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Design of Immersive and Interactive Application Based on Augmented Reality and Machine Learning

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***Abstract*—In view of the current situation of information expression in passive two-dimensional display space, from the perspective of improving users' willingness to use space, Augmented Reality technology is integrated with virtual space containing rich information, supplemented by Machine Learning to construct an immersive environment with interactive function. Under the integrated development environment of Unity3D, Vuforia, ARCore and Arm NN are adopted to integrate virtual information with markers, and applications with functions of image recognition, plane recognition, object recognition and command interaction are designed. The design scheme is introduced, and the realization processes are discussed in detail. Test shows that the applications provide rich information with three-dimensional virtual-fusion display and natural way of interacting, which bring space immersion and good interactive experience to users. The immersive and interactive space improves the interactive experience and strengthens the effect of information transmission, which could be further applied to other fields.**

Keywords—Augmented Reality; ARCore; Vuforia; Arm NN

I. INTRODUCTION

Characteristic of current information stage is that the information is represented in the form of digitization by computer technology, and the information display stays at the level of passive two-dimensional space demonstration, such as PPT. The interaction of digital resources provided is poor, and the attraction to users is weak. Therefore, enthusiasm and initiative of users are insufficient [1-4]. As an important branch of Virtual Reality(VR), Augmented Reality(AR) is a technology that integrates virtual space containing virtual information with the real scene in three-dimensional virtual-real fusion mode. When camera scans the markers, virtual space will be displayed in three-dimensional virtual-real fusion, generating a good sense of immersion, the perception of the real scene is enhanced with the help of virtual information, and greatly improving visual experience of users. At the same time, it provides a natural interaction function with virtual information, endows users with initiative, stimulates the internal interest and motivation of use, enables users to actively immerse themselves, and improves the effect of information transmission [5-7].

AR application includes two aspects: hardware environment and software environment. The hardware environment is used for application running. There are two types of hardware: mobile and head-mounted devices. The representatives of the former are embedded devices with camera, such as smartphone and tablet. The latter includes Microsoft's HoloLens and Meta's Meta2. Considering that head-mounted equipment is expensive, and the technology is still being improved, while mobile device such as smartphone has been popularized. Android smartphone is adopted as the hardware in this paper.

The software environment is responsible for making virtual space, achieving three-dimensional virtual-real fusion display, and writing function scripts. Select Unity3D to generate virtual space, virtual-real fusion development packages adopting PTC's Vuforia and Google's ARCore. Vuforia supports 2D and 3D recognition, especially used to achieve image recognition. Therefore, an application which uses image as the marker is designed based on Unity3D and Vuforia. Considering that image marker is not everywhere, plane is chosen as the second marker. Vuforia's ground plane could be used for plane recognition, while in the test, it is found that its function is unstable, drift and jitter often occur, and the heat of the running device is high. ARCore is an AR SDK which can realize plane recognition, and Machine Learning could recognize object information in camera data. Arm NN applying YOLO V1tiny neural network models could build and run Machine Learning application on mobile device seamlessly. Therefore, an application with plane recognition and object recognition is designed based on Unity3D, ARCore and Arm NN [8-10]. C# is selected for programming language. Two kinds of markers improve the practicability of the applications, and the object recognition function enriches functions of the applications.

In this paper, applications based on AR and Machine Learning are designed. The structure is organized as follows: Section 2 presents design scheme. Section 3 describes design processes of image recognition in detail. Section 4 describes design processes of plane recognition in detail. Finally, Section 5 concludes the paper and points out significance of study.

II. THE DESIGN SCHEME

Applications design includes three parts:

(1) Make virtual space for three-dimensional virtual-real fusion display, including text, image, video, model, and other objects, generally designed in the format of prefab.

(2) Write scripts for markers and object recognition, which could recognize markers and object then display related virtual space and object name in three-dimensional virtual-real fusion mode.

(3) Write human-computer interaction script and users could interact with objects contained in virtual space. Interaction includes command interaction, space point interaction and special tool interaction, among which command interaction realizes interactive function through touching, zooming and other hand gesture actions as input commands, which is in line with human's usage habits. In this paper, command interaction is adopted, which offers users the initiative of information and promotes interaction.

