Design and Implementation of Ar Library Navigation System for the Elderly Based on User Experience

Lixia Niu[1,a], Jingwen Kuang[1,b*]

327334231@qq.com[a], kjw183414954@163.com[b*]

[1]Liaoning Technical University, Longwan South Avenue, Xingcheng City, China

Abstract: Against the background of the aging population, an AR library navigation system with ideal user experiences is designed and developed for elderly users, in order to meet the needs of elderly users for library navigation services. This paper analyses the application status of AR technology for elderly users, with usability, emotional experience and value experience for user experience design principles, and uses Unity3D, Vuforia SDK and 3ds Max software for system augmented reality display and virtual information interface development and testing. The system realizes space-independent, instant and accurate navigation of library resource information for elderly users, and provided new ideas to improve the user experience of elderly library navigation service.

Keywords: The elderly, User experience, Augmented reality, University library, Navigation system

1 INTRODUCTION

China's aging rate has surpassed the global average. In China, the number of elderly Internet users aged 60 and over has reached 119 million as of December 2021. The digital divide is anticipated to expand as more services go online [10]. China suggests creating a smart society that takes elderly people's requirements into account and promoting smart services that can be customized to meet their demands. The use of augmented reality technology, as one of the key technologies of the new era, is still being explored for the elderly population. To help elderly people with cognitive health screening [6], cognitive function training [5, 9], and daily decision-making [7], AR technology is integrated with serious games. This helps to prevent cognitive decline, which includes memory loss and decision-making challenges in the aged population. In order to lower the risk of falls caused by old age, muscle weakness, and balance issues, augmented reality technology is utilized to guide active exercise in the senior population. Meiling C. et al. created an AR-based game system for seniors to prevent falls [3], and Jeon S. et al. confirmed that an AR-based exercise program for preventing muscle loss improved exercise sustainability [11]. Ku J et al. used a 3D interactive AR training system to improve balance in the elderly [12]. Researchers have used AR (AR calligraphy [13], AR artifacts [1], and so on) to boost the motivation of older adults to learn, in addition to its use in medical rehabilitation. The usage of AR technology in a variety of industries and the release of mobile applications has piqued the curiosity of both domestic and foreign libraries to think about the expansion of library services using AR technology. The augmented reality library instruction system (ARLIS), created by Chen C. et al., delivers the same learning performance as

EMIS 2023, February 24-26, Chengdu, People's Republic of China

DOI 10.4108/eai.24-2-2023.2330639

traditional librarian education [2] and can take the place of librarian training in libraries with a shortage of staff. Yingqi T at Jacksonville State University guides and familiarizes library spaces, services, and subject librarians using an AR-based scavenger hunt app [19]. By scanning the QR codes on books with a mobile device's camera to complete automatic identification, the ShelvAR smart navigation tool, created by Professor Bo Brinkman, assists librarians at the University of Miami Library in setting up shelves and taking inventory [22]. Chiang C et al. used SearchAR to increase the capacity of older persons to search for books and films in the library [4]. However, the senior population can have trouble locating the book and video sections on the library map due to a lack of spatial awareness. Older folks, who are gradually losing bodily functions and have a limited ability to accept and acquire new technologies, have difficulties understanding the spatial layout of the library, traversing library resource information, book categories, and self-study spaces, and there is an urgent need to improve the library navigation service.

Only a few studies have been conducted on the use of AR technologies in libraries for the senior population. It is challenging for older groups to use AR technologies due to the need for developing elderly people-centered technologies, the fight against age-related decline, and a propensity to deliver a bad user experience [4]. Transforming and upgrading the layout of public library facilities, as well as developing elderly people-centered platforms [20], are required by combining new technologies with the library's technological capabilities, basis, and actual demands [18].

