semi-Cycled Generative Adversarial Network (PDIE-VRT-SCGAN) deliberated. Block diagram of suggested PDIE-VRT-SCGAN technique is in Figure 1. It covers such stages as Multi-Window Savitzky-Golay Filter, Semi-Cycled Generative Adversarial Network and FOX-inspired Optimization. Thus, detailed explanation about every steps given below,

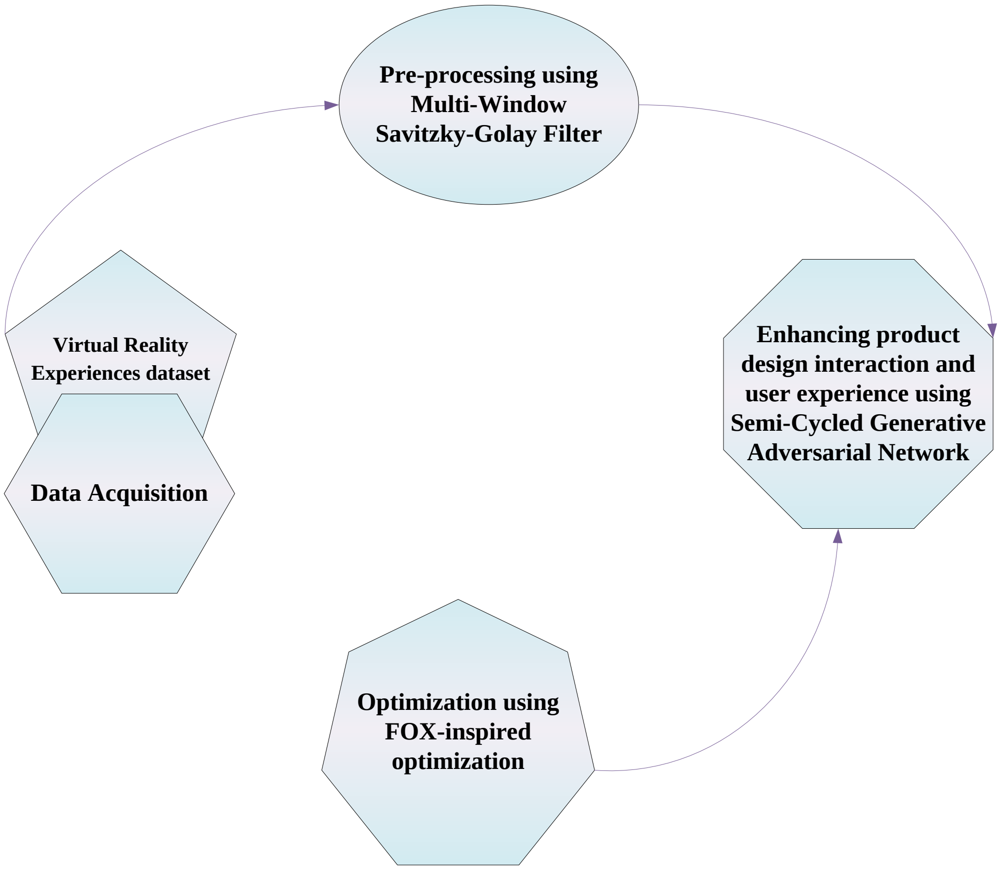

Figure 1: Block Diagram of Proposed PDIE-VRT-SCGAN Method

A. Product Design Interaction and Experience with Virtual Reality Technology

Virtual Reality (VR) dramatically changes how people engage with and perceive products. It enables designers to construct immersive 3D worlds in which customers can both see and interact with a product in a realistic manner. This can effect in considerable improvements in both product layout and experience for users.

1) Benefits of Virtual Reality for Product Design Interaction and Experience

Enhanced Visualization:

VR allows designers to see every detail up close and from every angle. This can assist detect potential concerns early in the design phase, allowing for better informed judgments.

Improved User Experience:

Virtual Reality enables people to cooperate with items in more usual and spontaneous manner. This can result in a more favourable user experience and higher product satisfaction levels.

Iterative Design Process:

Virtual reality can help you iterate quickly on product designs. This enables designers to test new concepts and solicit feedback from consumers early and frequently.

B. Virtual Reality Interaction Methods

Hand tracking:

VR headsets that include hand tracking allow users to cooperate with simulated items using their hands. This allows you to pick up things, rotate them, and press buttons.

Motion controllers:

Motion controllers are handheld gadgets that allow users to cooperate with items in the simulated world. They often have buttons and triggers that can be utilized to execute various functions.

Voice commands:

Virtual reality experiences can also be controlled with voice commands. This may be a useful option for people who have trouble using hand tracking or motion controllers.

C. Designing VR Interactions

Naturality:

Interactions should feel natural and intuitive to users. They should be able to engage with virtual objects in the same manner they do with real-world objects.

Ease of use:

Interactions should be simple to understand and use. Users should not have to spend a long time figuring out how to engage with the VR experience.

Comfort:

Users should find VR experiences comfortable to utilize. Users should not feel tired or dizzy after experiencing the experience for an extended amount of time.

