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Metaverse-based Field Evidence Analysis Integrated Management System

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***Abstract*—This study studies metaverse-based field evidence management devices and methods. This is done by analyzing events that occur within the metaverse space. This relates to a metaverse-based field evidence management device and method that can collect and manage evidence in an integrated manner. Metaverse refers to a virtual world that transcends reality. The metaverse-based field evidence management method is a step of collecting images in the metaverse space, analyzing the types of accidents that occur at the scene of an incident, and analyzing the behavioral characteristics, subjects, and objects that correspond to the kinds of accidents. In the case of fire scenes, there are many difficulties due to police control. To prepare for such cases, check and analyze scan data. Evidence at the fire scene can be preserved and confirmed even after the scene has been cleaned up. This is to create a system where experts in each field can jointly investigate and discuss in the metaverse space. In addition, real-world users use avatars within the metaverse space as their alter egos. We can perform various activities with our avatar in the metaverse space. Meanwhile, avatars operating in the metaverse space are controlled by users in the real world, and users can commit criminal acts within the metaverse space through avatars. In addition, it enhances field preservation and evidence analysis by creating 3D sites for incidents and accident sites, increasing the collaboration of experts and the efficiency of forensic science in the virtual space. With the acceleration of digital transformation, it can contribute to fostering a practical AI technical workforce that can be put into the field.**

***Keywords*— Metaverse; augmented reality; platform; avatar; 3D.**

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I. INTRODUCTION

Analyze the events within the metaverse space to collect evidence about them. It is to provide metaverse-based on-site evidence management devices and methods that can be integrated and managed. Metaverse-based on-site evidence management devices, with the image acquisition department that collects images in the metaverse space, analyze the types of accidents that occur at the incident scene, the behavioral characteristics that respond to the kinds of accidents, and the subject and object. Based on this, the learning department that learns the characteristics of the incident scene will select the incident scene video that includes the characteristics of the incident scene from among the videos in the metaverse space. Record the status information of the incident scene on the video of the incident scene. It can include a control unit that creates and stores virtual spaces [1], [2].

The control unit contains various types of files and images in virtual space. Create an object that provides embeddable space, and we can record the status information of the incident scene on the object. The metaverse-based on-site evidence management device contains a communications department that communicates with the electronic map server. The control unit is where we can transmit the location information of the incident scene video to the electronic map server if we select Incident Scene Footage. Control the communication department to receive detailed geographic information corresponding to location information from the electronic map server. Detailed geographic information can be reflected when creating a virtual space. The learning department tracks at least one of the behavioral characteristics and subject/object in real-time; based on this, it is possible to learn the likelihood that the characteristics of the scene of the incident will occur. If the control unit is likely to have an incident scene characteristic, predict when and where the scene of an incident will occur. It is possible to generate video footage of the incident scene in response to the location.

Metaverse-based field evidence management has some methods. The stage of collecting images in the metaverse space, Analyzing the types of accidents that occur at the scene

of an accident, and analyzing the behavioral characteristics and subjects and objects that respond to the kinds of accidents. Based on this, the characteristics of the incident scene and the videos in the metaverse space are included in the stage of learning the characteristics of the incident scene. This is the process of selecting footage of the scene of the incident and analyzing the video of the incident scene to analyze the status information of the incident scene. Also, it creates a virtual space that records the status information of the incident scene in the crime scene's video, and we can include steps to save.

This study consists of the theoretical background, the study's design, and the study's results. First, based on the existing research, we established a method of managing evidence at a crime scene through avatars. The research methods for verification are as follows. First, through avatars, behavioral characteristics, and subjects on the metaverse platform, track at least one of the objects in real-time; based on this, it is possible to learn the possibility of the occurrence of incident scene characteristics. Second, evidence of the accident should be collected through avatars. Creating and storing a virtual space where evidence is preserved is possible. Third, metaverse-based field evidence management devices can include a communications department communicating with an electronic map server [3]. Fourth, the virtual space and communication functions are Text, voice, video, etc., which can be used to communicate with user terminals or management servers.