An important factor in the development of the AR library navigation system is the physical and cognitive abilities of the elderly. At the same time, the user experience must be taken into account during the system development phase. In light of this, this paper develops an AR-based library navigation system taking into account the experience of older users, which aids in the acceptance and understanding of AR and VR technologies by elderly persons via mobile applications. Using 3D modeling and AR technology, the system can improve senior users' spatial awareness while also giving them quick and accurate navigation of the library's layout and book classification, among other things.

2 MANUSCRIPT PREPARATION

2.1 Implementation Methods

This paper develops an AR library navigation system for mobile applications primarily using Unity3D, Vuforia, 3ds Max, and Playmaker. As illustrated in Figure 1, the implementation is separated into five parts: model design and construction, database formation of markers, interaction design and development, system testing, and system release. The library's façade and floor plan are modeled using the 3ds Max, which is capable of both modeling and rendering. Vuforia, a software development kit for AR apps for mobile devices, is used to complete the f database formation of markers as it can identify a wide range of markers at one time and recognize photos, text, and 3D models with high recognition accuracy and speed.

Together, Unity3D and Playmaker realize interaction design and development, system testing, and system release. Unity3D is the world's leading development platform. It features superior cross-platform interoperability, 3ds Max modeling capabilities, and Vuforia SDK import. The system generates an installation package for Android, so elderly users don't have any additional hardware costs. The interactive features of this system are realized via the logical framework of the state machine FSM (Finite state machine) of Playmaker.

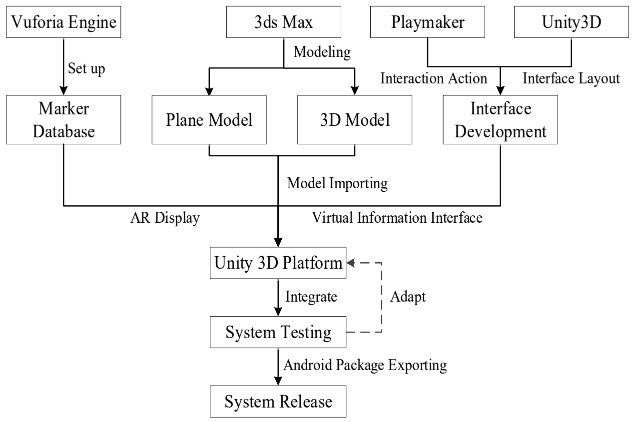

Figure 1: This caption has one line so it is centered.

2.2 Key Technologies

The core of the AR library navigation system is the AR display. The elderly user gathers image data from their smartphone camera, which is then linked with the marker database. After a successful pairing, the 3D model or other target objects bound in unity3D are output in the corresponding place to achieve the integration of virtual and real information. The key technologies of this system include registration tracking technology, 3D modeling and human-computer interaction technology.

(1) Registration Tracking Technology

The registration tracking technology is the most crucial component of AR display. In order to render virtual information in a position that corresponds to real information, registration involves creating 3D coordinates of the virtual information in the real one. Tracking is the merging of virtuality and reality, the re-creation of 3D coordinates depending on changes in the real information. Vuforia SDK is a software processing technique that uses registration tracking technology and examines the library marker map for feature information such as shape, color, and texture, in order to achieve the registration and tracking of library resources.

(2) Display Technology

One of the important components of AR is display technology. Common display devices include projection displays, mobile displays, and display devices for helmets. Since AR display devices tend to be lightweight, handheld displays are mostly used in this system. Handheld display devices, more popular than other devices, are equipped with a variety of sensors such as cameras, positioning systems, and gyroscopes, among others.

(3) Human-Computer Interaction Technology

In terms of user input, voice interaction, physical engagement, and touch interaction are common human-computer interaction technologies. With the use of the popular touch interaction, which is more in line with elderly users' everyday routines, human-computer interaction serves as a direct route for the exchange of information between elderly users and the system. Fingers are used to tap and slide across the screen of the mobile device to navigate.