A. The Design Flowchart

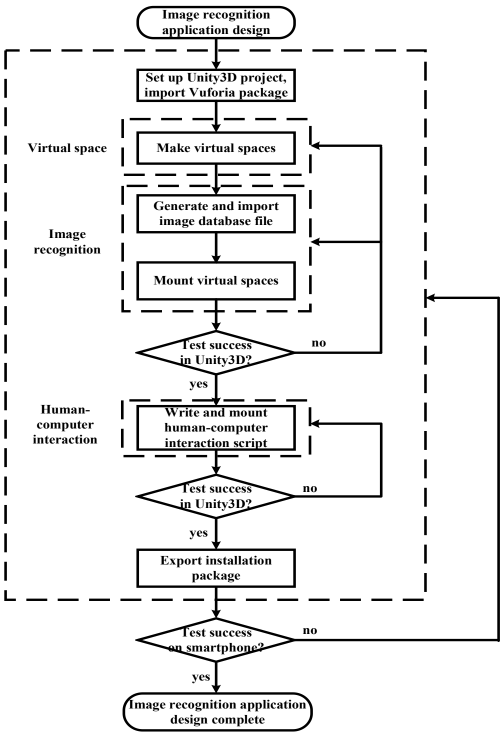

Fig. 1. The design flowchart of image recognition application.

As shown in Fig. 1, the design flowchart of image recognition application is as follows:

(1) Create a new Unity3D project for image recognition application, then new scripts and prefabs resources folders in the assets folder of project, after that import Vuforia package.

(2) Make virtual space of prefab format in Unity3D, then generate image database file on Vuforia official website and import file to project. Add ARCamera and ImageTarget to project. Put the License key copied from official website to ARCamera and mount virtual space for display on ImageTarget.

(3) Write and mount human-computer script on the related object contained in virtual space.

(4) After successful test in Unity3D, export the installation package and test on smartphone to complete application design.

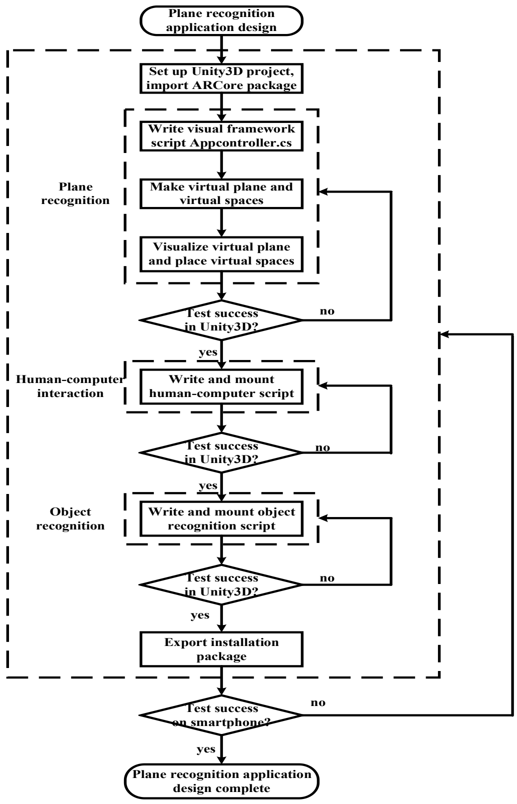

Fig. 2. The design flowchart of plane recognition application.

As shown in Fig. 2, the design flowchart of plane recognition application is as follows:

(1) Create a new Unity3D project for plane recognition application, then new scripts and prefabs resources folders in the assets folder of project. Import ARCore package then add ARCore Device, Environment Light and Event System to the project. ARCore Device is used to handle device-related events, and its first person camera is AR camera, which is responsible for tracking device status and rendering the background of scene. Environmental Light deals with light-related events such as direction, in-tensity, and so on. Event System provides functions of listening and processing event information.

(2) Make virtual plane and virtual space of prefab format in Unity3D. Write visual framework script Appcontroller.cs, then mount Appcontroller.cs on the object CONTROLLER and assign virtual plane and virtual space to the related parameters of Appcontroller.cs to achieve plane recognition.

(3) Write and mount human-computer script on the related object contained in virtual space. Write and mount object recognition script on the object ARMNN.

(4) After successful test in Unity3D, export the installation package and test on smartphone to complete application design.