D. Data Acquisition

The input gestures data are collected through Virtual Reality Experiences (VRE) dataset [28]. The dataset includes user experiences in virtual reality (VR) situations. It contains information about physiological responses, such as heart rate and skin conductance, thoughts and feelings, and preferences of users. The dataset aims to improve VR technology by evaluating user experiences. This study seeks to improve VR design, user comfort, and customisation by examining how users respond physiologically and emotionally to various VR situations. The dataset helps developers optimize VR systems and provide bespoke experiences that improve immersion and user pleasure.

E. Pre-Processing using Multi-Window Savitzky-Golay Filter

In this section, pre-processing using Multi-Window Savitzky-Golay Filter (MWSGF) [29] is discussed. The input gestures data then pre-processed using MWSGF to remove noise and improving the quality of gestures data. The Savitzky-Golay filter effectively removes noise from sensor data, which is critical for improving the accuracy of interactions in virtual reality environments. Using a multi-window technique, the filter can adapt to variable amounts of noise across multiple frequency bands, resulting in higher signal-to-noise ratios. The main objective is to improve the accuracy of how users interact with virtual objects by removing noise and artifacts from sensor data, resulting in accurate and reliable input for applications that use virtual reality. Additionally, dispersed information response fusion method resulting multi-sensor systems, and a multi-window savitzky-golay filter (MWSGF) with unknown noise statistics is proposed. MWSG filter productivity is equal to weighted average of input gestures data points in window. In this method the gestures data point has the high quality of the filter to gestures data resizing which has given in the equation (1)

$$y(a) = \sum_{l=-M}^{M} \omega_{a-l} \, z[l] \tag{1}$$

Attain weight coefficients vector $a=[a_1, a_2, ..., a_n]$ of polynomial, to execute differentiation on ω_{a-l} regarding a let derivatives equivalent to zero. Finally the MWSGF is removed the noises among the gestures data and this process will take to the next step for Enhancing product design interaction and user experience.

F. Enhancement using Semi-Cycled Generative Adversarial Network

In this section, enhancing product design interaction and user experience using Semi-Cycled Generative Adversarial Network (SCGAN) [30] is discussed. SCGAN is proposed to improving overall user engagement in product design interactions on virtual reality (VR) technology. Semi-Cycled GANs can produce high-quality, realistic images of virtual objects, surroundings, and textures, hence increasing the overall realism of virtual reality experiences. This results in more immersive interactions and a stronger sense of presence for users. The major goal is to create high-quality virtual material, such as objects, textures, and surroundings that closely mimic their real-world counterparts, thus improving the visual accuracy and authenticity of virtual reality experiences and its consistency that represents the degradation process from the user's experiences. The concatenated product designs interaction and users experiences producing a synthetic product designs interaction and the user experiences, the preference behaviour and interaction, then to learnable parameters is taught using adversarial and data loss functions enhancement of the overall user engagement in product design interactions on VR technology, then weights of dual loss functions are the adversarial loss and data loss for the product design interaction. Then the resolution of gestures data feature map the distribution of product design interactions on VR technology $\min$ denotes the minimum product design interactions on VR technology phase and the users experiences phase for the enhanced and improved experience for users. The product design interaction consistency for the parameter it is given in equation (2)

$$I_s S = R_{LS}(I_S L, \Theta_{LS}) \tag{2}$$

Where Θ_{LS} product design interaction consistency for the parameter and R_{LS} represents the product design interactions begins with a spectral normalization. After SCGAN is well trained, it is utilized to conduct semi-cycled source-to-target to product design interactions and experience on VR technology, the product design interactions and experience on VR technology with gestures data and their original source labels form into the Virtual Reality Experiences dataset. Finally the SCGAN was improved overall user engagement in product design interactions on virtual reality (VR) technology. In this work, Fox-inspired Optimization for product design interactions and experience, this method optimizes the SCGAN optimum parameter R_{LH} *and* S_{DL}. Here, RFO is applied for change the weight and bias measure of SCGAN.

G. Optimization using FOX-Inspired Optimization

In this section, optimization using Fox-inspired Optimization (FIO) [31] is discussed. Here the proposed SCGANs weight parameters R_{LH} *and* S_{DL} are optimized using FIO. Fox-inspired optimization algorithms, based on fox hunting behavior, may rapidly explore enormous design spaces with virtual reality technology, allowing designers to swiftly uncover optimal design configurations and solutions to numerous product design difficulties. Finding the best design configurations and settings to optimize user interaction and experience in virtual reality environments through the application of fox-inspired optimization algorithms is the salient, which will result in more user-friendly and captivating product designs. The initiation of FIO involves the initialization step.

1) Stepwise procedure of FIO

Here, step by step technique is well-defined to get perfect value of SCGAN depend on FIO. Firstly, FIO makes the equally allocating populace to enhance parameters R_{LH} *and* S_{DL} of SCGAN. Ideal solution promoted using FIO algorithm.

Step 1: Initialization

FIO is a new Fox-inspired optimization process proposed in this research, replicates the foraging and hunting behaviour of foxes in the wild. In order to perform an effective jump, process is depend on methods for calculating distance among fox, its prey. FOX first initializes population, often known as X matrix.

Step 2: Random generation

Input parameters produced at casual after starting point. Best fitness value assortment is depending upon their explicit hyper parameter state.