II. Materials and Method

A. Methodology

1) Methodology on-site evidence analysis integrated management system: In the intact era, offline activities such as work, leisure, and communication are moving to the virtual space. Second Life, Minecraft, Zepeto, etc. In the virtual space, where games and social activities are the mainstay, commercial activities such as actual education, training, conferences, and events and exhibitions are being added. Facebook, Apple, Microsoft, etc. In Fig. 1 and 2, Large multinational corporations have been paying attention to the potential and industrial and social impact of this complex reality since the industry's early days. They continuously expand their efforts to create an ecosystem to preempt the XR market [3], [4].

Fig. 1 Microsoft HoloLens2

Fig. 2 Apple Glass

The key driving force for the development and growth of the augmented reality and virtual reality market is out of the hands of the private consumer. As other new technologies have been, companies will have more significant momentum when they improve productivity and innovate. When these new technologies enter the corporate field, software solution providers, developers, and domain technical experts can work together to improve productivity optimally. Both the technology solution provider and the user are in dispute about the market potential. Many Fortune 500 companies have already begun adopting extended reality technology. Some of them have already started pilot projects. In this situation, an intelligent enterprise would have virtual and augmented reality technology that can have the most optimized impact and effect on a company's business area. As well as the fastest-changing companies in the information and communication sector. Automotive, manufacturing, media, and other leading companies must understand how to deliver measurable results of virtual/augmented reality [5].

2) Purpose of designing an integrated on-site scanning management system: Fig. 3 scans the exterior of the fire scene to give an overall picture of the accident site. In addition, even if the fire scene is demolished, the scan data can be restored to identify the scene.

Fig. 3 Scanning the Exterior of the Fire Scene

In the case of Fig. 4, evidence from the scene of the fire can be preserved. It can be checked even after the site clearance. This is because experts in each field will work together in the metaverse space to create a system that allows for investigation and discussion.

Fig. 4 Fire Scene Evidence

Fig. 5 allows us to scan and take images simultaneously. The shooting data from the photo can be converted to the black-and-white scan data. Carbonization depth analysis is possible. As a future research item, a function is expected to be necessary to verify and analyze the cause of the fire.

Fig. 5 Black & White Scan Carbonization Depth Analysis

3) 3D scanner metaverse technology: The metaverse system of the 3D scanner scans the entire site and converts it into data. The site has been preserved so that it can be checked without going to the site. In the case of the fire scene, there were many difficulties due to the control of the police. In such cases, the scan data can be checked and analyzed. In addition, even if the evidence is removed, it can be verified with previously scanned data. We can check only the part of the fire scene we want to check using Clopping. Even if it is a high-rise building, we can check the cross-section of the floor we want to see. Image taking is also automatically performed while collecting scan data, making it easy to check the site. It was designed to enable a prismatic scientific investigation by experts to conduct a joint investigation. The domestic metaverse industry is facing the non-face-to-face era. As the usefulness of XR is highlighted in the domestic sector, XR is expanding beyond entertainment and tourism to various fields such as education, medical care, manufacturing, distribution, culture, and defense. With the expansion of the metaverse market area, Korea's leading metaverse platform service, NAVER's ZEPETO, and SKT's Ifland's platform technology are also based on mobile environment activities. Service advancement is in progress to advance into the virtual world of various environments [5], [6].

a. Metaverse in Education:

In the aftermath of the spread of COVID-19, as online education has become prolonged, the need for an effective non-face-to-face lecture system increases, and the demand for creating immersive virtual learning environments is rising. Various domestic companies such as Thirty Floor, Brany, Darim, and Saline are launching virtual education systems using VR. At Hanyang University, a full-size professor who is implemented with HR gives lectures to students in multiple classrooms simultaneously. It provides the development and service of interactive remote lectures where questions can be answered. The usage rate of XR content for experiments and practice provided by Emergency Education has increased about ten times compared to before March 2020, when COVID-19 spread. Fig. 6 is used as an alternative to solve the demand for face-to-face experiences that are difficult to conduct due to concerns about COVID-19 infection [7]-[9].

Fig. 6 Metaverse in education

b. Metaverse in Healthcare:

Fig. 7 shows that the metaverse is mainly used for medical training and rehabilitation treatment in Korea and the medical field. Tetra Signum has developed a non-face-to-face medical education platform that has improved the domestic virtual education platform into surgical educational content. By conducting remote lectures and discussions in which doctors from 8 countries participated, including Japan, Singapore, and the United Kingdom. Recently, when overseas personnel exchange is limited, it proposes a new alternative to medical information exchange. The Near Wellness Center uses VR and hand gesture recognition devices to improve cognitive functions in people at high risk of mild cognitive impairment and dementia. We intend to develop cognitive rehabilitation content that enhances visual perception function and physical rehabilitation content for patients with brain injury.

