ISSN 2616-5775 Vol. 4, Issue 2: 83-90, DOI: 10.25236/AJCIS.2021.040215

Development Overview of Augmented Reality Navigation

Yuxiang Yao[1,a,*], Xinnan Zheng[1,b], Zheng Wang[1,c], Jiarui Jiang[2,d]

[1]BDIC, Bejing University of Technology, Beijing, China
[2]Information Science Department, Beijing University of Technology, Beijing, China
[a]yaoyuxiangyyx2009@126.com, [b]2966045046@qq.com, [c]zheng.wang@ucdconnect.ie, [d]judy_jjr@126.com

Abstract: *At present, with the increasing computing power of mobile phones, the wide application of AR technology in mobile phones has been realized. AR technology is not only used in mobile games, medical, video entertainment and other fields, but also become more and more popular in the perspective of navigation. This paper will firstly describe the development history of AR and related background knowledge, and focus on the application of AR technology in the field of navigation. Finally, it will discuss the development prospects and possible difficulties of AR+Navigation.*

Keywords: *Augmented Reality, Navigation, Mobile phones*

1. Introduction

1.1. Definitions & Development History of Augmented Reality

1.1.1. Definitions of Augmented Reality

Increased Perception software is used to seamlessly integrate data from the real world and knowledge from the virtual world (Arth, Grasset, Gruber, Langlotz, Mulloni & Wagner (2015)). This takes sensory knowledge (visual information, noise, taste, touch, etc.) that is hard to perceive in the real world in a certain time and space distance and extends it to the understanding of man.

Augmented Reality not only displays information from the real world, but also also depicts the digital information (Arth, Grasset, Gruber, Langlotz, Mulloni, Schmalstieg & Wagner (2015)). In this scenario, viewers can see the real world around it to synthesize the real world and computer graphics. Enhanced realism incorporates animation, 3D rendering, real-time video analysis and control, multi-sensor fusion, real-time tracking and recording, scene fusion, and other new technologies and techniques. Augmented Reality generally provides different human perception data.

Figure 1: Pokemon GO: one famous AR Game

1.1.2. Development History of Augmented Reality

1) The name AR was formally coined in 1992: Tom Caudell and his collaborators were designing head-mounted display systems that allow engineers to install complicated wiring harnesses on a circuit board utilizing virtual augmented reality diagrams superimposed on it. It greatly simplifies devices that historically used a large number of inflexible printed circuit boards as they virtualize wiring diagrams.

2) AR technology's first performance in 1994: AR technology was first used in art this year. A show

ISSN 2616-5775 Vol. 4, Issue 2: 83-90, DOI: 10.25236/AJCIS.2021.040215

called dancing in cyberspace was designed by artist Julie Martin. As a real existence, dancers communicate with the digital material displayed on stage, interacting between the virtual environment and the objects, which is a very good interpretation of the AR theory.

3) In 2000, the first AR game was born: Bruce Thomas Team released Arquake (Piekarski & Thomas (2002)), which is an extension of popular computer game. Arquake is based on the tracking system. The user carries a backpack of a wearable computer, an HMD and an input device with only two buttons.

Figure 2: Arquake

4) 2012, Google AR goggles:: the Augmented Reality glasses were revealed by Google in April 2012. It kind of Augmented Reality head-wear system projections mobile data to the face of the consumer and can also communicate directly via the app. Of note, with augmented reality engineering, Google glasses are far from becoming a breakthrough, but it has rekindled public interest in augmented reality.

1.2. Applications Area of AR

▪ **Retailing Areas:** Customers want to try on clothes, shoes, glasses or anything else they wear before they buy them. Similarly, when customers buy furniture, some customers will want to see what the furniture looks like at home. It was difficult to achieve, but now we can do that with AR. As the popularity of devices supporting AR applications (such as mobile phones and tablets) is very high, the growth rate of AR is faster. Amazon is one of the first brands to introduce AR technology (Bonetti et al. (2018)). Using AR allows consumers to ”try on” clothes online, providing unprecedented convenience for online shopping consumers.

▪ **Architecture Areas**: In architecture areas, AR allows architects and clients to see the three-dimensional architecture and interior design at any stage of construction, visualizing the entire building. In addition, AR technology can also help identify errors and problems in the job and point out the problems before they become difficult to correct. Augmented reality can also assist in the maintenance of buildings and facilities (Doswell (2006)). Service manuals with interactive 3D animation and other instructions can be displayed in the physical environment through augmented reality technology.