Step 3: Fitness Function

The outcome is determined by initialized judgments and random responses. The fitness is then computed using the equation (3)

$$FitnessFunction = Optimizing\ [R_{LH}\ and\ S_{DL}] \tag{3}$$

Step 4: Exploration Phase

During this phase, the fox looks in random locations based on the best spot it has identified thus far. Since it must move irregularly to investigate prey at search area, fox lacks jumping skill through this period. Here, the dimension of problematic to discovery minimum average time is denotes minimum time variable. a, is used to control this search, the fox's exploration strategy for locating novel location at search space variable has denoted by dynamic outcome during search phase to get a solution that is nearly superior. Figure 2 shows Flowchart for Fox-inspired Optimizing SCGAN.

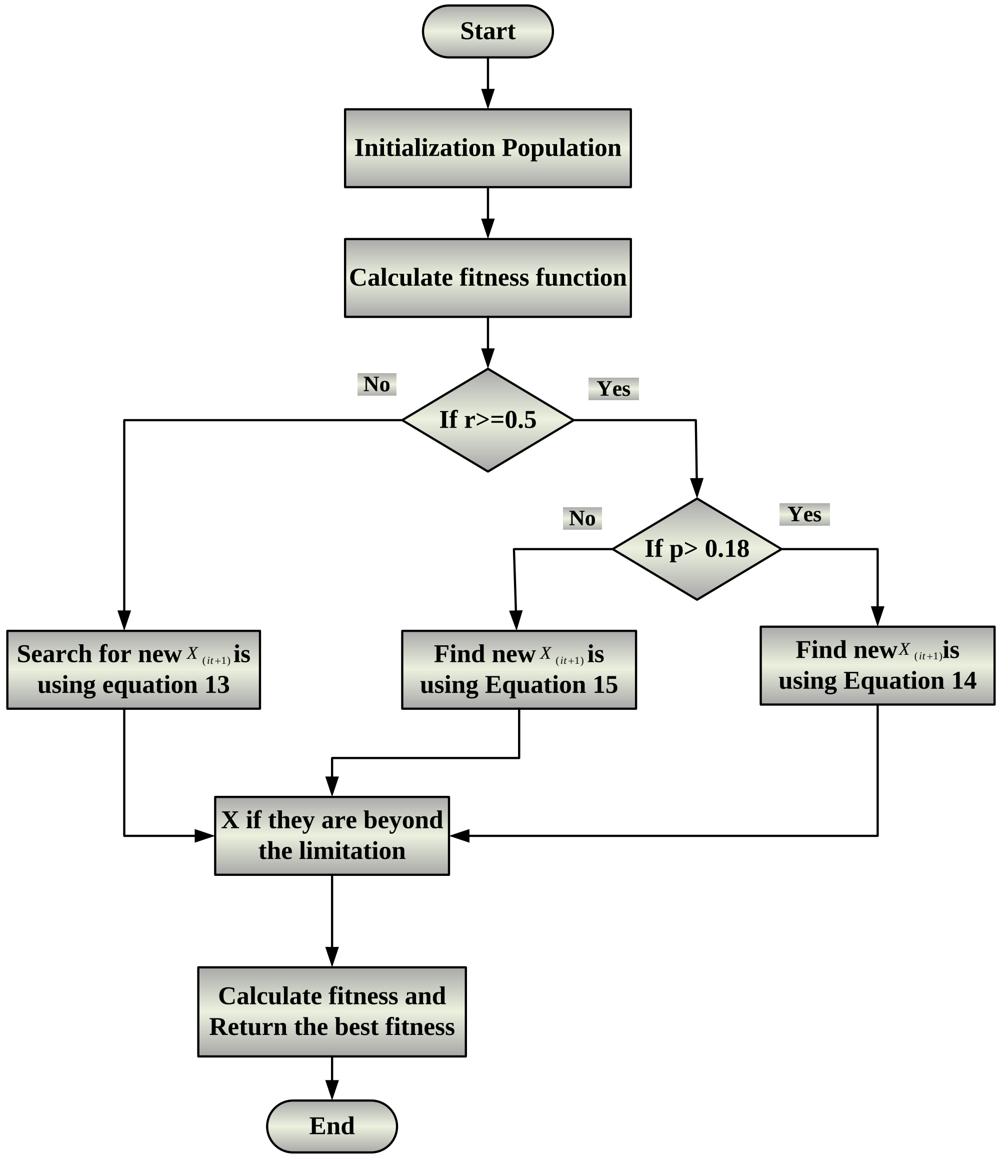

Figure 2: Flowchart for Fox-inspired Optimizing SCGAN

Step 5: Exploitation phase for optimizing R_{LH} *and* S_{DL}

It is random variable p value in interval [0, 1]. If it $Jump$ value taken two distinct times to travel up, down, average time, gravity are multiplied 0.5. Gravity, average time must therefore both multiply by 0.5, then Fox_Prey_{it} and c_1 are multiplied by the $Jump$ value. Thus it is given in equation (4)

$$X_{(it+1)} = Dist\_Fox\_Prey_{it} * Jump_{it} * c_1 \tag{4}$$

Here, the variable c_1 value is denoted by [0, 0.18] and Fox_Prey_{it} is denoted by $Jump$ value. Hence, both $Dist\_Fox\_Prey_{it}$ and $Jump_{it}$ are multiplied by c_2 . $X_{(it+)}$, represent that the distance and products values.