Fig. 7 Metaverse in Healthcare

c. Manufacturing Metaverse:

Fig. 8 shows that XR is a remote web-up solution that connects on-site workers and remote experts in the domestic manufacturing industry. Field workers can access remote experts via AR glasses or smartphones. We can share the on-site situation in real time and receive the support we need to solve the problem. Korea East-West Power, Formit, and E-Lantaek are solutions that can safely provide job training in a virtual training environment using VR to respond to specific on-site situations such as disasters and facility failures. Augmented Intelligence's industrial AR navigation platform provides work guides in smart factories and aircraft maintenance/facilities.

Fig. 8 Manufacturing Metaverse

d. Defense Metaverse:

Due to cost and safety concerns, the use of XR was low; recently, in the wake of COVID-19, reservist call-up training has been switched to remote; in the field of national defense, the development and introduction of training systems that can maintain power even in non-face-to-face situations is expanding. Fig. 9 shows the cost of building a VR urban combat training system, an actual urban combat training ground. We can train for much less money. Regarding safety, using XR-based video shooting-based simulators can reduce the risk of firearm accidents. This means that VR drop training simulators can also help reduce the risk of actual drop training [8], [9].

Fig. 9 Defense Metaverse

B. Research method

1) Metaverse-based Field Evidence Management Device: The video acquisition part collects images in the metaverse space. It determines the type of accident at the incident scene and analyzes behavioral characteristics, subjects, and objects that correspond to types of accidents. Based on this, Fig. 10 shows that the learning part learns the characteristics of the incident scene. Select the incident scene video that includes the above incident scene characteristics from among the images in the metaverse space. Analyze the incident scene video and analyze the incident scene status information. It consists of a control unit that creates and stores a virtual space that records the incident scene status information in the incident scene video [10], [11].

For the operation and management of incident and accident evidence data such as the Fire Department, etc. The search is mainly for the API function of the electronic map to improve system design and development technology; it is designed to be related to the display of broad search, address search, coordinate transformation, tilemap, etc. It provides a space where various files or videos can be embedded in a virtual space. It is to create an object and record the status information of the incident scene on the object [12].

Fig. 10 Electronic Map API Linkage Test Results

A variety of conventional methods can be used to detect human behavior. Specifically, direct recognition methods and statistical methods may be used. The direct recognition method uses the shape of the human image, the angle of the joint, and the physical characteristics such as the distance between each other. After comparing, testing, and measuring according to the rules, a person's behavior is judged from this. Statistical methods can detect human behavior based on pre-trained algorithms. In other words, the unique characteristics of human behavior are converted into data. It is a method of comparison and analysis with many prepared databases (the shapes of people and other subjects or objects).

In particular, human behavior can be detected according to pre-trained algorithms, such as MLP (Multi-Layer Perceptron) and SVM (Support Vector Machine). Or, through motion modeling, etc., a person's movement can be identified from the recorded image. In this case, motion modeling is an analysis process that converts human movements into digital information for processing, processing, and transmission, and one of the Active Shape Modeling (ASM) and Active Appearance Modeling (AAM) techniques can be used.

Train an artificial neural network model based on supervised learning. The artificial neural network model 20 uses input training data of behavioral characteristics. It is trained based on a pair of output training data of incident scene characteristics. The purpose of this study is to describe the construction of the virtual space created by the metaverse-based field evidence management device. Metaverse-based field evidence management devices: It is possible to create and save a virtual space that records the incident scene status information in the incident scene video. The virtual space can be displayed on the user's device or management server.

The virtual space can be linked to the geospatial information system for on-site analysis and data accumulation. Here, the Geographic Information System (GIS) digitizes the geospatial information of the entire country and creates a digital map. It is a high-tech information system that aims to be used for disaster, environment, facilities, national space management, and administrative services through various information and communication technologies. Virtual space comprises spaces, objects, and avatars [11]. The space can be conFig.d to allow for layout design based on the desired concept of the site. In addition, it can be designed to allow for various zoning within the space.

