Development of Technology for Creating an Augmented Reality Application for Business Purposes

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Abstract

The scientific novelty of this work is the development of technology for creating an augmented reality application for managing to advertise. The use of augmented reality is becoming a standard format in advertising. The main difference between augmented reality advertising is the ability to present consumer goods or services and involve them in their use. This article aims to develop technology for creating a mobile AR application for Android devices. The article develops a mental map of the distribution of AR systems. The technology of generating an AR mobile application with elements of interactive interaction for a device running Android OS is proposed. An information scheme of the AR application development process has been created, which reflects the relationship between external and internal development factors.

Keywords: Mobile Application Management, Augmented Reality, Interactive Content Management, Virtual Information, Business Advertising Management

1.   Introduction

Advertising is an essential part of business marketing and augmented reality (AR) technology turns out to be very helpful in creating an exciting advertisement. The practical need to create technology for the development of AR applications leads to the emergence of relevant scientific interest in multimedia publishing. N. Aralova [1] proposes a method for assessing the quality of product development technology, which can be used to evaluate the quality of technology and tools for designing AR applications. H. Tolliver-Walker [2] proposes a step-by-step procedure for creating a web portal. O. Pushkar et al. and N. Hood and A. Littlejohn focus on evaluating the effectiveness of multimedia product development and optimizing download speeds [3,4]. Issues of optimization of information and multimedia resources in creating AR applications are considered by L. Ao et al. [5], Y. or B. Brij et al.[6]. Research on cross-functional impact and the development of a methodology for creating a user-centric application is proposed by E. Schön et al. [7]. The development of multimedia materials in terms of 3D installations is presented in studies by V. Babenko et al. [8], Y. Hrabovskyi et al. [9], L. and H. Junjie et al. [10]. Theoretical and applied aspects of improving the effectiveness of visual perception of multimedia publishing products are proposed by J. Kuisma [11]. M. Hu [12] offers an empirical study of assessing the quality of information services of a multimedia application based on the use of AHP and CA tools. Y. Hrabovskyi

et al. [13] present the technology of visualization of multimedia materials, which can be used to visualize the critical components of the mobile application of augmented reality. Issues of information security of multimedia applications are considered by R. Kustori et al. [14]. In this article, the authors aim to develop technology for creating a mobile AR application for Android devices. In the development of modern information systems, two main directions can be distinguished: 1) information systems built into production processes; 2) information systems focused on the end user. Among the information systems of the second direction, augmented reality occupies a key place as a multimedia technology that fully meets the requirements of the modern impression economy. At the same time, today there is no clearly regulated technology for creating augmented reality systems. Therefore, this work is an applied scientific research, the end user of which is the developers of augmented reality systems.

2.   Background and the Basic Idea of the Approach

2.1.   Theoretical Principles of Developing Augmented Reality Application Technology

The technology of AR applications is the future. The audience of owners of smartphones of the latest generation with the built-in support of AR grows. The number of AR applications increases in the "Application Stores". Sales of tablet mobile devices grow and the Internet speed (4G network) increases. New cross-platform application development tools are being created. Fig. 1 shows the problem tree.
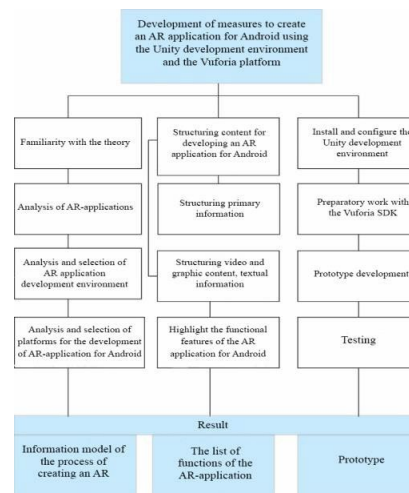

Fig. 1. Problem-solving tree. Source: Authors' development on the basis of systematization and generalization of information from sources [1], [3], [7], [9], [11].

The task of the AR application is to expand the user's interaction with the environment. Layers with the help of a computer device with virtual objects on the image of the natural environment are informative. In this way, information contextually related to things through augmented reality becomes available to the user in real-time. Each of the AR applications has a specific set of functions, which made the authors to create a system classification (Table 1) depending on the tasks.