Step 6: Termination Condition

The weight measure values R_{LH} *and* S_{DL} of generator from Semi-Cycled Generative Adversarial Network is enhanced with help of FIO, will progressively repeat the step 3 till fulfil the tentative criteria $X_{1n} = X_{1n} + 1$ is met. Then SCGAN has improving overall user engagement in product design interactions on virtual reality technology with higher tracking accuracy.

IV. RESULT AND DISCUSSION

The trial outcomes of suggested technique are conferred this sector. Proposed PDIE-VRT-SCGAN method is implemented in C++ software development kit (SDK) platform on computer with 16 GB RAM, Intel ®core

(7M) i5-6100CPU @ 4.80 GHz processor under several performance metrics the number of repetitions is equal to number of batches wanted to finish one epoch. The gestures data found using VRE dataset, Complex virtual reality experiences with elaborate settings, complex interactions, and genuine simulations may necessitate more training time. The availability of high-performance computer resources, including powerful GPUs or distributed computing systems, can drastically shorten training times. Training timeframes might vary from a few hours to many months or even days for larger and more sophisticated datasets. The quantity of sample gestures data collected with related VRE values is a significant aspect. Furthermore, the system's effectiveness is confirmed by contrasting the performance indicators of the proposed PDIE-VRT-SCGAN approach with those of the existing method like DVRI-PS-AI-DL, VES-PD-VR, and AUUE-UP-VRE-DLA respectively.

A. Performance measures

This is a crucial step for determining the exploration of optimization algorithm.

Performance measures to evaluate to access performance such as tracking accuracy, frame rate, latency, rendering time, error rate, and user error.

1) Tracking Accuracy

The term tracking accuracy describes how precisely a virtual reality system can monitor an individual's head, hands, or any other tracked object inside the virtual environment.

2) Frame Rate

The number of frames or gestures presented in a virtual reality application each second is known as the frame rate, and it is commonly expressed in frames per second (fps). Smoother and more immersive experiences are usually the consequence of a greater frame rate.

3) Latency

Latency refers to how long it takes a model to make a prediction, whereas throughput measures how many predictions a model can make in a given amount of time.

4) Rendering Time

The amount of time a virtual reality system requires to analyze and produce each frame of the virtual environment before the user sees it is referred to as rendering time.

5) Error Rate

The degree of forecast fault of model made in relation to the genuine model is measured by the error rate.

6) User Error

Errors or inconsistencies committed by the user when interacting with virtual items or navigating around the environment are referred to as user errors.Formulas are typically not used to quantify user error; instead, usability testing, user input, and observation are used.

B. Performance Analysis

The imitation outcomes of the suggested PDIE-VRT-SCGAN methods are shown in Figure 3-8. The proposed PDIE-VRT-SCGAN techniques linked to the DVRI-PS-AI-DL, VES-PD-VR, and AUUE-UP-VRE-DLA techniques,

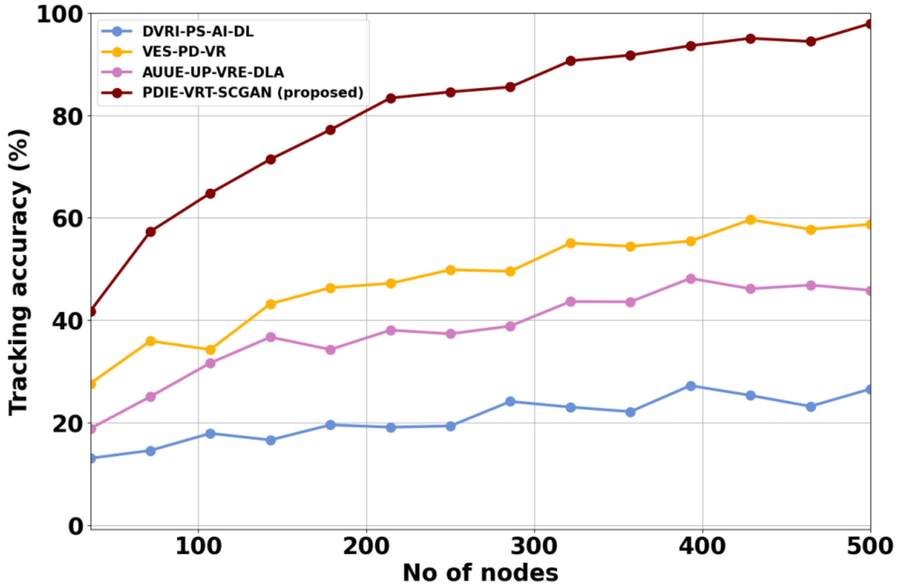

Figure 3: Analysis of Tracking Accuracy

Figure 3 shows analysis of Tracking Accuracy. The PDIE-VRT-SCGAN technique reaches in the range of 20.26%, 29.22% and 30.27% higher tracking accuracy at No of nodes 100; 27.29%, 18.31% and 16.26% higher tracking accuracy at No of nodes 200; 26.26%, 17.59% and 28.35% higher tracking accuracy at No of nodes 300; 29.21%, 26.38% and 25.25% higher tracking accuracy at No of nodes 400; 19.21%, 23.38% and 21.25% higher tracking accuracy at No of nodes 500; compared to current techniques such as DVRI-PS-AI-DL, VES-PD-VR, and AUUE-UP-VRE-DLA respectively.