▪ **Tourism Areas**: With the help of AR technology, tourism brands can provide a immersive experience for potential tourists. With AR technology, agents and destinations can provide visitors with more information and signposts. AR applications can help holidaymakers navigate the resort and understand their destinations (Kounavis et al. (2012)). Gansu Provincial Museum introduces AR interactive technology into the exhibition. When the audience uses the mobile phone camera to identify the cultural relics, the cultural relics can further present the ”living state”.

2. AR Navigation Discussion

2.1. Basic Introduction of AR Navigation

The cross platform indoor and outdoor AR navigation solutions based on AR technology meet the indoor and outdoor AR real scene navigation requirements of scenic spots, shopping malls and other scenes. Put in one simply way, AR navigation is the combination of AR technology and navigation function, through the mobile phone camera can see the panoramic route and destination location. The user’s travel route is displayed in the mobile phone camera in real time, so it is unnecessary to check the map repeatedly. Specifically, the mobile phone camera is opened through the map application to display the real road scene, and then the calculated navigation landmarks / instructions are overlaid on the real scene to realize panoramic navigation.

2.2. Motivation for Using AR Navigation Applications

The benefits of increasing routing truth might seem simple, but we will explain them:

ISSN 2616-5775 Vol. 4, Issue 2: 83-90, DOI: 10.25236/AJCIS.2021.040215

▪ **Interest of visitors:** You can plan cool city tours with mixed reality. For example, if a person takes advantage of the AR Navigation application with a traveling mode in the sight of monuments or historical structures, the device shows information on a specific cultural location, such as a brief overview, video and photographic content, etc.

▪ **Time-saving**: Applications with increased routing capabilities often help pave the fastest path to the destination. In addition, such programs will provide real-time data on traffic delays.

▪ **Safe**: The new programs improve driving safety. To do this, a particular procedure must be used, scanning the area around and measuring the distance to points inside the eye (to send a timely signal if necessary).

2.3. Techniques to Support AR Navigation

The technology of AR displaying information is similar to HUD, and its key lies in the real-time combination of virtual information and real scene:

2.3.1. High Precision Navigation and Positioning

AR navigation requires high positioning accuracy and real-time performance. For example, it is only possible to identify which lane the vehicle is in or whether it has pressed the line almost without delay, which undoubtedly needs the help of 5G communication technology.

2.3.2. Real Time Traffic Monitoring

Only cloud data is not enough. Scanning and processing of real-time road conditions is also one of the necessary conditions for AR navigation. The real-time traffic information can be obtained from two aspects (Ferrier et al. (1994)):

1) The traditional road condition information detection method is to install ground sensing coil, speed radar and video monitoring tools on the main road of the city. These devices are mainly used to detect the road occupancy rate, traffic flow, speed and other traditional road information.

Figure 3: Video Monitoring Tools

2) Road condition information monitoring based on GPS: For example, the GPS terminal on taxi will send information to the monitoring center every certain time (10s-30s), including the location information, speed, driving direction and so on. When there are enough taxis equipped with GPS terminals, a dynamic and real-time road information monitoring network is formed in the whole city.

2.3.3. AR Integrated Algorithm

Combining all kinds of information with the real scene, and finally presenting the navigation instructions on the screen accurately and accurately, this task mainly tests the algorithm and computing power of the machine. In the current algorithm, the core is 3D object recognition and 3D scene modeling. In particular, in 3D scene modeling, we need to solve the problems mainly including: identify what is in the scene, their spatial location and interrelationship, etc.

Especially, when AR and navigation technology are combined, we need to involve one of the important technologies: SLAM, Simultaneous Localization And Mapping (Durrant Whyte & Bailey (2006)): by scanning a scene, and then superimposing virtual battlefield and other 3D virtual content. If only based on ordinary 2D image recognition, there is a need for specific pictures, and the recognition fails when the picture is not visible. In SLAM technology, even if a specific plane does not exist, spatial positioning is still very accurate because of the help of surrounding 3D environment.

SLAM process is completed by several steps. The main purpose of SLAM is to update the position information of robot by using environment. The general process includes landmark extraction, data association, state estimation, state update and landmark update.

It is not accurate to rely on the motion of the robot to estimate its position, because the odometer of the robot usually has some errors. Usually with the help of lidar and other ranging equipment to obtain environmental information and odometer information fusion, so as to obtain the position of the robot more accurately. There are many ways to implement it. EKF is a common SLAM implementation (Bailey et al. (2006)). EKF is the core of SLAM. It continuously estimates the position of the robot and the surrounding environment information, and estimates the position of the robot accurately through iterative operation. The following is a simple process description of SLAM.