Table 1. Classification of augmented reality systems

№ п/п	Criteria classification	Types of AR applications
1	Type of information presentation	Visual systems, Audio systems, Audiovisual systems, Text or graphic systems, Sensor systems, Holographic systems
2	Object recognition method	Geopositional, By image recognition, Markerney
3	The way to interact with the user	Autonomous, Interactive
4	Type of mobility	Stationary, Mobile
5	Purpose of the service	Medicine, Assembly, repair, service equipment, Abstract and visualization, Management robotic systems, Games and entertainment, Trade Education, Military industry
6	Security type	Elevated objects danger, Safe objects
7	The degree of impact on the environment	Managers, Informative

Source: Authors' development on the basis of systematization and generalization of information from sources [4], [5], [6], [10], [14].

The authors also developed a mental map (Fig. 2) of the distribution of augmented reality systems.
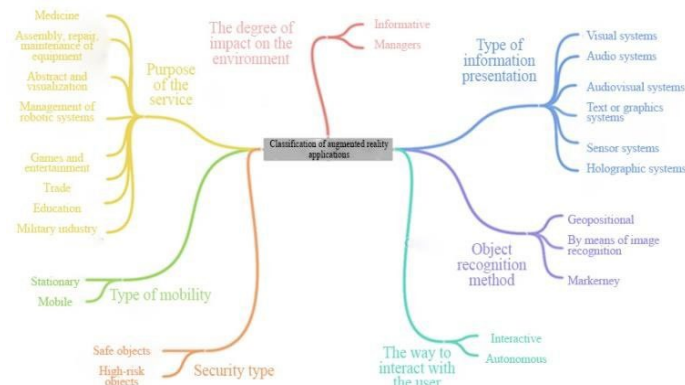

Fig. 2. Mental map of the distribution of augmented reality systems. Source: Authors' development.

The affiliation of a system to one or another type is determined by its functionality. Based on the analysis, one can conclude in Table 2 the classification of the project's subject area.

Table 2. Analysis of the classification of the AR application of the project

Classification criteria	AR-Appendix
Type of information presentation	Audiovisual, text-graphic
Object recognition method	markerless
The way to interact with the user	interactive
Type of mobility	mobile
Purpose of the service	informative
Security type	safe

Source: Authors' development on the basis of systematization and generalization of information from sources [1], [3], [4], [7].

Some basic principles of research must be considered when developing an AR application. First, the principle of mass availability. Modern widely available mobile devices will be considered as platforms for the application of research results. This study focuses on the mass introduction of AR technology. Secondly, the principle of realism. Virtual objects must be integrated into the natural environment as realistically as possible to implement augmented reality technology fully. The main obstacle is the limited hardware and computing capabilities of mass devices. Thirdly, the principle of functionality. It is necessary to fully reveal the potential of augmented reality technology in solving practical problems. Analysis of the problems of the subject area allows to determine the following functional requirements for the development of AR applications: a unique idea or a kind of creative interpretation; the speed that is an essential factor for users (good performance that will cope with the maximum possible loads); usability - it is necessary to adhere to technical aesthetics: convenient navigation, clear, intuitive interface, and harmonious design; rational energy consumption and simple graphics; the need to test different types of gadgets to check the adequacy of display on screens of any format (the program must use augmented reality technology); the application must allow the user to control the object and change its position in space and rotation angle. As a result of the analysis of functional requirements, the following non-functional requirements were formulated: a) the application must be developed on the Vuforia platform; b) the application must be written in C # for the Android platform. The application must be developed using the Unity cross-platform computer game development environment. When developing an AR application, it is advisable to provide: ease of navigation regarding the information provided; the availability of unique devices and printed advertising products to motivate users and support their attention and interest; the use of icons and other special symbolsthat provide a clear functional load; preservation of common symbols and terminology.

2.2. Structuring the Stages of Technology for Creating Augmented Reality Mobile Applications

The technology of developing an AR mobile application with elements of interactive interaction for a device running Android OS can be divided into stages, which we present in

Table 3.

Table 3. Stages of developing the AR mobile application

Stage	Tasks
Conceptual stage	One must analyze in detail similar applications according to different criteria (convenience, functionality, design, compliance with user requirements, and search queries), also the target audience and the feasibility of creating an application and software analysis, and the existing analogs of the project, based on which to create a project scenario.
Design stage	In this stage, the design solutions for project implementation are developed: designing the general structure of sections of the AR application, plash screen layout design (animation screen), designing layouts of internal screens, designing marker-label layouts, design of printed advertising products, choosing software to develop. All interface elements are carefully developed so that they are easy to use, clear and useful to the user and take into account the specifics of use.
Stage of design development	The stage should include the development of a graphic solution and design of the main screen of the application, the development of the design of internal screens based on the developed models, creation of the necessary graphic elements. A bright and practical design is developed. The application must look equally attractive on the screens of different devices. Layouts of printed products and labels for the application are created.
Implementing the project and software development	To implement this stage, the following steps should be taken: installing and configuring the Unity development environment, preparatory work with SDK Vuforia 6.2.10, creating a project in Unity and its general settings, development of an augmented reality application in Unity, compilation of the program for Android, testing and determining areas for further product development. The result of this stage is a ready-to-use AR application. For a mobile device, development should be done using the Unity development environment and the Vuforia component for Android OS.
Functional stage	This stage includes the development of mobile functionality and the refinement and optimization of functional modules and components. At the testing stage, there is testing and verification of the received software product to comply with the technical task requirements and identify hidden shortcomings in the application.