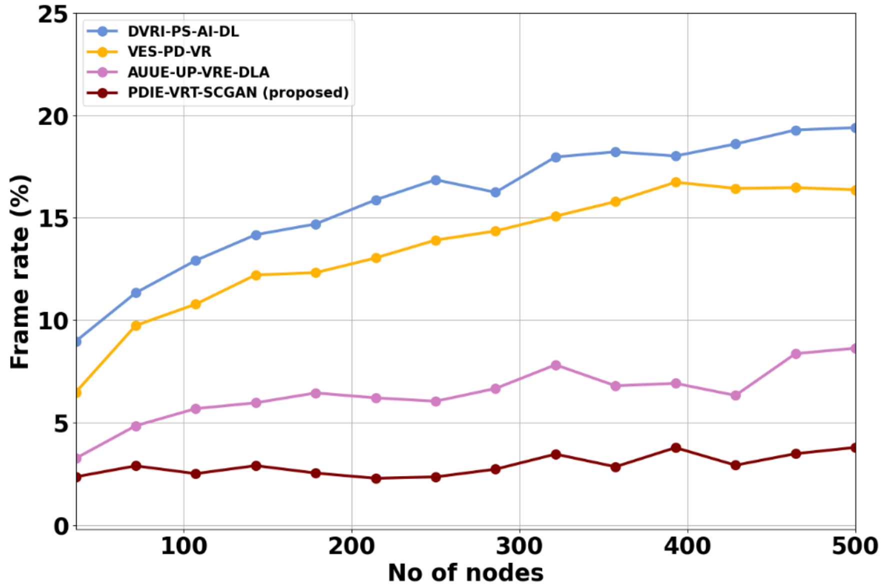

Figure 4: Analysis of Frame Rate

Figure 4 shows analysis of Frame rate. The PDIE-VRT-SCGAN technique reaches in the range of 21.26%, 19.22% and 28.27% lower frame rate at No of nodes 100;19.29%, 25.31% and 25.26% lower frame rate at No of nodes 200; 27.26%, 29.59% and 19.35% lower frame rate at No of nodes 300; 24.21%, 19.38% and 23.25% lower frame rate at No of nodes 400; 18.21%, 26.38% and 29.25% lower frame rate at No of nodes 500; compared to current techniques such as DVRI-PS-AI-DL, VES-PD-VR, and AUUE-UP-VRE-DLA respectively.

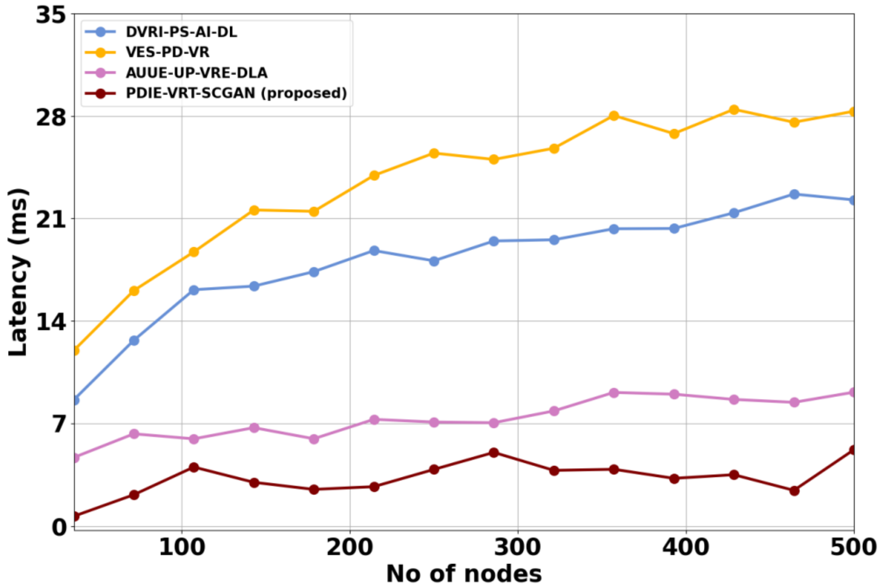

Figure 5: Analysis of Latency

Figure 5 shows analysis of Latency. The PDIE-VRT-SCGAN technique reaches in the range of 28.26%, 18.22% and 27.27% lower latency at No of nodes 100;18.28%, 25.31% and 24.26% lower latency at No of nodes 200; 29.26%, 16.29% and 15.35% lower latency at No of nodes 300; 27.21%, 28.38% and 22.25% lower latency at No of nodes 400; 28.21%, 27.38% and 29.25% lower latency at No of nodes 500; compared to current techniques such as DVRI-PS-AI-DL, VES-PD-VR, and AUUE-UP-VRE-DLA respectively.