A space can be composed of 2D images or 3D images. In addition, the space is Augmented Reality. AR), Virtual Reality (VR), or Mixed Reality (MR). According to one embodiment, behavioral characteristics, subjects, and objects that need to be collected as evidence can be embodied as virtual information. Objects can provide a variety of embeddable sub-spaces in a space. For example, the sub-space provided by an object can contain Word files, ppt files, images, videos, etc [13]-[15].

Avatars exist within the metaverse space and alter users' egos in the real world. Users can perform various activities with their avatars in the metaverse space. In this case, the user can move freely by the avatar in the metaverse space based on the mouse. In addition, it is designed to allow for various interactions between people or within a space. Virtual space has a communication function. The communication function uses text, voice, video, etc., to communicate with the user terminal or management server. It can carry out various forms of communication [6], [16].

This study is an example of a virtual space created by a metaverse-based field evidence management device. The metaverse-based field evidence management device can be linked with an electronic map server to create a virtual space that reflects detailed geographic information. The application server of the metaverse-based field evidence management device can communicate with the electronic map server [13]. In this case, the application server sends the location information of the incident scene image to the electronic map server when the incident scene image is selected. Control the communication department (unknown city) to receive detailed geographic information corresponding to location information from the electronic map server. Detailed geographic information can be reflected when creating a virtual space. To this end, the application server focuses on the API function of the electronic map. Actions related to displaying search, broad search, address search, coordinate transformation, tilemap, etc., can be designed. An example is shown in Table 1 below [17], [18].

TABLE I
API FUNCTIONALITY OF ELECTRONIC MAPS

Major Classification	**Subcategories**	**Explanation**
Autocomplete	search word	Search term ranking information
POI search	POI	POI information retrieval
	POI Category	POI Retrieving classification information
Broad match	ExtentionSearch	Search for extended content
Address Search	Administration	Retrieving administrative boundary information
	Geocoding	Search for coordinates of old → new addresses.
	Reverse Geocoding	Search for old → new addresses through coordinates
Coordinate Transformation	Projection	Coordinate Transformation
Tile Map	TileMaps	Tile image map

Site preservation and evidence analysis according to the creation of the 3D scene of the accident site: Train an artificial neural network model based on unsupervised learning. Fig. 11 shows that based on unsupervised learning, only input data is entered without using output data. Artificial neural network models can be trained. The artificial neural network model consists of behavioral and incident scene characteristics [19], [20]. It can be learned based on the labeled input training data (Behavioral Trait N-Event Scene Trait N).

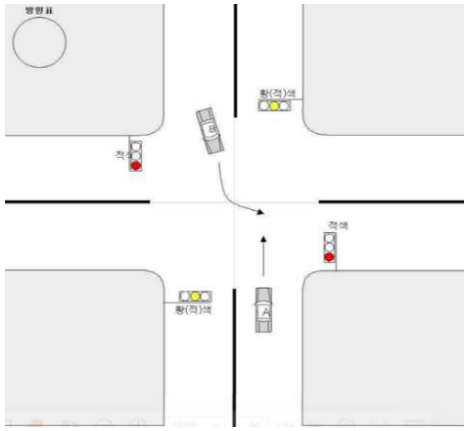

Fig. 11 API linkage test results

2) Metaverse-based Field Evidence: It Occurs under the jurisdiction of the Fire Agency, the National Police Agency, the Electrical Safety Corporation, and the Ministry of National Defense (Army, Navy, Air Force). Based on a detailed incident record, the on-site evidence analysis management system is not a dedicated program [21], [22]. Document management programs such as Hangul Word, MS Word, PowerPoint, etc. are used. There are limitations in management: in close relation to the scene of a fire or a crime, temporary storage, and management of open issues (on-site storage or maintenance issues), which is required to build a system that requires solutions to solve social problems. If it is a fire incident disguised as a crime, the cooperation of the National Police Agency and the Fire Agency is required. There is a need for an integrated solution for collecting 3D-based field evidence. In Fig. 12 and 13, multiple experts can access the site simultaneously and provide their opinions, thereby inducing the advancement of judgment [23]-[25].