3 THE DESIGN CONCEPT OF USER EXPERIENCE

3.1 Characteristics of Senior Users' Demands

Physiological characteristics of elderly users: Elderly persons typically begin to lose their physical abilities slowly, and their senses of sight, hearing, and touch gradually deteriorate leading to a weakened perception of the outside world. Behavioral characteristics: The elderly frequently exhibit predictable behavior, and since their behavior is influenced by both internal and external factors, they are slower to act and react; Cognitive characteristics: The memory speed, memory capacity, and cognitive ability of the elderly are all decreased. In large indoor spaces like libraries, museums, and exhibitions, it can be challenging for the elderly to get information about location resources, and not being able to immediately grasp the layout of the space can cause unease and anxiety. The AR library navigation system should take into account the functional, psychological, security, and social demands of elderly users, as indicated in Figure 2, in accordance with Maslow's hierarchy of needs theory and the demands of elderly users.

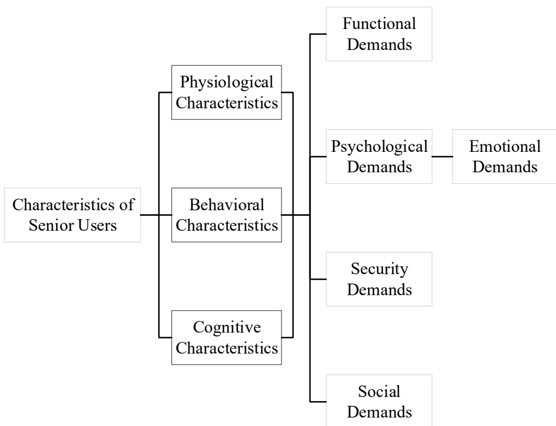

Figure 2: Characteristics of Senior Users' Demands

3.2 The User Experience Design AR Library Navigation System

The practice of designing for the user's ideal experience and the potential for a positive one is known as the so-called user experience design [21]. In order to gather opinions from academics, businesses, and users about user experience in the cell phone industry, Park J et al. employed literature research, user interviews, and observations. They suggested usability, emotion, and user value as the key components of user experience [17]. This paper considers user experience as a broader concept than usability and classifies the user experience design of the AR library navigation system into three levels, i.e., usability, emotional experience and value experience.

Ease of use, effectiveness, ease of understanding, usefulness, and satisfaction are sub-elements of usability. The user interface of the AR library navigation system for seniors needs to be straightforward, uncomplicated, and simple to learn. This will simplify the content of the virtual information interface, give seniors accurate information about the library resources, and increase system usage effectiveness. Entertainment, fun, and attractiveness are the sub-elements of emotional experience. Basic human needs are easily met, while aesthetic and emotional considerations are frequently crucial criteria when picking a product or service [21]. Products can evoke emotions in three different ways, according to Forlizzi J et al.: (1) as stimulants for fresh emotional experiences, (2) as expansions of already existing emotional experiences, and (3) as previous emotional experiences [8].

AR displays can be used as a stimulus for new experiences and as a catalyst for new emotional experiences, enhancing the appeal to older users in terms of color design and tactile interaction. At the same time, it brings entertainment and fun to older users.

Trust, novelty, and enjoyment are the value experience's sub-elements. The fully unique user experience that mobile AR applications offer is unusual in and of itself, and it can instill a sense of value in elderly consumers. While the experience is an implicit component that is difficult to simply describe and express explicitly, the needs of elderly users in terms of AR library characteristics and user experience design levels are examined from two angles [15]. The explicit way of expression and design of it is attempted, as shown in Table 1.

