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AUGMENTED REALITY BASED INFORMATION TECHNOLOGY FOR OBJECTS 3D MODELS VISUALIZATION

At the current stage of IT industry development, augmented reality is of interest both from the side of science and from the business side, since it is an advanced and newest tool for introducing a new immersive user experience. Today there are plenty ready-to-use applications that use AR for business, educational, medical and other purposes. Augmented Reality is currently one of the most popular upcoming technologies most commonly known for its use within games and advertising. By combining three-dimensional modelling with augmented reality, it could be possible to obtain new user friendly applications for the representing 3D models of objects in real time and in real size. The topic of research in the field of augmented reality is currently relevant both for science and for the business industry.

The paper proposes a multifunctional information system for three-dimensional models visualization in augmented reality, which is implemented in the form of a cross-platform mobile application. The proposed information system uses a device camera as a mean of object visualization and provides quick reproduction of the selected from the application's database model in augmented reality in real size and in real time.

The developed application works quite well, has a user friendly and intuitive interface and allows user to add own models, that makes this tool multipurpose. Test 3D models have been created for conducting experiments for verification the proposed information system operation.

The further efforts of the authors will be directed to improving the existing algorithms for extending the current functionality of the proposed tool for 3D objects models visualization in augmented reality and application of the developed tool for real-life needs, such as digitization and visualization of museum exhibits and archaeological artifacts of Khmelnytskyi region. Keywords: information system, Augmented Reality (AR), 3D model, visualization, cross-platform mobile application.

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ІНФОРМАЦІЙНА ТЕХНОЛОГІЯ ДЛЯ ВІЗУАЛІЗАЦІЇ 3D-МОДЕЛЕЙ ОБ'ЄКТІВ У ДОПОВНЕНІЙ РЕАЛЬНОСТІ

На сучасному етапі розвитку інформаційних технологій доповнена реальність становить інтерес як з боку науки, так і з боку бізнесу, адже є передовим та новітнім інструментом для впровадження нового досвіду користувача. Наразі вже є багато розроблених застосунків із використанням доповненої реальності для комерційної, освітньої, медичної та інших сфер застосування. Доповнена реальність сьогодні є однією з перспективних технологій, яка відома своїм застосуванням у рекламі та ігровій індустрії. Через поєднання 3D моделювання та доповненої реальності стало можливо створити новий зручний застосунок для відтворення тривимірних моделей у доданій реальності у режимі реального часу та в реальному розмірі. Тема досліджень у сфері доповненої реальності наразі є актуальною як для науки, так і для бізнес-індустрії.

У роботі запропоновано багатофункціональну інформаційну систему для візуалізації тривимірних моделей у доповненій реальності, яка реалізована у вигляді кросплатформного мобільного додатку. Запропонована інформаційна система використовує камеру пристрою як засіб візуалізації об'єкта та забезпечує швидке відтворення обраної з бази даних додатку моделі в доповненій реальності в реальному розмірі та в режимі реального часу.

Розроблений додаток працює досить добре, має зручний та інтуїтивно зрозумілий інтерфейс і дозволяє користувачеві додавати власні моделі, що робить цей інструмент багатоцільовим. Також було створено тестові 3D моделі для проведення експериментів для перевірки роботи запропонованої інформаційної системи.

Подальші зусилля авторів будуть спрямовані на вдосконалення існуючих алгоритмів для розширення поточної функціональності запропонованого інструменту для візуалізації 3D моделей об'єктів у доповненій реальності та застосування розробленого інструменту для реальних потреб, таких як оцифрування та візуалізація музейних експонатів та археологічних артефактів Хмельницької області.

Ключові слова: інформаційна система, доповнена реальність (AR), 3D-модель, кросплатформний мобільний застосунок

Introduction

Currently, augmented reality technology is gaining more and more frequent use and is applied to more areas of human life. We can see mobile applications, commercial and educational simulators, mobile games and even the advertisement using augmented reality. AR technology has huge commercial potential in a variety of industries, from opening new marketing channels to improving employee training processes. According to the information of the International statistical company Statista [1], in recent years there has been a significant increase in the number of software products using augmented reality. According to forecasts [2], by 2024 there will be around 2.4 billion augmented reality applications users in the world. This technology is expected to reach \$70-\$75 billion in revenue by 2024. The diagram (Fig. 1) shows the growth dynamics of the number of software products based on augmented reality, both for commercial use and user applications. The graph also shows positive dynamics from an economic point of view, since the development and use of AR-based applications means the growth of global profits.

Therefore, the topic of research in the field of augmented reality is currently relevant both for science and for the business industry.