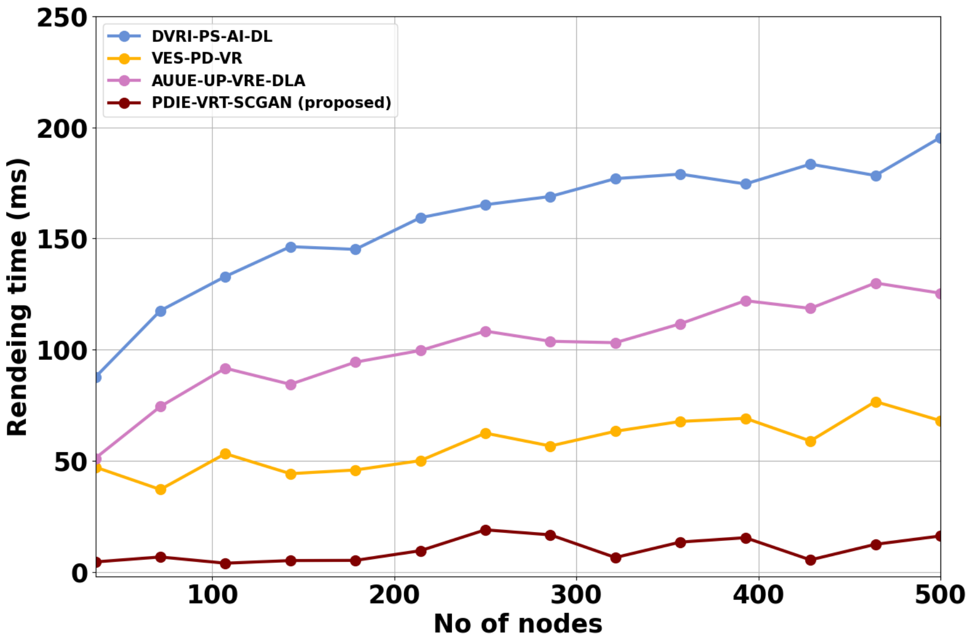

Figure 6: Analysis of Rendering Time

Figure 6 shows analysis of Rendering Time. The PDIE-VRT-SCGAN technique reaches in the range of 21.26%, 29.22% and 29.27% lower rendering time compared to current techniques such as DVRI-PS-AI-DL, VES-PD-VR, and AUUE-UP-VRE-DLA respectively.

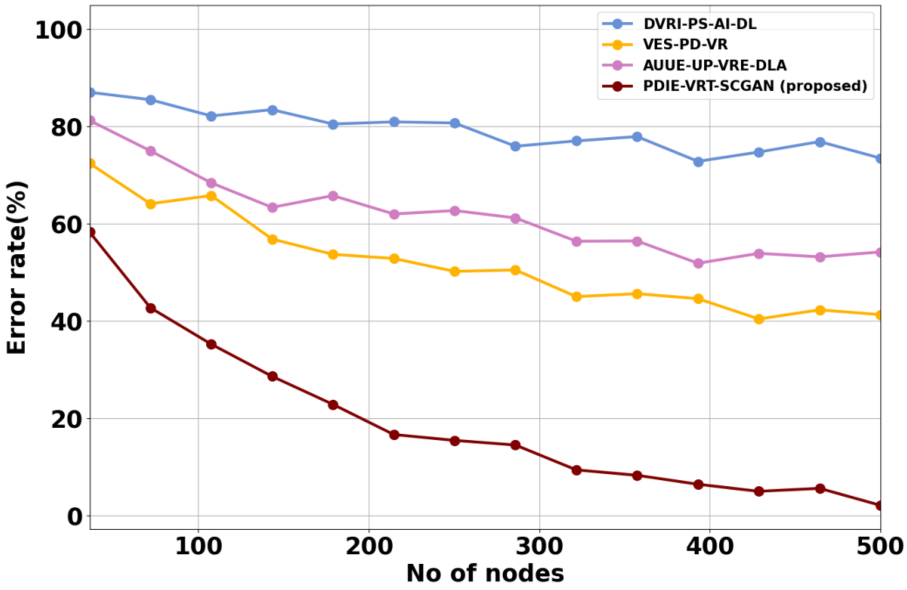

Figure 7: Analysis of Error Rate

Figure 7 shows analysis of Error rate. The PDIE-VRT-SCGAN technique reaches in the range of 26.26%, 17.22% and 25.27% lower error rate at No of nodes 100;29.29%, 24.31% and 21.26% lower error rate at No of nodes 200; 22.26%, 15.59% and 19.35% lower error rate at No of nodes 300; 26.21%, 28.38% and 29.28% lower error rate at No of nodes 400; 22.21%, 28.38% and 19.25% lower error rate at No of nodes 500; compared to current techniques such as DVRI-PS-AI-DL, VES-PD-VR, and AUUE-UP-VRE-DLA respectively.