Table 1: The User Experience Design AR Library Navigation System

Usability	Ease of Use	Simplification of the system's user pages
	Effectiveness	Accurate information on library resources for older users
	Ease of Understanding	Shorten the length of study and depletion of energy
	Usefulness	Addressing the needs of elderly users looking for information in the library
	Satisfaction	Satisfaction for elderly users
Emotional Experience	Fun	System content, colors, images, and other displays provide an emotional experience for elderly users
	Entertainment	
	Attractiveness	
Value Experience (User Value)	Trust	Provide services that exceed the expectations of older users and increase their trust in the system
	Novelty	Novelty and uniqueness of new technologies of the system
	Enjoyment	Vibrant system interaction brings pleasure and vitality
	Enjoyment	Vibrant system interaction brings pleasure and vitality

4 THE REALIZATION OF AR LIBRARY NAVIGATION SYSTEM FOR THE ELDERLY BASED ON USER EXPERIENCE

4.1 Content Design

The foundational principle of the system design and realization is the content design of the AR library navigation system. The system's content design has an impact on the model design, marker database, and interaction techniques. To lessen the difficulty of access, basic and immediate information presentation should be chosen as much as possible. This is in accordance with the physiological, behavioral, and cognitive features of elderly users and analysis of the user experience hierarchy. The largest issue facing seniors aged 60 and over is that "the digital reading medium is too complex to operate" [14], and the way content is displayed can help enhance the system's usability. Given that "convenience" is a key motivator for the majority of customers [16], libraries can take into account the accessibility, time, and geographical convenience of library use [23]. As a result, the system combines AR displays and virtual information interfaces for browsing and accessing resources and information, enabling elderly users to instantly access resource information inside or outside of libraries, direct book categories and study areas, experience the system's convenience, and finally realize the possibility of providing elderly users with a positive user experience

4.2 Model Design and Construction

The model in this system is built with 3ds Max to deliver accurate information about library resources for elderly users. A 3D model is the most effective approach to display augmented reality and may display a variety of resource information. The model comprises the appearance of the library and the distribution of resources on five floors, using the architecture and layout of the library at Liaoning Technical University's Huludao Campus as a reference. The scene also includes visual features like colors and authentic-looking buildings. This system chooses green as the base color and white as the auxiliary color based on the easy-to-read color-matching sequence.

The specific process is as follows: The appearance Plane model for the library is built first. The appearance Plane model for the library is built in 3ds Max using the library's actual size as a guide. PS is employed to produce the library appearance, which was adjusted to match the Plane model and improve the library building's vividness, as seen in Figure 3. Second, a 3D model of the resource distribution on each floor of the library has to be created. For the layout, a plane the same size as the Plane model is built, the first-floor plan of the library is then imported into the plane, and the wall is sketched out with sample lines according to the scale of the plan, ignoring the redundant lines in the original plan and "attaching" the lines as a whole and "extruding" them to a certain height. The ground, text labels, and others were built with 3ds Max's self-contained 3D objects. Based on the 3D model for the first floor, the 3D models for the other four are altered and modified, as seen in Figure 4. The library appearance Plane model and the five-floor 3D models are exported into the format of ".FBX " in 3ds Max before being imported into Unity3D for model and text label adjustments.

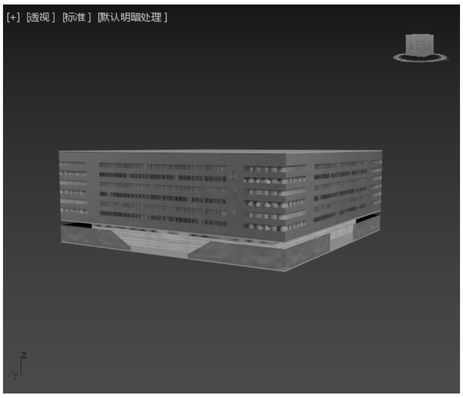

Figure 3: The Appearance Plane Model for the Library of Liaoning Technical University (Huludao Campus)