Fig. 12 Virtual Space VR Composition Blueprint

Fig. 13 2D Avarta

Fig. 14 Asset Import

Fig. 15 Asset Import

Fig. 14 and 15 show 2D Assets 2D Avatar, leading the innovation of Korea's digital content business. This is to make it easier for online users to use the content, such as user convenience, system compliance, customer care, etc. Enhancing external credibility by receiving content provision service quality certification is expected to not only inspire but also greatly affect directory books and related services [26], [27].

3) Metaverse platform linkage and system construction: The 3D scanner uses laser sensor technology to scan with high accuracy (±1mm@10m) and range. It has a fast scanning speed of over 2,000,000 pts/sec and a low noise range (0.1mm@10m). It identifies multiple areas to be scanned through the Scan Group function to detect targets accurately. While collecting data from the fire scene, we want to use it to register the data in real-time. The system is certified to IP 54 and is designed to be used in difficult weather conditions of -20°C ~ 55°C. With its compact size (230 x 183 x 103 mm) and weight (4.2 kg including battery), it uses an interface commonly used in standard CAD systems. Fig. 16 shows the 3D modeling, rigging, UV mapping, and texturing work that constructs the metaverse space. By linking the open platform client and the game engine, we create a customized interaction function that can realize the overall direction of the service. Improving the collaboration of experts and the efficiency of forensic science in the virtual space, Metaverse 3D world construction technology linked to GIS technology will be enhanced to develop devices [28]-[30].

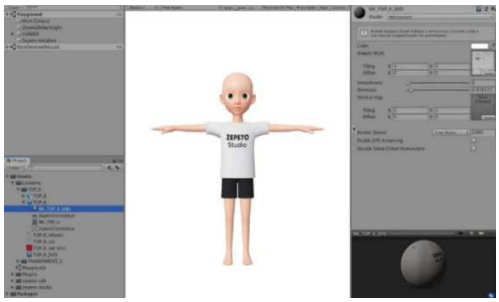

Fig. 16 3D modeling of the metaverse space

III. Results And Discussion

In this study, we seek to secure and utilize technology to build a metaverse service-based system using extended reality (XR) technology. The research purpose of the Metaverse field analysis management system is to expand the application areas of Metaverse extended reality technology. Create a 3D scene of the accident site to improve and utilize site preservation and evidence analysis work. By scanning the entire site and documenting it, the site is preserved and can be checked without going to the site. This can be confirmed with previously scanned data even if the evidence is removed. It is possible to automatically acquire images while collecting scanned data (accessible to confirm on-site). In virtual space, the value of use can be increased, such as collaboration between experts and improved scientific investigation efficiency.

Prism-type scientific investigation is possible through a joint investigation by experts. Clopping allows us to check only the parts we want to check. It was designed so that it is possible to check the cross-section of the floor we want to see, even in a high-rise building. Therefore, the metaverse system proposed through more in-depth research in the future will be used, as well as fire detection by the National Fire Agency and investigation into the cause of the fire by the National Police Agency. It was designed to enable joint response and confirmation based on scan data from the fire scene.

Fig. 17 Virtual space law

Fig. 17 is a web reporter that distributes various functions to the digital output system in conjunction with the metaverse as a virtual space law. This can be printed after editing tables, photos, and drawings. In addition, multiple pages can be output in A4 size for each function. Components can be provided and integrated by function, and conversion and production in various formats such as Korean, PDF, and JPG are possible.

Fig. 18 Field evidence analysis integrated management system object

Fig. 19 On-site evidence analysis integrated management System

Fig. 18 and 19 above show the integrated management system. The virtual space was designed to enable layout design according to the desired concept of the site. It was designed to allow various zone settings within the virtual space. Objects provide various embeddable spaces (Word, ppt, images, videos, etc.) in the virtual space. In addition, all activities and performances are possible with an avatar in the space. It is designed to move freely, using a mouse, and allows various interactions between people and within the space. The communication function of the system can be used through text, voice, and video. It was designed to enable various forms of communication and various zone settings within the virtual space.

IV. Conclusion

In this study, we developed a metaverse-based field evidence management device as an image acquisition unit that collects images in the metaverse space. We aim to analyze the types of accidents that occur at the scene of an incident and the behavioral characteristics, subjects, and objects that correspond to these types of accidents. Based on this, an incident scene video containing incident scene characteristics is selected from among the images in the learning unit and the metaverse space that learns incident scene characteristics.