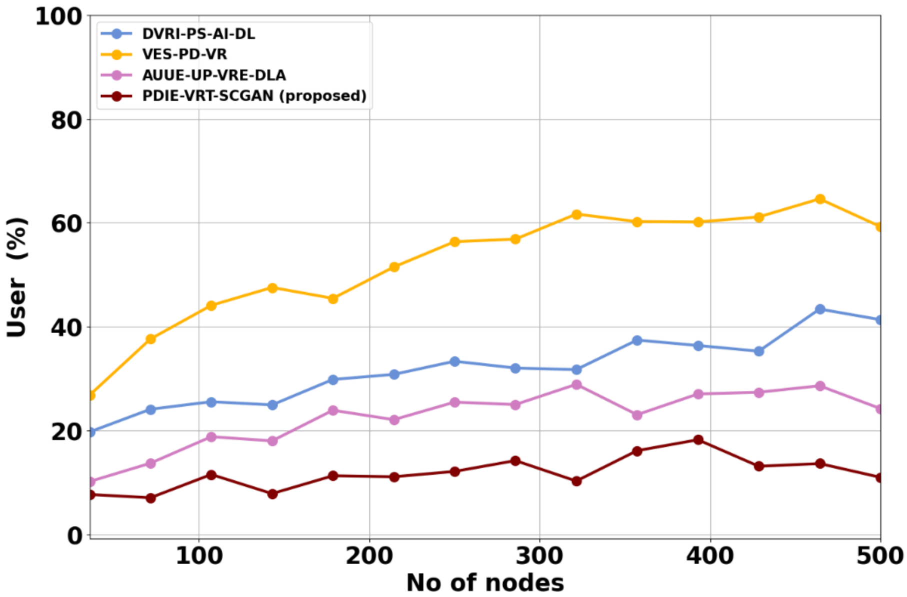

Figure 8: Analysis of User Error

Figure 8 shows analysis of User error. The PDIE-VRT-SCGAN technique reaches in the range of 28.26%, 15.22% and 22.27% lower user error at No of nodes 100;29.29%, 24.31% and 27.26% lower user error at No of nodes 200; 27.26%, 17.59% and 28.35% lower user error at No of nodes 300; 20.21%, 29.38% and 21.25% lower user error at No of nodes 400; 24.21%, 25.38% and 18.25% lower user error at No of nodes 500; compared to current techniques such as DVRI-PS-AI-DL, VES-PD-VR, and AUUE-UP-VRE-DLA respectively.

C. Discussion

This study proposes product designing interaction and experience on virtual reality using artificial intelligence deep learning algorithms. Creating embedded systems, C++ SDK interfaces, deep learning algorithms for artificial intelligence, and hardware for a virtual reality glove. The trial outcomes show that the VR interactive product depend on nine-axis sensor can arrest then recognize gestures, including selecting, attracting, zooming, rotating, shooting, calling out, and closing.There are eight different recognition rates: 94%, 96%, 100%, 92%, 100%, and 100%. In a virtual reality environment, the hand's whole range of motion is synchronously recreated, and the gesture interaction's purpose is identified, thereby achieving the goal of natural hand interaction. Nine-axis sensors record the movement data of the fingers and palms, and an artificial intelligence deep learning system is used to recognize gestures, with assistance of the secondary software development kit (SDK) software. It has been demonstrated that the deep learning algorithm for artificial intelligence is capable of efficiently realizing the plan of interactive VR software.Because gesture motion detention only allows motion around a reference point due to its lack of spatial positioning functionality, using the product's inertial sensor to calculate movement and spatial positioning will result in significant errors.

V. CONCLUSION

In this paper**,** A Product Design Interaction and Experience on Virtual Reality Technology using Semi-Cycled Generative Adversarial Network (PDIE-VRT-SCGAN) was successfully implemented. Here, Virtual Reality Experiences (VRE) dataset were used in thorough virtual reality to improve overall user experience in the presented technique. The proposed PDIE-VRT-SCGAN method is executed in C++ SDK. The presentation of proposed PDIE-VRT-SCGAN method covers 22.36%, 25.42% and 18.27% higher tracking accuracy, 23.26%, 28.32% and 31.17% higher latency, and 26.16%, 18.17% and 17.18% higher frame rate compared with existing DVRI-PS-AI-DL, VES-PD-VR, and AUUE-UP-VRE-DLA methods. In the future process the proposed PDIE-VRT-SCGAN model, the virtual reality goods may require third-party placing equipment to perform additional spatial putting for research purposes.

REFERENCE

[1] Cruz, E., Orts-Escolano, S., Gomez-Donoso, F., Rizo, C., Rangel, J. C., Mora, H., & Cazorla, M. (2019). An augmented reality application for improving shopping experience in large retail stores. *Virtual Reality*, *23*, 281-291.

[2] Liao, C. Y., Tai, S. K., Chen, R. C., & Hendry, H. (2020). Using EEG and deep learning to predict motion sickness under wearing a virtual reality device. *Ieee Access*, *8*, 126784-126796.

[3] Le, H., Nguyen, M., Yan, W. Q., & Nguyen, H. (2021). Augmented reality and machine learning incorporation using YOLOv3 and ARKit. *Applied Sciences*, *11*(13), 6006.

[4] Lin, Q. (2020). Application and development of virtual reality technology in artificial intelligence deep learning. In *IOP Conference Series: Materials Science and Engineering* (Vol. 740, No. 1, p. 012151). IOP Publishing.

[5] Parisi, T. (2015). *Learning virtual reality: Developing immersive experiences and applications for desktop, web, and mobile*. " O'Reilly Media, Inc.".

[6] Domínguez, A., Pacho, G., Bowers, L., Wild, F., Alcock, S., Chiazzese, G., ... & Masneri, S. (2023). Dataset of user interactions across four large pilots on the use of augmented reality in learning experiences. *Scientific Data*, *10*(1), 823.

[7] Jayamini, C., Sandamini, A., Pannala, T., Kumarasinghe, P., Perera, D., & Karunanayaka, K. (2021). The use of augmented reality to deliver enhanced user experiences in fashion industry. *Lecture Notes in Computer Science*, *12936*.