B. *Issues For Attentiont*

(1) When camera dose not focus automatically on real-time detection, it may lead to the blurring of the scanned object, which will inevitably have a great impact on the recognition of the markers, and the performance of detection and tracking will be reduced. Therefore, automatic focusing operation should be carried out in Start and Update functions. There are several focus modes, such as FOCUS_MODE_TRIGGERAUTO , FOCUS_MODE_CONTINUOUSAUTO, etc. FOCUS_MODE_CONTINUOUSAUTO could be applied to Android and IOS devices. This mode is a continuous auto-focusing mode with switchable driver level, which is the best focusing mode for AR application and is adopted in this paper. If this mode is not available, FOCUS_MODE_TRIGGERAUTO could be used. However, the problem with FOCUS_MODE_TRIGGERAUTO is that most camera drivers will randomly choose one direction to focus, resulting in 50% probability of image defocused and then focused on the target. So in this mode the tracking may be lost for a while until camera provides a clear image again.

(2) In Vuforia, smartphone's rear camera is called by default. Considering the increasing popularity of devices equipped with front and rear cameras, if you need to use front camera, CAMERA_FRONT should be selected in the camera direction of AR camera.

III. The Design of Image Recognition Application Based on Unity3D and Vuforia

A. *Virtual space*

UGUI is Unity3D built-in system for virtual space development, including two basic objects Canvas and EventSystem. Canvas is a canvas, and all UI objects in the scene, such as Text, Image, are its child objects. If there is no Canvas in the scene, it would be automatically created when adding UGUI objects. Canvas could set UI rendering mode, which supports Screen Space-Overlay, Screen Space-Camera and World Space modes. Screen Space-Overlay would fill the whole space, and Canvas will always cover other three-dimension objects, resulting in objects such as three-dimension models cannot be observed. Screen Space-Camera mode is similar to World Space mode but can be adopted to display three-dimension models on the Canvas. World Space mode treats the Canvas as a normal object, which is no different from other objects. Screen Space-Camera mode is chosen in this paper. EventSystem is used to mount and listen for events. It is the event system for the entire UGUI, and it could also assign events for non-UGUI objects. EventSystem includes three essential components: Standalone Input Mod-ule, Touch Input Module and Event System. Standalone Input Module and Touch Input Module respond to standard input and touch input, respectively. Both mod-ules encapsulate calls to the Input Module. Event System is used to obtain and distribute events, and the parameters of the above three modules remain default values. The basic principles of EventSystem are as follows: m_SystemInputModules, m_CurrentInputModule and m_CurrentSelected variables are defined as the system input table, the current input module, and the currently selected object for EventSystem. The m_SystemInputModules variable is a list of Base Input Module class and Pointer Input Module inherits from Base Input Module. Standalone Input Module and Touch Input Module inherit from Pointer Input Module. Standalone Input Module corresponds to the PC inputs, and Touch Input Module corresponds to the mobile inputs. EventSystem processes these input modules every frame, calling TickModules method to update each input module, and then traverses m_SystemInputModules to determine if the input mod-ule supports current platform and is activable. The input module is assigned to m_CurrentInputModule if there exists qualified input module. If there is no eligible input module, then select the first module that supports the current platform and assign it to m_CurrentInputModule. When the value of m_CurrentInputModule changes and m_CurrentInputModule is not null, the process method is called. This method passes input event to m_CurrentSelected, selects the current object through OnSelect method of the static ExecuteEvents class and performs event operation. At the same time, the OnDeselect method unselects the previously selected object to realize the object update of the event operation.

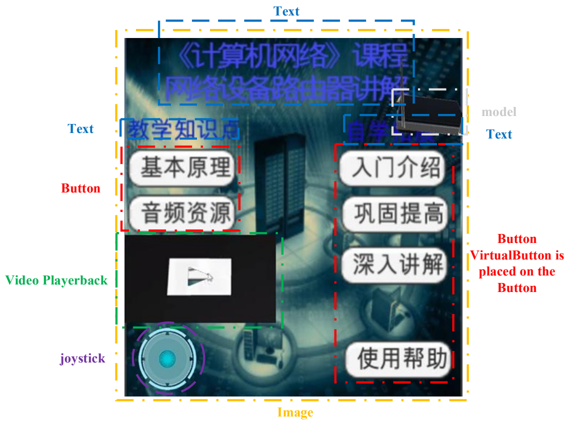

Fig. 3. Virtual space.

Virtual space includes Text, Image, Button, model, audio and video objects, an example is shown in Fig. 3.