Analyze incident scene status information by analyzing incident scene video; incident scene video may include a control unit that creates and stores a virtual space in which incident scene status information is recorded. Avatars active in the metaverse space are controlled by users in the real world. Users can commit criminal acts within the metaverse space through their avatars.

In addition, creating 3D scenes of incidents and accidents improves site preservation and evidence analysis tasks. It also increases collaboration and forensic investigation efficiency among experts in virtual space. As digital transformation accelerates, it can contribute to nurturing a practical AI technical workforce that can be deployed in the field.

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References

[1] S. Choi, "Haptic augmented reality," *Journal of the Korea Society of Broad Engineers*, vol. 16, no. 3, pp. 31–35, 2011.

[2] K. Choi, "Image Recognition and Clustering for Virtual Reality based on Cognitive Rehabilitation Contents," *J. of the Korea Digital Contents Society*, vol. 18, no. 7, pp. 1249-1257, 2017.

[3] H. Park and T. Hwang, "A Study on the Heart Rate Variability for Improvement of AR/VR Service," *J. of the Korea Institute of Electronic Communication Sciences*, vol. 15, no. 1, Feb.2020, pp. 191-198.

[4] N. Yang. H, Park, T. Yoon. And J. Moon, "Effectiveness of Motion-Based Virtual Reality Training(Joystim) on Cognitive Function and Activities of Daily Living in Patients with Stroke," *J. of the Korea Rehabilitation Engineering and Assistive Technology Society*, vol. 12, no. 1, pp. 10-19, Dec. 2018.

[5] D. Suh, K. Park, "IoT-based office environment improvement plan," *J. of the Korea Institute of Electronic Communication Sciences*, vol. 15, no. 1, pp. 61-70, 2020.

[6] J.-M. Lee and Y.-K. Lee, "Comparative analysis and utilization plans of realistic content(AR/VR/MR) in the field of interior design: Focusing on the application of realistic content in the interior design process," *Korea Institute of Design Research Society*, vol. 8, no. 2, pp. 232–247, Jun. 2023, doi: 10.46248/kidrs.2023.2.232.

[7] W. Seok, "Analysis of Metaverse Business Model and Ecosystem," *Electronic and telecommunications trends*, vol. 36, no. 4, pp. 81-91, 2021.

[8] B.-H. Kang, J.-S. Kim, and H.-W. Kim, "Study for Operation Teaching Machine Using 3D Virtual Reality System," *Journal of Digital Contents Society*, vol. 17, no. 4, pp. 287–293, Aug. 2016, doi:10.9728/dcs.2016.17.4.287.

[9] Y. Kang, "A Study on Development of Instructional Model for Smart Education Based on Game App," *The Journal of Humanities and Social sciences* 21, vol. 10, no. 3, pp. 1617–1628, Jun. 2019, doi:10.22143/hss21.10.3.117.

[10] K. Kim and I. Hong, "A Study on Effective Management of the (Reading and Discussion) Class in Liberal Arts Education - Focusing on Sunmoon University," *The Journal of Language & Literature*, vol. 67, p. 373, Sep. 2016, doi: 10.15565/jll.2016.9.67.373.

[11] G. H. Lee and Y. C. Kim, "Deep learning application plan for the military's smart VR education system," *Korean Journal of Military Art and Science*, vol. 75, no. 1, pp. 214–215, 2019.

[12] J.-K. Oh, G.-S. Kim, J.-Y. Kim, and Y.-S. Choi, "Real-time temperature map service for street space in summer using Internet of Things technology," *Journal of Digital Contents Society*, vol. 23, no. 11, pp. 2283–2291, Nov. 2022, doi: 10.9728/dcs.2022.23.11.2283.

[13] P. L. Brantingham and P. J. Brantingham, "Nodes, Paths, and Edges: Considerations on the Complexity of Crime and the Physical Environment," *Classics in Environmental Criminology*, pp. 289–326, May 2010, doi: 10.4324/9781439817803-16.

[14] J. Ryu and D. Suh, "A Novel Weighting Method of Multi-sensor Event Data for the Advanced Context Awareness in the Internet of Things Environment," *J. of the Korea Institute of Electronic Communication Sciences*, vol. 17, no. 3, pp. 512-520, 2022.