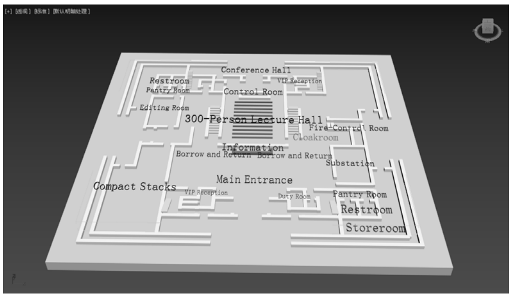

Figure 4: The 3D Model for the First Floor of the Library of Liaoning Technical University (Huludao Campus)

4.3 Database Creation for Markers

Application for license (License Manager) is required at the Vuforia website in order to obtain the license key of the AR library system for Vuforia SDK-based AR development. The system can manage the marker database for images, rectangles, cylinders, round tables, and 3D objects through Target Manager on the Vuforia website. In order to create the marker in the library and upload it to the Target Manager database, this paper chooses the QR code as the image target, as illustrated in Figure 5. To compress the marker database for import into Unity3D and make it simple to subsequently match and modify the model and map, check "Upload Image", click "Download Database", and then choose "Unity Editor".

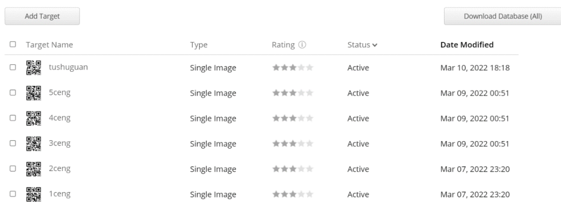

Figure 5: The Images in the Marker Database to Be Recognized

4.4 Interaction Design and Realization

To better guide senior users in interacting, the system's interface should be simple, easy to learn, and incorporate commonly used and diversified interaction methods. The interactive function is achieved using Unity3D and Playmaker. Unity3D has a comprehensive UI framework, and the UI used in this paper mostly consists of Canvas, Button, and Text. Touch Event, Activate Game Object, Rotate, Load Level, and Application Quit are interactive functions provided by the Playmaker visual programming plug-in. The system includes three scenes: library overview, floor guide, and augmented reality display, with the book classification scene coming later. Scene switching is primarily accomplished through Scene loading. The following are the specific steps.

(1) Create three scenes in Unity3D, with the name "Scene 1" (library overview), "Scene 2" (floor tour) and "Scene 3" (AR display), then add Canvas components appropriately, and click "Canvas" to establish parameters with the scaling option of UI being "Scale with Screen Size". Canvas must be used to display UI components, while Scene1 is used to generate "Button" components such as "Library Introduction", "Floor Tour", "Book Category", "Camera", "Back" and "Exit". The "Inspector" panel controls the position, color, size, and other aspects of the UI interface's visual style. The base color of the "Button" component is configured to be that of the system. The "Camera", "Back", and "Exit" components are added using common control icons, and the "Text" component under the "Library Introduction", "Floor Guide", and "Book Category" is configured with relevant names. Similar to how the "1F" to "5F" and "Back" components are formed in Scene 2 and Scene 3, respectively, the "Back" component is built in Scene 3. To improve the three-dimensional effect of the UI, the components are rotated by a specified angle and the skybox in Unity is rendered, as illustrated in Figure 6.

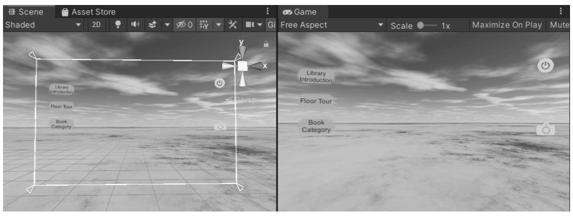

Figure 6: Some Screenshots of the UI Interface

(2) AR Display: The system's centerpiece and focal point are the AR display. Senior users can engage with the model by identifying the image to comprehend the information about library resources and foster their interest in the system. The first step involves importing the appearance Plane model, 3D models for floor guides, and marker database into Scene and removing the "Main Camera" and replacing it with "ARCamera" in Scene 3. Then, to use the Vuforia SDK for recognition, click "ARCamera" and then locate "APP License Key" to enter the license key in the "Inspector" panel. The second step involves using the Vuforia Engine to create 5 "Image Targets" under the "ARCamera," choosing "Image Recognition" from the "Inspector" panel, and placing the Plane model and 3D models for the floor guide into each of the 5 "Image Targets" in the appropriate locations. The image target and model can then be adjusted in terms of size and position, as shown in Figure 7.