Text is used to display specific text information, and Image is used for illustration or decoration. Since Image can only be used for Sprite format, the Image type must be changed. Button is an interactive object. Text, Image and Button are provided by UGUI, model could be imported or custom-made. For audio playback Audio Source component is used , by Unity3D->GameObject->CreateEmpty to create an empty object AUDIO, which is added Audio Source component. AudioClip parameter of Audio Source should select the audio file to be played and ARcamera parameter is Audio Listener. Considering the influence of distance on the audio source, the sound file should be set to 2D sound. For video playback, Video Playback provided by Vuforia is imported in Unity3D. Video component of Video Playback is responsible for playing video, Path parameter of which represents the path of video to be play. VIDEO object is created by Unity3D->GameObject->CreateEmpty and mount Video component. Video Playback supports two ways to play video: (1)Local file. Default video file to be played should be placed in Unity3D->assets->streamingassets folder. Full name and suffix of the video file should be entered in the Path parameter. (2)Web video, which could be accessed in the form of URL. In this paper, local file is selected for playing video. Auto Play option of Video component could realize the automatic video playing function. The principle is as follows: when the marker is recognized, the OnTrackingFound method of TrackablEventHandler script is executed. If the video file is not empty and Auto Play option is chosen, then the status of video file is determined. If it is STOPPED, PAUSED or READY, the video file will be played from the last position by execute VIDEO.VideoPlayer.Play(false, VIDEO.VideoPlayer.GetCurrentPosition()). If it is REACHED_END, the video file will be played from the beginning by execute VIDEO.VideoPlayer.Play(false, 0). In this paper, video playback is controlled by clicking Button, so the Auto Play option of Video component is not selected.

If the play size of video and the VIDEO object are not compatible, there would be a situation of mismatching between them, which would reduce users' experience. The play size of video could be modified in Inspector window, then the test is successful in Unity3D debugging mode. But the compiled application will fail when it runs on smartphone and modifications are needed in VideoPlaybackBehaviour script. VideoPlaybackBehaviour script defines enumerated type variable MediaState, including REACHED_END、PAUSED、STOPPED、PLAYING、READY、NOT_READY、ERROR and PLAYING_FULLSCREEN states. Add state judgement codes in OnRenderObject method, when the state is one of the REACHED_END,PAUSED,STOPPED,PLAYING and READY, transform.localScale = new Vector3(*, *, *) is executed, where localScale is used to set play size of video and value of * is determined according to the size requirements. All these objects contained in virtual space are done and arrange the locations according to the display needs, then drag them into prefabs folder as a whole and virtual space in prefab format is make.

B. Image recognition

Image recognition includes operations on official website and operations in Unity3D. The steps are as follows:

(1) Operations on official website. Register a Vuforia official account, log in and click Develop->License Manager->Get Development Key. Customize name of image application and select running platform type of application, Mobile is chosen for the running hardware is smartphone. Then click application name and copy the License key, which needs to be used in Unity3D. Select Target Manager->Add Database to define new database and choose device type. Attention should be taken that Vuforia offers free and paid services, the former only provides Device for device type choosing, while the latter also provides Cloud service. Select the new database to add target and Single Image is chosen for image recognition, then click Browse to upload the image marker to database. Click Add to complete operations on website and download the database file. Since Unity3D is the software environment, Unity Editor is selected as the downloaded image database development platform.

(2) Operations in Unity3D. Import Vuforia package and Vuforia database file. Since it is image recognition, delete main camera and add ARCamera and ImageTarget in Unity3D project. Click ARCamera, put the License key copied from official website in the App License Key to load the image database and activate it. Select ImageTarget and choose loaded image marker in Database and Image Target, then mount the virtual space to be displayed on the ImageTarget to complete operations of image recognition. There may be a situation where the image to be identified becomes a while color after chosen in Database and Image Target. The solution is as follows: find the image marker in the imported database folder by Unity3D->project->editor->qcar->imagetargettexture. Select the image marker and view the Inspector to change the Texture Type to Default and Texture Shape to 2D. Save operations then the image marker would be displayed normally.