Global AR Revenue

Consumer & Enterprise AR Revenue, by Source*

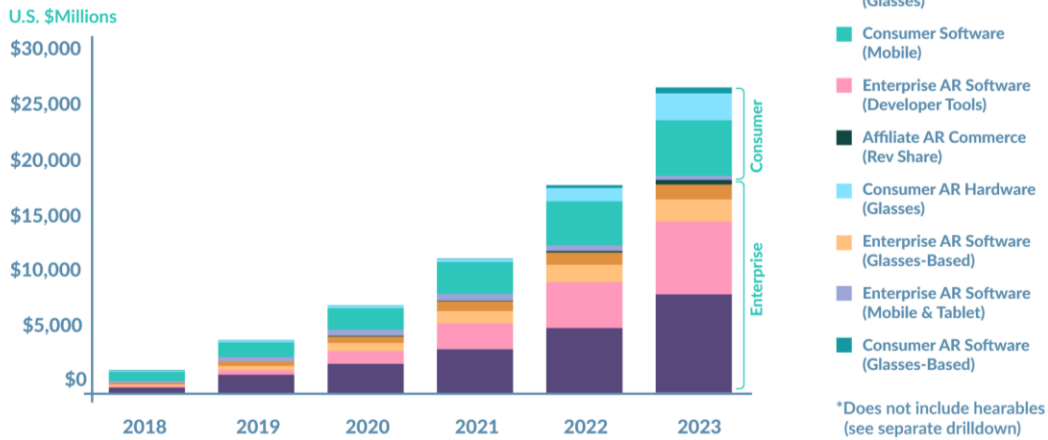


Fig.1. The prospects for AR industry development in the world [2]

Domain analysis and literature review

According to market research [3-4], the industries that the most actively leverage AR technology are E-commerce and advertising (IKEA Place and WannaKicks – the applications that provide virtual products fitting and try on using AR), E-learning (Civilizations - an application launched by the BBC for British Museum; provides visualization of ancient historical artifacts in AR) gaming industry (AR-games ZombiesRun and PokemonGO), medicine and healthcare (SentiAR – the platform features a 3D visualization of a patient’s heart anatomy to assist with diagnostics and surgery), social networking (Instagram and Snapchat AR-filters). The integration of augmented reality technology in various areas of modern society is presented in Fig.2



Fig.2. The examples of augmented reality technology integration in various areas of modern society

During the research the analysis of the existing trends and directions of augmented reality application for different areas of life has been conducted. The results of the analysis are presented in Table 1.

The analysis of scientific publications for 2021-2022 and already existing solutions presented on the world market showed that augmented reality is most often used for educational simulators, in immersive technologies, in the field of advertising, e-commerce, for the development of the latest VR/MR user interface. The results of the recent scientific publications topics using augmented reality are shown on a diagram in Fig. 3.

In Ukraine, augmented reality domain is also of interest to scientists. In recent years, the number of publications on the application of augmented reality for the field of education has increased significantly [6-12]. Thus, the paper [6] presents an analysis of the current state and prospects for the development of augmented reality in

Ukraine in business and education. The authors of [7] propose the application of augmented reality for educational purposes. In [8] using augmented reality-based technologies in professional training of future teachers of Ukrainian language and literature is proposed. The authors of [9] propose augmented reality-based approach for immersive training for some specific professions. In [10] augmented reality is proposed to be used in university education of future IT specialists. The source [11] considers application of augmented reality as an interactive form of pre-school and primary school teaching. The authors of [12] propose using AR technology for visualization of atoms and molecular structures at Chemistry lessons. The paper [13] is devoted to using of augmented reality for navigation and paving routes in real time. However *none of the considered works is devoted to application of AR technology for three-dimensional objects visualization.*

Table 1

Trends and directions of augmented reality application for different areas of life