[8] Lv, Z., Poiesi, F., Dong, Q., Lloret, J., & Song, H. (2022). Deep learning for intelligent human–computer interaction. *Applied Sciences*, *12*(22), 11457.

[9] Barnes, S. (2016). Understanding virtual reality in marketing: Nature, implications and potential. *Implications and Potential (November 3, 2016)*.

[10] Mittal, H. (2024). Virtual Reality Applications in Healthcare: A New Age Technology Perspective. In *Immersive Virtual and Augmented Reality in Healthcare* (pp. 50-62). CRC Press.

[11] Liu, L. (2022). The artistic design of user interaction experience for mobile systems based on context-awareness and machine learning. *Neural Computing and Applications*, *34*(9), 6721-6731.

[12] Dirin, A., & Laine, T. H. (2018). User experience in mobile augmented reality: emotions, challenges, opportunities and best practices. *Computers*, *7*(2), 33.

[13] Craig, A. B., Sherman, W. R., & Will, J. D. (2009). *Developing virtual reality applications: Foundations of effective design*. Morgan Kaufmann.

[14] Dampage, U., Egodagamage, D. A., Waidyaratne, A. U., Dissanayaka, D. W., & Senarathne, A. G. N. M. (2021). Spatial augmented reality based customer satisfaction enhancement and monitoring system. *IEEE Access*, *9*, 97990-98004.

[15] Yang, L. I., Huang, J., Feng, T. I. A. N., Hong-An, W. A. N. G., & Guo-Zhong, D. A. I. (2019). Gesture interaction in virtual reality. *Virtual Reality & Intelligent Hardware*, *1*(1), 84-112.

[16] Portman, M. E., Natapov, A., & Fisher-Gewirtzman, D. (2015). To go where no man has gone before: Virtual reality in architecture, landscape architecture and environmental planning. *Computers, Environment and Urban Systems*, *54*, 376-384.

[17] Inamura, T. (2023). Digital Twin of Experience for Human–Robot Collaboration Through Virtual Reality. *International Journal of Automation Technology*, *17*(3), 284-291.

[18] Wang, J., Yang, Y., Liu, H., & Jiang, L. (2024). Enhancing the college and university physical education teaching and learning experience using virtual reality and particle swarm optimization. *Soft Computing*, *28*(2), 1277-1294.

[19] Quintero, L. (2023). *User Modeling for Adaptive Virtual Reality Experiences: Personalization from Behavioral and Physiological Time Series* (Doctoral dissertation, Department of Computer and Systems Sciences, Stockholm University).

[20] Sagnier, C., Loup-Escande, E., Lourdeaux, D., Thouvenin, I., & Valléry, G. (2020). User acceptance of virtual reality: an extended technology acceptance model. *International Journal of Human–Computer Interaction*, *36*(11), 993-1007.

[21] Wang, Y., & Sun, J. (2022). Design and implementation of virtual reality interactive product software based on artificial intelligence deep learning algorithm. *Advances in Multimedia*, *2022*.

[22] Wang, Y., & Liu, Q. (2023). A virtual evaluation system for product designing using virtual reality. *Soft Computing*, *27*(19), 14285-14303.

[23] Zhang, X., Yan, Q., Zhou, S., Ma, L., & Wang, S. (2021). Analysis of unsatisfying user experiences and unmet psychological needs for virtual reality exergames using deep learning approach. *Information*, *12*(11), 486.

[24] Ipsita, A., Duan, R., Li, H., Chidambaram, S., Cao, Y., Liu, M., ... & Ramani, K. (2024). The Design of a Virtual Prototyping System for Authoring Interactive Virtual Reality Environments From Real-World Scans. *Journal of Computing and Information Science in Engineering*, *24*(3).

[25] Chu, C. H., & Liu, S. (2024). Virtual Footwear Try-On in Augmented Reality Using Deep Learning Models. *Journal of Computing and Information Science in Engineering*, *24*(3), 031002.

[26] Mu, M., Dohan, M., Goodyear, A., Hill, G., Johns, C., & Mauthe, A. (2022). User attention and behaviour in virtual reality art encounter. *Multimedia Tools and Applications*, 1-30.

[27] Choi, S., Jung, K., & Noh, S. D. (2015). Virtual reality applications in manufacturing industries: Past research, present findings, and future directions. *Concurrent Engineering*, *23*(1), 40-63.

[28] https://www.kaggle.com/datasets/aakashjoshi123/virtual-reality-experiences

[29] Liu, W., Wang, H., Xi, Z., & Zhang, R. (2023). Smooth Deep Learning Magnetotelluric Inversion based on Physics-informed Swin Transformer and Multi-Window Savitzky-Golay Filter. *IEEE Transactions on Geoscience and Remote Sensing*.

[30] Hou, H., Xu, J., Hou, Y., Hu, X., Wei, B., & Shen, D. (2023). Semi-cycled generative adversarial networks for real-world face super-resolution. *IEEE Transactions on Image Processing*, *32*, 1184-1199.

[31] Mohammed, H., & Rashid, T. (2023). FOX: a FOX-inspired optimization algorithm. *Applied Intelligence*, *53*(1), 1030-1050.