C. Human-computer interaction

There are two types of human-computer interaction involved in this paper: transform operations and click operations. Transform operations includes move, zoom and so on. There are two implementation methods: one is by plug-ins, such as Easy Touch, Leantouch and the other is by custom programming with Input class provided by Unity3D. Taking Easy Touch as an example, joystick is provided to realize move operations. The steps are as follows:

(1) Create a joystick object and set parameters. Joystick Name is the key parameter, by which application finds the joystick object that triggers event. Joystick Position and

Size is the position and size of the joystick object. Anchor and Offset are used to modify position of the joystick object. Joystick Axes Properties & Events are joystick axis properties and events, in which the event-driven type selects event notification. The speed of Enable X Axis and Enable Y Axis are set to 1, which are adopted to set the X and Y axis sensitivity of the joystick object. Joystick Textures is joystick texture that can be loaded to modify look of the joystick object. All these parameters could be set according to requirements.

(2) Write script and mount the script on the object which could be moved. First determine the name of object that triggers move operation event is the same as the Joystick Name. if not, execute return to end script. Otherwise, obtain X and Y coordinates of the joystick object offset center. Then check whether the value of X or Y is 0, if it is not 0, which indicates that the joystick object has been operated. Finally, invoke lookat method to get the orientation of controlled object and translate method is called to shift the position of controlled object according to the orientation.

Custom programming is implemented by Unity3D built-in Input class, using Touch structure and Touchphase enumeration class. First according to users' gesture information to determine the number of touch points and gesture direction, then the corresponding method is called to achieve transform operations. The flowchart is shown in Fig. 4, touchNum indicates the number of fingers contact with the screen. If touchNum equals 1, which represents that a single point operation is under way, and then according to the touch.phase to make next decision. If touch.phase equals TouchPhase.Moved, which indicates it is a moving operation, then obtain direction and position information to achieve moving operation. If touchNum equals 2, which represents a two-point touch operation is taking place. The isEnlarge method is introduced to determine whether to zoom in or out. Length1 and Length2 represent the spacing of the last two touch points and the current two touch points, respectively. If Length1 greater than Length2, then the zoom out operation is carried out, otherwise the zoom in operation is carried out. Since the scaling operations of models have boundaries, initialScale and realScale variables are used to represent the original size and current size of model, respectively. Zoom out operation is performed when the current size of model is no less than the minimum of the original size, and vice versa. Considering that there are other UI objects contained in the displayed virtual space, in order to avoid touch UI objects to trigger move or zoom operation, the above flowchart needs to be optimized. Take a single move operation as an example. If return value of EventSystem.current.IsPointerOverGameObject(Input.GetTouch(0).fingerId) equals false, indicating that the controlled object is not UI and move operation could be performed. Similarly, zoom operation could be executed if return values of EventSystem.current.IsPointerOverGameObject(Input.GetTouch(0).fingerId) and EventSystem.current.IsPointerOverGameObject(Input.GetTouch(1).fingerId)) are all equal false. In this paper, custom programming is used to achieve transform operations.

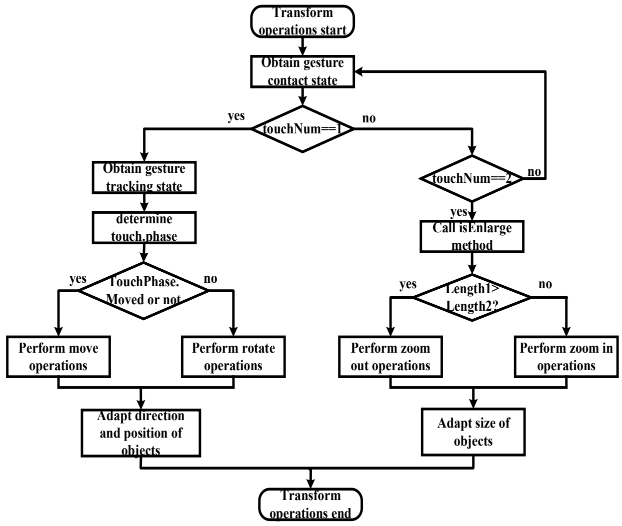

Fig. 4. The flowchart of custom programming.

Button provided by UGUI and VirtualButton provided by Vuforia are adopted to realize click operations, which offer the functions of clicking Button to display Text or play video. VirtualButtonEventHandler class and IVirtualButtonEventHandler interface are involved and the processes are as follows:

(1) Add the VirtualButton component to the corresponding Image Target.

(2) Find all the VirtualButtonBehaviour components and register events.