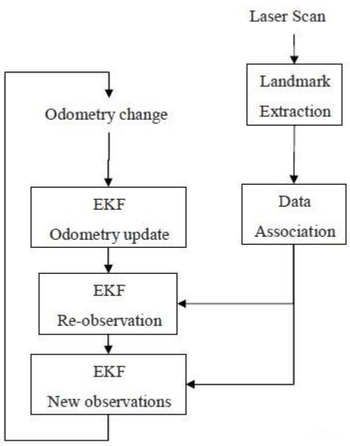

Figure 4: SLAM Process

It should be noted that the research on computer vision, which is closely related to AR, can be divided into two directions: one is based on deep learning, such as feature extraction and feature analysis; the other is based on geometric vision, which deduces the spatial structure information of objects from lines, edges and 3D shapes. The representative technology is SFM / SLAM (Weingarten & Siegwart (2005)). In the direction of deep learning, it occupies the main advantage, but in the fifield of geometric vision, there is little progress. At the SLAM technology symposium organized by ICCV in 2015, based on the rapid development of deep learning in other fifields of vision in recent years, some experts have proposed the possibility of using deep learning in SLAM, but there is no mature idea. Generally speaking, it is a worthy research direction to integrate deep learning and slam in the short term.

2.4. AR Navigation Examples

2.4.1. AR Navigation on IOS

With the release of IOS 11, owners of the newest iPhones got access to applications built on ARKit - a toolkit which simplifies the process of working with augmented reality.

Moreover, it is now possible to navigate the area using AR. You need to do the following: first of all, run maps in IOS (11 and higher) and make sure you see the blue dot. Now you have to specify the address, and the application will build the route. Next, you should click ”View in AR” to call the locator and the image from the camera.

Figure 5: iPhone AR Maps

ISSN 2616-5775 Vol. 4, Issue 2: 83-90, DOI: 10.25236/AJCIS.2021.040215

2.4.2. AR Navigation on Yahoo Maps

Around one year ago, by adding the AR module to the Japanese Yahoo office changed its IOS charts. Thus, the AR Software with true view navigation is available today for Japanese consumers.

The developers approached the concept of using computer graphics in a real world creatively and used ARKit. The consumer leaves marks (or footprints) and sees distance markers.

It's only operating in Japan (with local maps) but of course it's only the beginning. Yahoo will make every attempt to boost the AR experience worldwide (and thus to draw more GPS users).

Figure 6: Yahoo AR Maps

2.4.3. AR Navigation on Google Maps

GPS specifies the device position in general. Though we can not be sure that a system of this sort would produce an effective outcome when dealing with near town growth. Google wants to use this camera to address this issue and to incorporate user interface in AR.

By matching the picture with images from Streetview database the service already recognizes and determines estimated coordination more specifically. During the course of the trip the user showed tips on the real world in his Google GPS navigation software. These tips tend to be arrows showing instructions.

Google alerts people not to go out on the streets without taking your eye off your phone in order to deter all types of crashes and other awkward situations: immediately after AR mode is launched, an alert appears, and if there is no subsequent response, the screen brightness reduces instantly

3. Potential & Limitations of AR Navigation

3.1. Basic Introduction of AR Navigation

3.1.1. AR Navigation in Commercial Space

AR navigation for commercial space (such as shopping mall). Based on this scheme, shopping malls can provide accurate indoor navigation services for consumers (Zhu et al. (2004)).

After the navigation system is connected with the shopping mall operation system, it can provide AR navigation, AR landscape, AR red packets, AR games and other space interactive experience in the mall, continuously guide the offline shopping malls, realize the online and offline traffic interchange, and promote the store sales transformation.

Figure 7: AR Applications in Commercial Space

ISSN 2616-5775 Vol. 4, Issue 2: 83-90, DOI: 10.25236/AJCIS.2021.040215

3.1.2. AR Navigation in Scenic Area & Exhibition Hall

Whether in scenic spots, museums or exhibition halls, the deployment of AR navigation can not only solve the problem of poor navigation experience in complex scenes (Wojciechowski et al. (2004)), but also realize a brand-new interactive experience of virtual and real integration such as AR virtual guide, 3D display of cultural relics, restoration of historical scenes, architectural readability, interactive games, AR treasure hunting, etc., which can effectively improve the line through deep connection with tourists in multiple dimensions.

Figure 8: AR Applications in Scenic Area & Exhibition Hall

3.1.3. AR Navigation in Airport & Railway Station & Hospital

Deployment of AR navigation in airports, high-speed railway stations, hospitals and parks with extremely complex spatial structure can easily and effectively solve the problem that the public are easy to get lost and the indoor navigation error (Bagassi et al. (2016)), which makes the public travel more convenient. In addition, it can also combine all kinds of product display, marketing activities, public welfare publicity with AR real scene navigation.