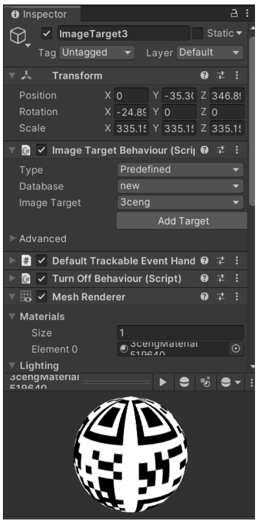

Figure 7: Inspector Panel Settings for Image Recognition

(3) Model Activation and Return: Elderly users can press the button to activate the model and return to the UI. Playmaker can be used to develop this kind of interactive feature. Taking the library introduction button as an example, the first step is to create the Playmaker FSM, the library introduction button. To do that, the Plane model should be imported into Scene 1, and then change its position on the Canvas and undisplay it, and then select the "Library Introduction" button from the Hierarchy menu, then click "Playmaker" to add the state machine. Then, click "Events" to set up two events (the events must be named as letters or numbers), entitled "Plane model" and "Return" and add the events into the state machine. The "Plane model" event leads the plane model state to be created. To do so, one can click "State" → "Action browser" → "Activate Game Object", and select the "Plane model" as "Specify Game Object”, and check "Activate". In the same way, continue to add "Activate Game Object”, select the return button as "Specify Game Object”, and check "Activate". The "Return" event leads to the creation of the return state. To do that, one can first copy the two "Activate Game Objects" in the plane model state to the "State", and uncheck "Activate". The second step is to set the runtime status: select the "Library Introduction" button, go to "On Click" → "Runtime" in the Inspector panel to add the button. To select the function, go to “Playmaker FSM" → "SetState (string) ", and add the state of the plane model. Similarly, the return state can be added and the model activation and return can be realized within the logical framework.

(4) Model Rotation, Scene Switching and System Exit: The model will appear on the mobile terminal's screen once it has been activated. Senior citizens can rotate the model and speed its rotation by clicking or moving one finger, which is realized by the "Touch Event" and "Rotate" of the Playmaker. Figure 8 illustrates the Playmaker FSM's logical structure. To load Scene 2 (floor tour), use "Load Level" and "Application Quit" in Playmaker. When the "Floor Tour", "Camera", and "Exit" buttons in Scene 1 are clicked, Scene 2 (floor tour) scene, Scene 3 (AR display), and the exit system are all loaded.

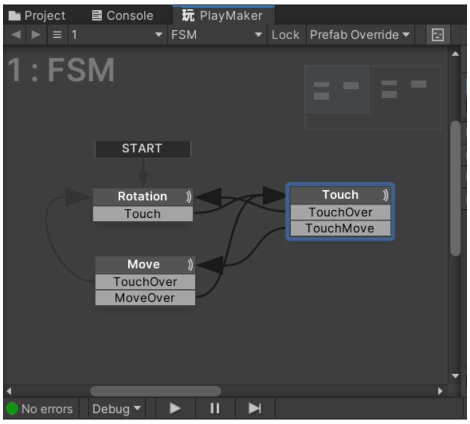

Figure 8: The Logical Framework of the Rotation Feature in FSM

4.5 System Testing

Figure 9 illustrates the result after clicking the "Run" button on the Unity3D platform for testing and interacting with the visual elements in the Game. The AR navigation system will be packaged for mobile testing, and Scene 1, Scene 2, and Scene 3 will be moved into "Build Settings". After clicking "Build", the Android installation package will be exported and then imported into the cell phone for installation and testing, as shown in Figure 10. In order to provide some concepts for the subsequent development of book classification, the initial study of the AR library navigation system is conducted.