(3) Handle different events according to different Button name. The registration algorithm of Vuforia is based on the natural feature points. In order to improve the triggering rate of Button, the VirtualButton should be placed on the location with abundant feature points. When clicking the VirtualButton, fingers block the VirtualButton, resulting in the change or loss of the feature points information on relevant position, resulting in the error of matching to detect the triggering position. The principle of VirtualButton position detection is as follows: As shown in Fig. 5, the image size is 1500*1050px. The blue square represents the VirtualButton size, which is 200*75px. The coordinate on the upper left corner is (90,850)px, on the lower right is (290,925)px. In Unity3D a three-dimensional coordinate system is used, so it is necessary to solve the new position of the VirtualButton in the three-dimensional coordinate through dimension transformation, that is, values of *a* and *b*. The similarity formula $\frac{90}{750}=\frac{(123.5-a)}{123.5}$ is used to solve *a* is 108.68 and $\frac{325}{525}=\frac{b}{86.5}$ is used to solve *b* is 53.55, so the upper left corner value in Unity3D three-dimensional coordinate is (-108.68,-53.55). Similarly, the lower right corner is (-75.75,-65.87). In this way, the VirtualButton position transformed from two-dimensional

coordinate system to three-dimensional coordinate system is realized, then detect the position feature points information of VirtualButton in three-dimensional coordinate system to determine whether click operation occurs. In this paper, the official SDK provided by Vuforia is adopted to automatically calculate position for simplifying application design. Taking click Button to display Text as an example, first place a VirtualButton TEXTBUTTON on the Button object, then define a Text object SHOWTEXT for display content. SHOWTEXT is hidden at the initial time, when the VirtualButton event is triggered, switch statement is executed to determine which object is. If it is TEXTBUTTON, Set_Active(true) is executed to set SHOWTEXT to display, thus realizing the function of clicking Button to display Text. Play Video script is used to achieve video playback by clicking Button. During the test, it is found that if video is played in full screen, exiting the full screen will cause the video to be played from beginning, and the VideoPlaybackUIEventHandler script needs to be modified to achieve video continue playback function. This script is responsible for full screen settings, camera settings and other control options. If in full screen playback mode, exiting full screen would make the OnTappedOnFullscreenButton function executes VIDEO.VideoPlayer.Pause() to pause the video then VIDEO.VideoPlayer.SeekTo(0.0f) is executed to return the video to starting position by default. Therefore, VIDEO.VideoPlayer.Play(false, video.VideoPlayer.GetCurrentPosition()) is performed in OnTappedOnFullscreenButton function to realize the function of exit full-screen video continue playing, in which the GetCurrentPosition() is the current playback position and false indicates that is not full screen mode.

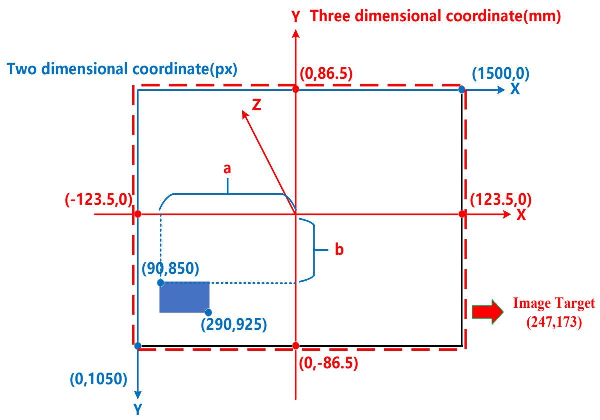

Fig. 5. VirtualButton position calculation

IV. THE DESIGN OF PLANE RECOGNITION APPLICATION BASED ON UNITY3D, ARCORE AND ARM NN

A. Plane recognition

Plane recognition consists of four steps. The first step is to build a visual framework. Appcontroller.cs framework script based on C# is written, which implements checkdevice, applicationlifecycle, showmessage and doquit methods. Checkdevice method is called in the Start function to check working status of device at the initial time, which includes whether camera is authorized, whether device supports ARCore and operation is wrong. If any error occurs, doquit method is called to exit the application. Applicationlifecycle method is called in Update function at each frame to check whether device is in a valid tracing state currently. If in a valid tracing state, track device all the time, while not, let the application sleep for a while. If in the exit state, no further action is done and the application is terminated.

The second step is to make virtual plane and virtual space of prefab format. Create a plane object SHOWPLANE by Unity3D->create->3D object->plane, position parameters are set to 0 and scale parameters are set to 1 to avoid offset of position after plane visualization. Mount rendering script Detected Plane Visualizer to complete the design of virtual plane. Steps of making virtual space is described in section III.A.