3.1.4. AR Navigation in Vehicle Compass

Using AR technology, combined with real-time scene, GPS, sensors (gyroscope, inertial navigation) and other technology, the real road situation captured by map and camera in real time is deeply integrated with AI algorithm. The virtual model, arrow, dotted line and other elements guide the users direction.

3.2. Development Limitations of Mobile AR Navigation

Even though AR technology have made great progress, there are still many problems in the current development, which will be illustrated in the following points (Van Krevelen & Poelman (2010)):

3.2.1. Slow Hardware Compatibility Coverage

The development of technology is inseparable from the upgrading of hardware. At present, the coverage of ARCore models is still very low. There are only 2 Xiaomi and 7 Huawei mobile phones supporting ARCore in China. It is difficult to see the large-scale application of Android mobile phones where the consumption is sinking in the short term. The coverage of ARKit is relatively wider, but it is also limited by the system and some model restrictions (IOS 11 or above, 6S or above), and some users are still unable to use it.

3.2.2. Technology Development Tends to Bottleneck

At present, as for mobile AR, most of the users can think of multi-user sharing, persistent experience, map storage, etc., and other technologies including scene recognition, virtual and real occlusion will not play a decisive role, so how will AR and VR technology break through in the next step? Many people think of AR cloud, but like maps, AR cloud needs a little bit of data and content to build. At present, there is no molding technology available, no unified content standards, no explosive content creation.

3.2.3. High Content Production Cost

As mentioned above, there are many reasons for the lack of explosive content creation, one of them is the high cost of content production. Based on the analysis of the current situation, most of the platform’s content relies on model, picture, audio, video and other serial connection to build a relatively rich scene to provide the user experience. The cost of producing these content is too high.

3.2.4. Homogenization of Entertainment Scene Content

In 2018, AR technology was applied to short video, camera, and live broadcast and other

ISSN 2616-5775 Vol. 4, Issue 2: 83-90, DOI: 10.25236/AJCIS.2021.040215

entertainment scenes. However, with the elimination of technical barriers, more and more products of the same kind have aligned functions, and the content presented to users has gradually become homogeneous. It can be seen that there are similar special effects playing methods in many different apps, and the user's shooting content is also the same. The gain effect of AR special effects on entertainment scenes is gradually weakening.

3.3. Design Issues In AR Navigation Software

3.3.1. Design Issues Due to Software

From the view of product design, most of the current products holds on the opinion: ”AR Navigation = General Navigation + AR Module”. But in fact, AR Navigation and general navigation focus are completely different. It is not a simple function superposition, but the transformation of emphasis and use mode. For example, when users are using general navigation, the priority of the core function area is map first, followed by text information, and then some peripheral prompts. However, after adding AR module, the user's attention ranking list does not just insert the AR content into the first place, and the rest of the list will be arranged in turn. However, focusing on the content inside the AR alone will occupy 70% - 80% of the user's attention. Therefore, it is very important for AR Navigation and other AR Navigation products to better coordinate the important levels and usage of AR content and other functions.

3.3.2. Design Issues Due to Hardware

In terms of technology implementation, as the main carrier of AR Navigation is mobile phones, mobile phones can achieve good support for AR technology due to the rapid change of mobile phones. However, the support range of different machines is not exactly the same: for example, in the iPhone 12 pro, the ”matting” ability in AR display is realized due to the equipped lidar, but the iPhone 12 cannot achieve this capability because it is not equipped with a lidar

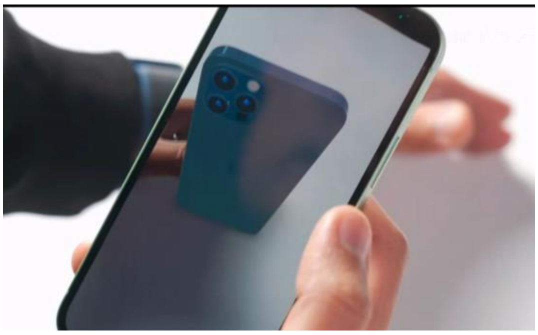

Figure 9: AR in iPhone 12

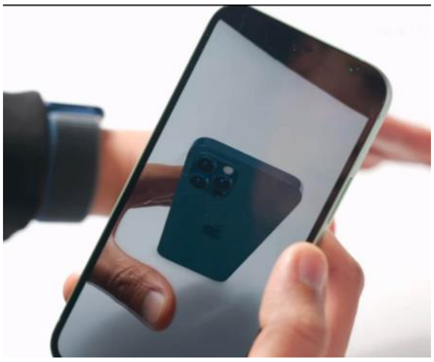

Figure 10: AR in iPhone 12 Pro (with Lidar)