[15] T. H. Kim and H. J. Choo, "Augmented reality as a product presentation tool: focusing on the role of product information and presence in AR," *Fashion and Textiles*, vol. 8, no. 1, Jul. 2021, doi:10.1186/s40691-021-00261-w.

[16] S. Y. Jung and H. N. Lee, "Experiential Marketing Case Analysis of Online Shopping Mall Using VR, AR," *Journal of The Korean Society Design Culture*, vol. 25, no. 3, pp. 393–402, Sep. 2019, doi:10.18208/ksdc.2019.25.3.393.

[17] N. El Barhoumi, R. Hajji, Z. Bouali, Y. Ben Brahim, and A. Kharroubi, "Assessment of 3D Models Placement Methods in Augmented Reality," *Applied Sciences*, vol. 12, no. 20, p. 10620, Oct. 2022, doi:10.3390/app122010620.

[18] P. A. Rauschnabel, "Virtually enhancing the real world with holograms: An exploration of expected gratifications of using augmented reality smart glasses," *Psychology & Marketing*, vol. 35, no. 8, pp. 557–572, May 2018, doi: 10.1002/mar.21106.

[19] J. H. Lee, "VR System Environment Technologies and User Input Elements," *Journal of The Korean Society Design Culture*, vol. 24, no. 2, pp. 585–596, Jun. 2018, doi: 10.18208/ksdc.2018.24.2.585.

[20] S. Hong, "Design and implementation of healthcare system based on non-contact biosignal measurement," *J. of the Korea Institute of Electronic Communication Sciences*, vol. 15, no. 1, pp. 185-190, Feb. 2020.

[21] H. S. Son, K. Y. Kang, and K. H. Lee, "A Study on the Architectural Design Elements for CPTED in Public Toilet," *Korea CPTED Association*, vol. 10, no. 2, pp. 141–170, Aug. 2019, doi:10.26470/jcssed.2019.10.2.141.

[22] J. Seo and K. Joo, "Korean AI Learning Model Based on E-learning for Artificial Intelligence Education," Journal of The Korean Association of Artificial Intelligence Education, vol. 3, no. 2, pp. 14–22, Aug. 2022, doi: 10.52618/aied.2022.3.2.2.

[23] V. Lavoye, J. Mero, and A. Tarkiainen, "Consumer behavior with augmented reality in retail: a review and research agenda," The International Review of Retail, Distribution and Consumer Research, vol. 31, no. 3, pp. 299–329, Mar. 2021, doi:10.1080/09593969.2021.1901765.

[24] M. Brengman, K. Willems, and H. Van Kerrebroeck, "Can't touch this: the impact of augmented reality versus touch and non-touch interfaces on perceived ownership," Virtual Reality, vol. 23, no. 3, pp. 269–280, Feb. 2018, doi: 10.1007/s10055-018-0335-6.

[25] S. Lee, J. Lee, and H. Sim, "AI-based object recognition research for augmented reality character implementation," *J. of The Korea Institute of Electronic Communication Sciences*, vol. 18, no. 6, pp. 1321-1329, 2023.

[26] W. Kim and M. Ok, "A Review of Research on Using Augmented Reality and Virtual Reality for Learning Achievement and Attitude of Students with Disabilities," *The Korea Learning Disabilities*

Association, vol. 16, no. 3, pp. 51–72, Dec. 2019, doi:10.47635/klda.2019.16.3.51.
[27] Y. Oh and E. Kim, "Design and Implementation of Augmented Reality based Food Menu Guidance System," *J. of the Korea Institute of Electronic Communication Sciences*, vol. 15, no. 3, pp. 573-57, 2020.
[28] H. Kim, "Remarks on Visualizations of 3D Virtual Reality," *Journal of Korea Multimedia Society*, vol. 14 no. 4, pp. 88-98, 2010.
[29] W. Choi and K. Seok, "Survey on ways to improve the system in preparation for changes in the radio management system," *J. of the Korea Institute of Electronic Communication Sciences*, vol. 13, no. 6, pp. 1145-1154, 2018.
[30] S. Lee, J. Lee, and H. Sim, "AR-Based Character Tracking Navigation System Development," *J. of the Korea Institute of Electronic Communication Sciences*, vol. 17, no. 2, pp. 325-332, 2022.