The third step is to visualize the virtual plane. In Appcontroller.cs script, add public GameObject variable PLANEOBJECT and two List variables ALLPLANES and NEWPLANES. PLANEOBJECT stores virtual plane made in the second step to be visualized, NEWPLANES stores new detected plane and ALLPLANES stores all detected planes. Then locate to the Update function, the new detected plane marked as new in Sessions is saved to NEWPLANES. According to the number of NEWPLANES, each newly detected plane is instantiated and assigned to the variable PLANEOBJECT for visualization, and finally save all the detected planes to ALLPLANES. Return to the Hierarchy window of Unity3D, a new object CONTROLLER is created, mount Appcontroller.cs script and assign SHOWPLANE to parameter PLANEOBJECT of Appcontroller.cs script. In addition, another way to achieve plane visualization is also provided. Look up Detected Plane Generator script provided by ARCore official in Unity3D, mount the script on CONTROLLER, and assign SHOWPLANE to the detected plane prefab parameter of the script. This method is more convenient and could speed up the design.

The fourth step is to place virtual space on the visual plane after identifying the plane marker. ARCore adopts raycast ray detection method to confirm the display position of virtual space. In Appcontroller.cs script, define the filter variable HITTYPES, array to record the collision positions variable HITPOINTS, AR camera variable ARCAMERA and displayed virtual space variable SHOWSPACEPREFAB, the types of collision detection include polygon and inside boundary. The raycast method is called in the Update function at each frame for collision detection. If a collision occurs, virtual space is instantiated in the nearest position to the ray and an anchor is generated, virtual space is mounted on the anchor to update the attitude of virtual space in real time. Since it is plane recognition, it is necessary to determine whether the detected is back of plane. Dot product is made between the vector of AR camera to the collision point and the normal vector of the collision point. Less than 0 means that the hit is back, instead of instantiating virtual space. Return to the Hierarchy window to select CONTROLLER, assign virtual space of prefab format for display and First Person Camera as parameters to the SHOWSPACEPREFAB and ARCAMERA. When camera recognizes the plane, the set virtual space would be displayed.

B. *Human-computer interaction and Object recognition*

Steps of achieving Human-computer interaction is described in section III.C, then mount the script on the related object contained in virtual space. The plane recognition application provides the function of object recognition by Arm NN, which is the neural network Machine Learning software provided by ARM. It bridges the existing neural network framework such as Caffe and the hardware platform of the embedded mobile. After conversion by Arm NN, it could run directly on the hardware platform. Object recognition process includes three steps.

The first step is to compile shared library. Currently, Unity3D supports ARMV7-A, which is adopted to manually compile Arm NN shared library, enabling OpenCL to realize GPU acceleration. The Arm NN version is 1.64, and the parameter link is static cxxflags=--fPIC --with-filesystem --with-test --with-log --withprogram_options --prefix=path/to/installation/prefix. Since for supporting ARMV7-A, extra_cxx_flags parameter of SCons is set to fPIC. Add parameters opencl and embed_kernels and all set to 1 to enable OpenCL. darmcomputecl parameter of cmake is set to 1. The parameter arch which is set to arm64-v8a is needed if supporting ARMV8-A is required. Libarmnn.so, UnitTests and some other files could be obtained in the build directory after compilation.

The second step is to implements initdetector and detectobjects methods. The former is used to load the Machine Learning model and initialize the neural network, and the latter is adopted to receive camera data and detect objects. ParseOutputTensorsYoloV1 method provided by Arm NN is introduced in detectobjects method to return the output results, which should be completed by developers themselves. This paper refers to the GitHub/ARM-software/YololnferenceTest file for implementation. Then the libyoloDetector.so library file compiled by NDK, and the ARMV7-A files compiled in first step are all saved to the assets->plugins->android directory of Unity3D project. YOLO CoCo tiny and UnitTests generated in first step are pushed to the testing Android smartphone device.