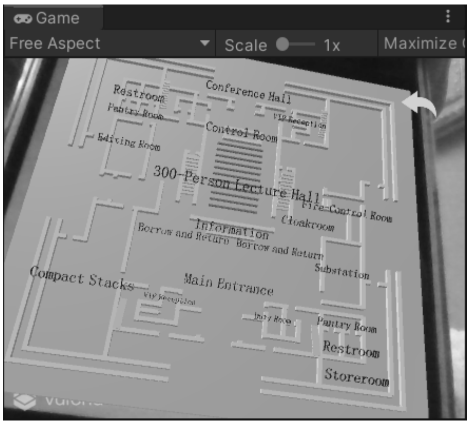

Figure 9: The Testing Result on Unity3D

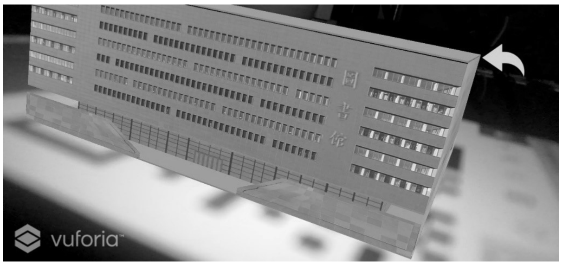

Figure 10: The Testing Result on Mobile Devices

5 CONCLUSIONS

This paper presents an AR library navigation system for elderly users, takes into account the characteristics of elderly users and user experience demands, creates an initial user experience hierarchy analysis of the AR library navigation system, and completes the system's content, model, and interaction design and development. The flexibility and convenience of presenting text, models, and photos, among other things, are improved by the combination of AR display with a virtual information interface. The system's instant, effective, novel, and above-expectation qualities are reflected in the successful testing on Unity3D and mobile devices. These features enable senior users to understand the appearance and layout of the library, direct the classification of books, direct the location of the self-study area, and provide other types of resource information without space limitation. It aids in bridging the digital divide and enhancing the special qualities and experiences of library touring services. It gives a fresh reference for improving the experience of AR technology and library tour services for elderly users. In order to further improve the system's design and development in future research and practice, there are numerous more factors that require consideration: the system can personalize the service according to the subject background of elderly users; the system can combine with library search database to improve the development of book classification scenarios; the user experience is a service concept, and the system can create a better user experience in the service interaction between libraries and elderly users.

REFERENCES

[1] Alelis, G., Bobrowicz, A., & Ang, C. S. (2015). Comparison of engagement and emotional responses of older and younger adults interacting with 3D cultural heritage artefacts on personal devices. J. Behaviour & Information Technology. 34(11), 1064–1078.

[2] Chen, C. M., & Tsai, Y. N. (2012). Interactive augmented reality system for enhancing library instruction in elementary schools. J. Computers & Education, 59(2), 638–652.

[3] Chen, M. L., Tang, Q. F., Xu, S. J., Leng, P. F., L., & Pan, Z. G. (2020). Design and Evaluation of an Augmented Reality-Based Exergame System to Reduce Fall Risk in the Elderly. J. International journal of environmental research and public health, 17(19), 7208.

[4] Chiang, C. W., Liu, Y. H., & Wang, C. P. (2020). An elderly assistive device substitutes for traditional online library catalogs. J. The Electronic Library, 38(2), 223–237.

[5] Costas, B., & Simon, M. (2016). Augmented Reality Cubes for Cognitive Gaming: Preliminary Usability and Game Experience Testing. J. Int. J. Serious Games, 3(1), 3–18.