| Technology or Trend of AR application | Application or Device | Description |
|---|-----------------------------------|--|
| AR-based virtual companions | Hybrid virtual companion [4] | Such an app will allow users to create an AR-based AI companion which resembles real-life humans. |
| Leverage AR glasses for different use cases | Google company | Giants like Apple are already working on bringing unique AR experience through glasses slated to release in late 2025. |
| Cash in on the metaverse | Microsoft Azure | Microsoft is one of the technology giants looking to dominate the AR experience. Their concept of merging cloud computing with AR/VR excellence makes it an interesting case study. |
| Mobile Augmented Reality | Instagram Snapchat | One of the finest examples of mobile AR is the image filter users can use in social media apps like Snapchat and Instagram. Snapchat is preparing to introduce NFT(Non-fungible tokens) as filters in their mobile applications. |
| Remote collaborations with AR | - | One fine example is cryogenic operations in oil refineries, where temperature maintenance is critical. While on-site employees come across issues that need expert assistance, AR can help with necessary response assistance. |
| Immersive AR gaming applications | AR games like Pokemon GO and Egg. | One of the critical AR trends is the use of Augmented Reality in creating interactive entertainment for users. In addition, Inc and Harry Potter the wizards unite have provided enhanced gaming experience on smartphones. |
| AR-based marketing & advertising campaigns | Loreal Burberry | Youtube has helped businesses with a “beauty try-on” feature that allows cosmetic brands to let users experience the product. Following the AR market trend, brands like Loreal has already created unique and immersive shopping experience in their apps. Not just as a marketing approach, AR is an excellent way to advertise your products. For example, Burberry allows its customers to create a custom handbag AR model, which they can experience through the web app. As a result, brands can leverage AR technology and create a customized experience for their customers. |
| Supply chain efficiency improvement with AR | Walmart | For example, Walmart converted four of its physical retail stores into the testing environment for an AR-based inventory app. The idea was to reduce the time needed for bringing products from backroom inventory to the sales floor. |

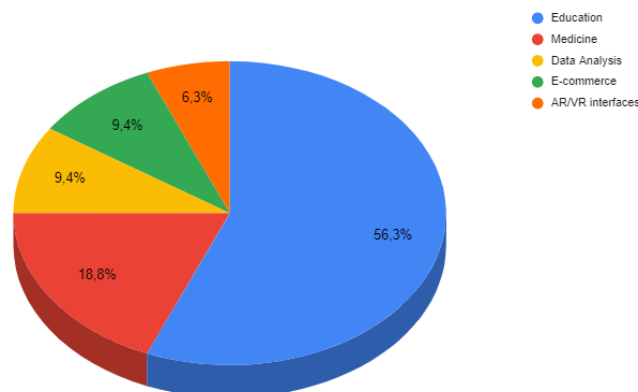


Fig.3. The results of the recent scientific publications topics using augmented reality

Thus, taking into account the relevance and importance of this task, the purpose of this work is to develop an information system for visualization of three-dimensional objects based on augmented reality in the form of a cross-platform mobile application and conduct experiments for visualization of 3D models of objects using the proposed information technology.

Augmented reality based information technology for objects 3D models visualization

In our previous works, a method and algorithm of information technology work for visualization of three-dimensional objects based on AR were proposed. For developing the information system for objects 3D models visualization, we will be using smartphone camera as a tool for representing the objects in augmented reality. To present a 3D model in a real world space, it is necessary to consider that we need to work with three-dimensional space.

The smartphone must also be located at the intersection of the X, Y and Z axes in the 3D Cartesian coordinate system as shown in Fig. 4

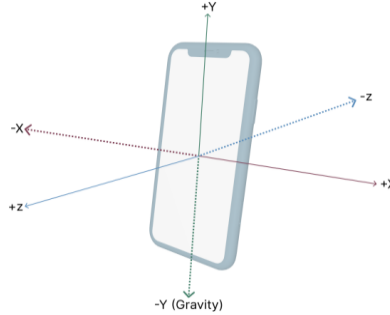


Fig.4. Location of the user's smartphone in the three-dimensional Cartesian coordinate system

The principle of operation of the proposed information system is that the user enters the mobile application. Since the application is cross-platform, it provides visualization of models from both Android and iOS devices. Next, the user can either upload his own model to the system database or choose one of the proposed ready-to-visualize models contained in the system database. Once selected, the model is available to the user for preview with the option to display in augmented reality in real time. The user can adjust the size and position of the model in the field of view of the smartphone camera and take a photo or video of the model in the environment. The principle of the proposed information system operation is presented in Fig.5.