Source: Authors' development.

Considering all the above, we present an information scheme for developing an AR application in Fig. 3, which reflects the relationship between external and internal factors in the development of the subject area.
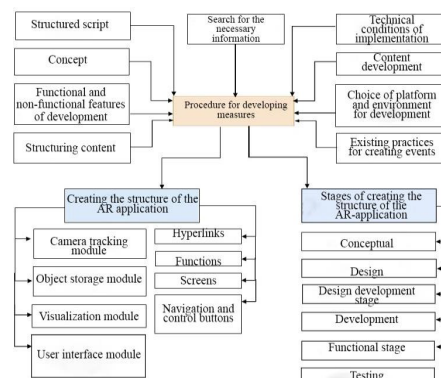

Fig. 3. Relationship between external and internal development factors. Source: Author's development on the basis of systematization and generalization of information from sources [1], [2], [8].

The described interrelation of external and internal factors of development allows planning the process of creating an augmented reality application.

3.   Evaluation

Approbation of the proposed technology allowed obtaining a practical result in the form of an AR application for Android devices, which is designed to add interactive content to printed advertising products of the Simon Kuznets Kharkiv National University of Economics (KhNEU, named after S. Kuznets), and provide opportunities for the user to interact with virtual information. A system prototype is being developed for mobile devices running the iOS operating system. The Vuforia SDK framework and the Unity 4 game engine were used for development. Considering the architecture of the system, the following modules are required for the operation of this system, which are shown in Table 4.

Table 4. Modules for the operation of this system

Modules	Features
Camera	The camera component ensures that each frame view is captured and transmitted efficiently to the tracker. The developer initializes the camera to start and stop recording the frame, which automatically converts to a hardware-dependent format and sets the desired image size.

Image converter	The format converter converts frames from a format camera (e.g., YUV12) to a format suitable for OpenGL ES rendering (e.g., RGB565) and tracking. This conversion also includes reducing the image from the camera at different resolutions available in the converted stack of frames.
Tracker	The tracker component contains computer vision algorithms to detect and track real-world objects within the camcorder. Based on the image from the camera, various algorithms take care of detecting markers and evaluating virtual buttons. The results are stored in the object's state, which uses the background video visualization and can be accessed from the program code. The trackercan download several data sets at once and activate them.
Play graphics	This visualization module creates an image that is stored in the object. Device-specific video visualization performance is optimized.
Application code	All of the above components must be initiated in the code, and three conditions must be met. It is necessary: to define objects for newly discovered purposes, markers; update the logic of the application with new input data; reproduce a layer of AR. For each processed frame, the object is updated and the playback method is called.
Marker database	The device will create a database of markers using the online Target Manager. It makes a particular XML configuration file and a binary file that contains a database to track. These files are added by the application developer to the application installation package and are used at runtime.

Source: Authors' development.

Based on above issues, we present in Fig. 4 the architecture of the prototype.
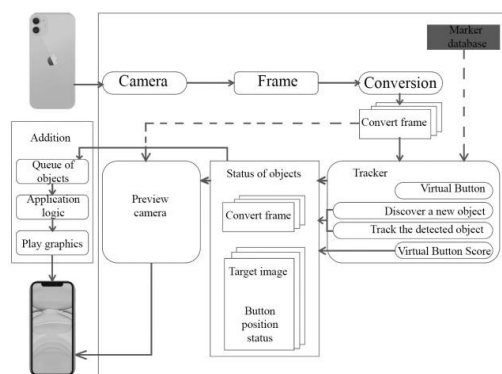

Fig. 4. AR application prototype architecture.
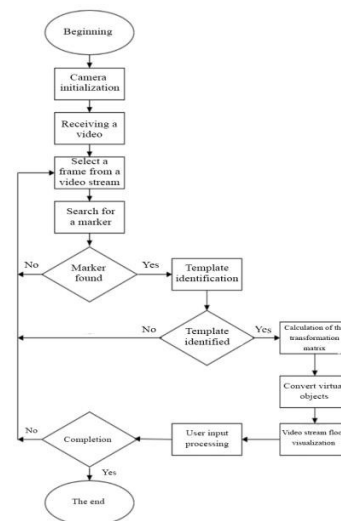Source: Authors' development.