[6] Costas, B., Simon, M. (2016). Smartkuber: A Serious Game for Cognitive Health Screening of Elderly Players. J. Games for health journal, 5(4), 241–251.
[7] Fatemeh, G., Mahsa, F. T., & Mehdi, D. (2022). Towards an intelligent assistive system based on augmented reality and serious games. J. Entertainment Computing, 40, 100458.
[8] Forlizzi, J., Disalvo, C., & Hanington, B. (2003). On the Relationship between Emotion, Experience and the Design of New Products. J. The Design Journal, 6(2), 29–38.
[9] Han, K., Park, K., Choi, K. H., & Lee, J. (2021). Mobile Augmented Reality Serious Game for Improving Old Adults' Working Memory. J. Applied Sciences, 11(17), 7843.
[10] Hill, R., Betts, L. R., & Gardner, S. E. (2015). Older adults' experiences and perceptions of digital technology: (Dis)empowerment, wellbeing, and inclusion. J. Computers in Human Behavior, 48, 415–423.
[11] Jeon, S., & Kim, J. (2020). Effects of Augmented-Reality-Based Exercise on Muscle Parameters, Physical Performance, and Exercise Self-Efficacy for Older Adults. J. International Journal of Environmental Research and Public Health, 17(9), 3260.
[12] Ku, J., Kim, Y. J., Cho, S., Lim, T., Lee, H., & Kang, Y. J. (2018). Three-Dimensional Augmented Reality System for Balance and Mobility Rehabilitation in the Elderly: A Randomized Controlled Trial. J. Cyberpsychology, behavior and social networking, 22(2), 132–141.
[13] Lee, C. J., & Hus, Y. (2021). Promoting the Quality of Life of Elderly during the COVID-19 Pandemic. J. International journal of environmental research and public health, 18(13), 6813.
[14] Li, Y. Y., Huang, X. Y. (2020). Research on Digital Reading Promotion for the Elderly in the New Media Era. J. Digital Library Forum, (06), 62–67.
[15] Luo, S. J., Gong, R. R., & Zhu, S. S. (2010). User Experience-oriented Software Interface Design for Handheld Mobile Devices. J. Journal of Computer-Aided Design and Computer Graphics, 2010, 22(06), 1033–1041.
[16] Oates, L. 2007. *The book*, Service Marketing: Asian Edition. Kuo, S. D., Fan, S. S., & Lu, X. W., translators. Beijing, China Renmin University Press.
[17] Park, J., Han, S. H., Kim, H. K., Cho, Y., & Park, W. (2013). Developing Elements of User Experience for Mobile Phones and Services: Survey, Interview, and Observation Approaches. J. Human Factors and Ergonomics in Manufacturing & Service Industries, 23(4), 279–293.
[18] Sun, Z., Qi, X. C., & Sun, H. Y. (2021). Library Equipment Operation and Maintenance Supported by Mixed Reality Devices - the Application of Microsoft HoloLens in Libraries. J. Journal of Academic Library and Information Science, 39(03), 120–124.
[19] Tang, Y. Q. (2021). Help first-year college students to learn their library through an augmented reality game. J. The Journal of Academic Librarianship, 47(1), 102294.
[20] Tao, C. (2021). A Study on the Current Reading Situation and Strategies of the Elderly in Yunnan under the Background of "Active Aging". J. Journal of Academic Library and Information Science, 2021, 39(06), 30–35.
[21] Wu, Q. (2018). The Discernment of User Experience Design. J. Art & Design, 2018(10), 30–33.
[22] Yu, D. F. (2021). Survey and Analysis of Virtual Reality Services in American University Libraries. J. Digital Library Forum, (09), 49–55.
[23] Zhang, M. X., Qi, Y. L., Li, L. Q., & Jin, M. L. (2015). The Connotation of Library User Experience and Strategies for Improvement. J. New Century Library, (07), 10–13.