The third step is to integrate Arm NN in Unity3D. Create a blank object ARMNN in Unity3D project and mount Texture Reader script. The Image Width, Height, Image Sample Mode, and Image Format is set to 448, 448, Keep Aspect Ratio and Image Format Color, respectively. To achieve object recognition function, write Armnndetect.cs and Armnncontrol.cs scripts and mount them to ARMNN object. Armnndetect.cs script defines Armnndetect class, which calls initdetector method load Machine Learning model and initialize neural network in the constructor. The detectasync method is implemented in Armnndetect.cs, which adopts the detectobjects method for receiving camera data and conducting continuous object recognition. Armnncontrol.cs script instantiates Armnndetect class and sets the callback function for the Texture Reader to get camera data by OnImageAvailable method and save it in the variable M_CAMIMAGE. Then wake up armnndetector method, which is implemented in Armnncontrol.cs, calls detectasync method and passes variable M_CAMIMAGE as a parameter. The probability data and bounding box of detected object are returned by armnndetector method, and then marks detected object by visual bounding box.

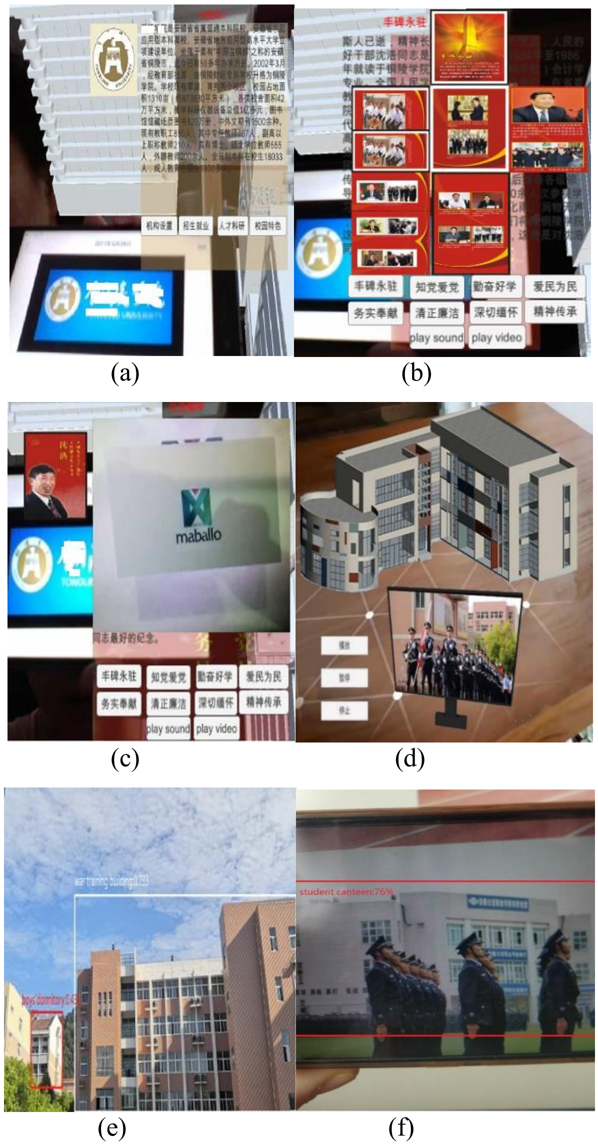

Fig. 6. Effects of the applications.

V. TEST AND CONCLUSIONS

Image application based on Unity3D and Vuforia is designed, which takes image as the marker. When camera scans image marker in the real scene and related virtual space is displayed in three-dimensional virtual-real fusion as is shown in Fig. 6(a). The application allows users to view kinds of information by hand gesture. Click Button "xiaoyuantese" to view relevant content, as is shown in Fig. 6(b). Click Button "play video" to play video, as is shown in Fig. 6(c). Plane recognition application based on Unity3D, ARCore and Arm NN is designed, which takes plane as the marker. When camera scans plane such as desktop to display related virtual space as is shown in Fig. 6(d). The object recognition function effect is shown in Fig. 6(e) and Fig. 6(f), which recognize the buildings in camera data and show the names.

In this paper, aiming at the characteristics of passive two-dimensional space and poor interaction of current information display, Augmented Reality and Machine Learning are applied to design applications, which provides rich digital resources in three-dimensional virtual-real fusion mode. Users can view information of interest in a natural interactive way, and rich functions deepen users' experience. Virtual-real integration and immersive experience bring freshness to users. Natural hand gesture interaction endows users the initiative of information. The attraction of information to users is enhanced. Compared with the passive two-dimensional space, this research enriches the methods of information presentation, improve the effect of information transmission, and could be extended to other fields in the future.

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