Fig. 5. Application algorithm.
Source: Authors' development based on [4], [10], [13].

The operation of the system as a whole will consist of gradual stages: 1. Defining the contours of objects in the user's area of interest on the mobile device. Each of these circuits will be assigned a label that the device will track. 2. Sending contours and their contents to the server for processing. 3. Processing the received data by the server, identification of objects, and construction of virtual objects. 4. Sending finished objects, accompanied bythe tag ID on the original document. 5. Reproduction of virtual objects. Based on the analysis, the work of the application can be represented as a typical algorithm. It is demonstrated in Fig. 5.

Furthermore, the appendix must contain components that reflect its internal structure: a) splash screen (screen with animation) in blue, which will gradually appear the logo of KhNEU named after S. Kuznets; b) onboarding is the first greeting screen where we see the university's name, its logo, and the "Forward!" button, with which we can go further; c) screen for watching a video of the university; d) screen for watching the video of the Faculty of Information Technology with interactive buttons that have a set of functions; e) slider screens for viewing images with a list of university faculties and viewing images with a complete set of specialties, educational programs of each faculty; f) downloaded markers for recognition; g) hyperlinks; h) screen for displaying the location map of the university; i) screens for testing; j) user control buttons. The application is designed for viewing flyers and business cards, so we will develop different screens depending on what printed products you plan to scan. It is planned to develop two screens to view the flyer. The title page is planned for review a commercial for the university and the list of faculties in the form of slides. The back of the flyer is designed for viewing each faculty's educational programs and

specialties. Each screen will have buttons for use: start the video and pause; exit button; right or left navigation buttons to view slides; video volume down button. To view the business card of the Faculty of Information Technology, we will develop the main screen with the image of the logo, which will be superimposed on a short video about the faculty. To convey the text, we will develop screens with different information outputs. Under the screen and on the right, it is planned to place navigation and control buttons. Exit buttons are scheduled on each screen. The complete internal logical structure of the application is presented in Fig. 6.
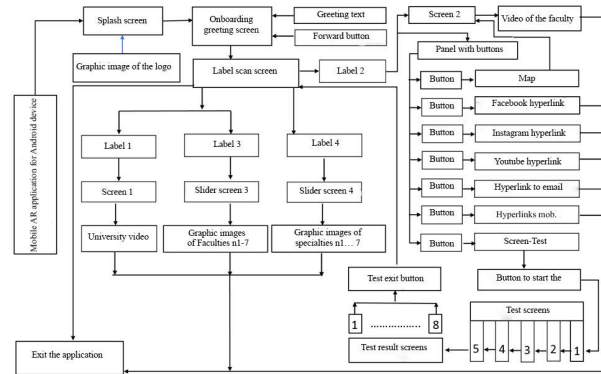

Fig. 6. The internal logical structure of AR-application. Source: Authors' development.

Flyer and business card layouts and buttons for user navigation are implemented in the graphic editor Adobe Illustrator. The final result of the development can be seen in Fig. 7 and Fig. 8.

Fig. 7. Images of finished flyer pages and business cards. Source: Authors' development.
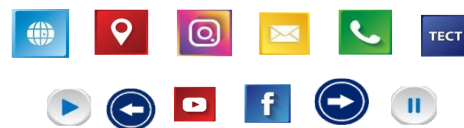
Fig. 8. Developed images of AR user application buttons. Source: Authors' development.

To run the application, one needs to write Script. C # is chosen as the Unity programming language, an industry-standard language similar to Java or C ++. Unlike other Asset scripts, scripts are usually created directly in Unity. Create a script: Create a menu in the upper left corner of the Project panel or select Assets → Create → C # Script in the main menu. The new Script will be created in the folder selected in the Project panel. Procedures - handlers for button presses will be placed in one file with scripts (it will have the extension * .cs). Create an empty object named ControlMainMenu in the project structure ("Hierarchy" window). Add a component to it (button "Add Component" of the window "Inspector"). In the window, enter the script's file name "MainController." The Script with the specified name will be created in the Assets folder next to the scene files. One can move script files to the Scripts folder. If one does not have it, they can create it themselves. It needs to open the created Script in "Visual Studio" by double-clicking on the script name in the "Inspector" window and adding the code required for our menu. We show the software implementation of button processing on the flyer in Fig. 9. And we present the software implementation of flyer slider buttons are presented in Fig. 10.