4. Conclusion

AR Navigation systems based on AR technologies satisfy real-time criteria of scenic areas, shopping centers and others indoor and outdoor AR cross-platforms. Users' travel route is shown in real time on the mobile phone camera. According to the research, it is not difficult to see that the combination of AR and navigation shows vitality and considerable business profit margin in many fields. Through vivid display, more information can be displayed to users in the way of AR. Three core technologies support

ISSN 2616-5775 Vol. 4, Issue 2: 83-90, DOI: 10.25236/AJCIS.2021.040215

AR Navigation: High Precision Navigation and Positioning & Real Time Traffic Monitoring and AR Integrated Algorithm (specially SLAM). At present, AR Navigation has been realized in many scenarios, which proves its wide development potential and commercial value.

But at the same time, the research also pointed out that: AR Navigation in the past period of time development also showed some shortcomings and development bottlenecks: mainly reflflected in the product design and technical development. In the foreseeable future, we need not only breakthrough in AR technology, but

References

[1] Arth, C., Grasset, R., Gruber, L., Langlotz, T., Mulloni, A. & Wagner, D. (2015), The history of mobile augmented reality', arXiv preprint arXiv: 1505.01319 .

[2] Arth, C., Grasset, R., Gruber, L., Langlotz, T., Mulloni, R., Schmalstieg, D. & Wagner, D. (2015), The history of mobile augmented reality developments in mobile ar over the last almost 50 years'.

[3] Bagassi, S., De Crescenzio, F., Lucchi, F. & Masotti, N. (2016), 'Augmented and virtual reality in the airport control tower'.

[4] Bailey, T., Nieto, J., Guivant, J., Stevens, M. & Nebot, E. (2006), Consistency of the ekf slam algorithm, in '2006 IEEE/RSJ International Conference on Intelligent Robots and Systems', IEEE, pp. 3562–3568.

[5] Bonetti, F., Warnaby, G. & Quinn, L. (2018), Augmented reality and virtual reality in physical and online retailing: A review, synthesis and research agenda, in 'Augmented reality and virtual reality', Springer, pp. 119–132.

[6] Doswell, J. T. (2006), Augmented learning: context-aware mobile augmented reality architecture for learning, in 'Sixth IEEE International Conference on Advanced Learning Technologies (ICALT'06)', IEEE, pp. 1182–1183.

[7] Durrant-Whyte, H. & Bailey, T. (2006), Simultaneous localization and mapping: part i', IEEE robotics & automation magazine 13(2), 99–110.

[8] Ferrier, N. J., Rowe, S. & Blake, A. (1994), Real-time traffic monitoring. in 'WACV', pp. 81–88.

[9] Kounavis, C. D., Kasimati, A. E. & Zamani, E. D. (2012), 'Enhancing the tourism experience through mobile augmented reality: Challenges and prospects', International Journal of Engineering Business Management 4, 10.

[10] Piekarski, W. & Thomas, B. (2002), 'Arquake: the outdoor augmented reality gaming system', Communications of the ACM 45(1), 36–38.

[11] Van Krevelen, D. & Poelman, R. (2010), 'A survey of augmented reality technologies, applications and limitations', International journal of virtual reality 9(2), 1–20.

[12] Weingarten, J. & Siegwart, R. (2005), Ekf-based 3d slam for structured environment reconstruction, in'2005 IEEE/RSJ International Conference on Intelligent Robots and Systems', IEEE, pp. 3834–3839.

[13] Wojciechowski, R., Walczak, K., White, M. & Cellary, W. (2004), Building virtual and augmented reality museum exhibitions, in 'Proceedings of the ninth international conference on 3D Web technology', pp. 135–144.

[14] Wu, H.-K., Lee, S. W.-Y., Chang, H.-Y. & Liang, J.-C. (2013), 'Current status, opportunities and challenges of augmented reality in education', Computers & education 62, 41–49.

[15] Zhu, E., Hadadgar, A., Masiello, I. & Zary, N. (2014), 'Augmented reality in healthcare education: an integrative review', PeerJ 2, e469.

[16] Zhu, W., Owen, C. B., Li, H. & Lee, J.-H. (2004), 'Personalized in-store e-commerce with the promopad: an augmented reality shopping assistant', Electronic Journal for E-commerce Tools and Applications 1(3), 1–19.