By analogy, program code is created for the reverse side of the slider. Functional testing was performed to verify the application's functionality. Functional testing is software testing to test the ability to be implemented through functional requirements, the ability of software in certain conditions to solve problems required by users. After successful implementation, the application was tested. The application has been tested on many different devices on iOS and Android platforms. The results are in Table 5.

```
if (markerIndex == 1)
{
    if (tempName == "FlyerPlayStopButton")
    {
        if (arVideoPlayer.isPlaying)
        {
            arVideoPlayer.Pause();
            FlyerPlayStopButtonGO.GetComponent<MeshRenderer>().material.mainTexture = FlyerPlayTexture;
        }
        else
        {
            arVideoPlayer.Play();
            FlyerPlayStopButtonGO.GetComponent<MeshRenderer>().material.mainTexture = FlyerStopTexture;
        }
    }
    else
    if (tempName == "FlyerSliderPrevButton")
    {
        FlyerSliderPrev();
    }
    else
    if (tempName == "FlyerSliderNextButton")
    {
        FlyerSliderNext();
    }
}
```

Fig. 9. Software implementation of button processing on the flyer

```
if (markerIndex == 1)
{
    if (tempName == "FlyerPlayStopButton")
    {
        if (arVideoPlayer.isPlaying)
        {
            arVideoPlayer.Pause();
            FlyerPlayStopButtonGO.GetComponent<MeshRenderer>().material.mainTexture = FlyerPlayTexture;
        }
        else
        {
            arVideoPlayer.Play();
            FlyerPlayStopButtonGO.GetComponent<MeshRenderer>().material.mainTexture = FlyerStopTexture;
        }
    }
    else
    if (tempName == "FlyerSliderPrevButton")
    {
        FlyerSliderPrev();
    }
    else
    if (tempName == "FlyerSliderNextButton")
    {
        FlyerSliderNext();
    }
}
if (markerIndex == 2)
{
    if (tempName == "FlyerBackSliderPrevButton")
    {
        FlyerBackSliderPrev();
    }
    else
    if (tempName == "FlyerBackSliderNextButton")
    {
        FlyerBackSliderNext();
    }
}|
```

Fig. 10. Software implementation of flyer slider buttons

Table 5. Test results of the developed application

	Incoming data	Expected result	The result obtained	The test was passed successfully
1	User upload model	installing the model on a mobile device, adding an application to the screen	coincides with the expected	Yes
2	Changing the angle of rotation of the loadedobject	the user changes the angle of rotation of the model and it rotates in the direction selected bythe user	coincides with theexpected	Yes
3	Inclusion of occlusion	material objects located closer to the cameraare not closed by displaying a virtual object	coincides with theexpected	Yes
4	Exclusion of occlusion	tangible objects closer to the camera are closed by displaying a virtual object	coincides with the expected	Yes

Source: Author's development.

The test results showed that the application works stably and does not cause system errors that lead to closures or failures. The sold product meets all the requirements that were set in terms of area analysis and marketing review: light "weight" of the application; stable operation on various devices; ability to work without an Internet connection; continuous operation in video stream mode; the ability to get the name of the image when focusing on it; the ability to get advanced information with access to the browser. The usefulness of this applied development of augmented reality technology is confirmed by the positive results of its approbation in the form of the development of promotional products for applicants of Simon Kuznets Kharkiv National University of Economics.

4.   Conclusions

In this paper, the authors proposed technology for creating an exclusive interactive presentation on the display of a mobile device that is launched using a flyer or business card. The practical testing of the proposed technology was carried out by creating an AR application and advertising printing products for the Simon Kuznets Kharkiv National University of Economics. The developed application allows for turning printed polygraphic advertising products into a 3D presentation of any entity. Enough for the user to bring the device to print, automatically download and run the application by code, and immediately access all additional interactive content. It can be a video, a slideshow of images, or a site link. Virtual objects are combined with the provided polygraphy in a real video image, creating augmented reality, and the user has the opportunity to study in detail all the proposals, directing the mobile device to the label. Augmented reality can enrich printed video materials and visual information, as the printed page itself will become a marker. AR content is valuable to printed materials, including business cards, brochures, flyers, catalogs, and advertisements. The scientific novelty of this work is the development of technology for creating an augmented reality application for different business processes.

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