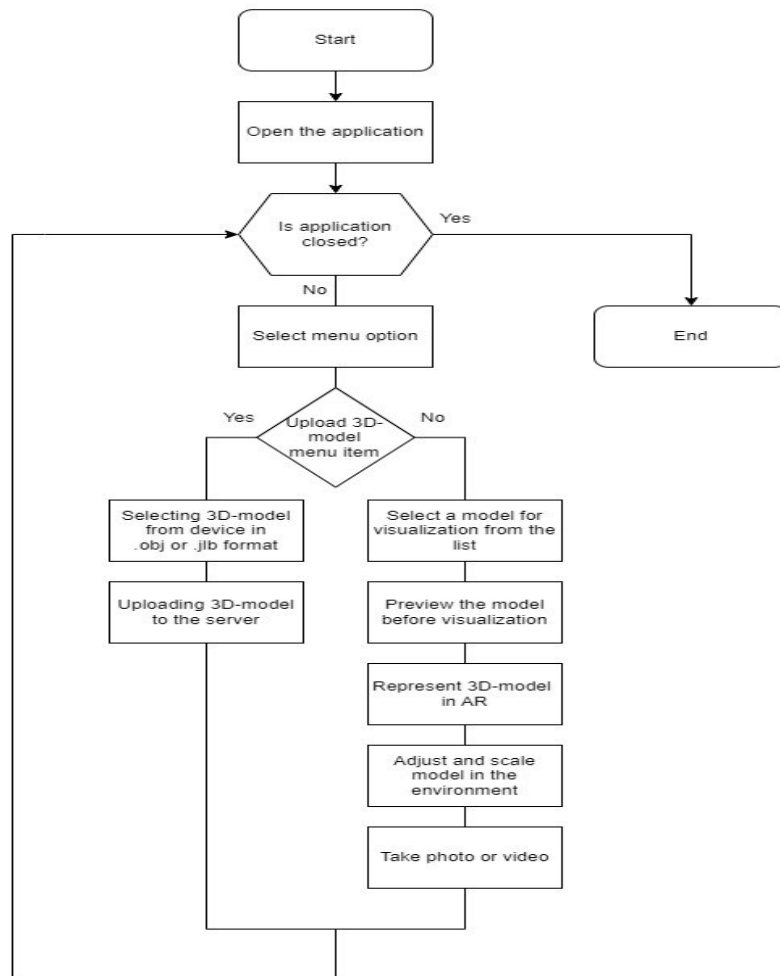


Fig.5. L The principle of operation of the information system for 3D models visualization in AR

Experiments and Discussion

To be able to conduct the experiments, we need to create the 3D models for testing. We chose the Botanical Garden of Khmelnytskyi National University as an environment for displaying the models and decided to create the models of the outdoor smart art objects than can be represented in AR in real size and in real time. We chose Blender as an environment for 3D models creating. The models are presented in Fig.6.

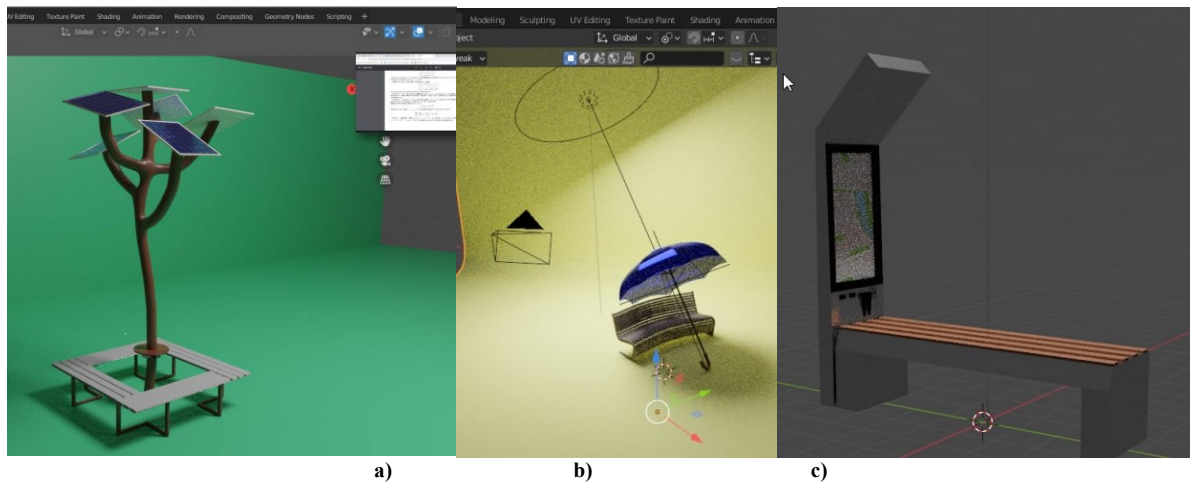


Fig. 6. 3D Models of art structures for Information Technology for 3D objects models visualization testing (Smart Solar Pannels Tree construction; b) The bench with Smart Solar Pannels Umbrella; c) Smart Bench with Solar Pannel based Information Screen)

For conducting the experiments the proposed Information Technology for 3D objects models visualization has been developed in the form of a cross-platform mobile application and installed on Andriod OS-driven mobile device. The interface screens of the developed information system are presented in Fig.7.

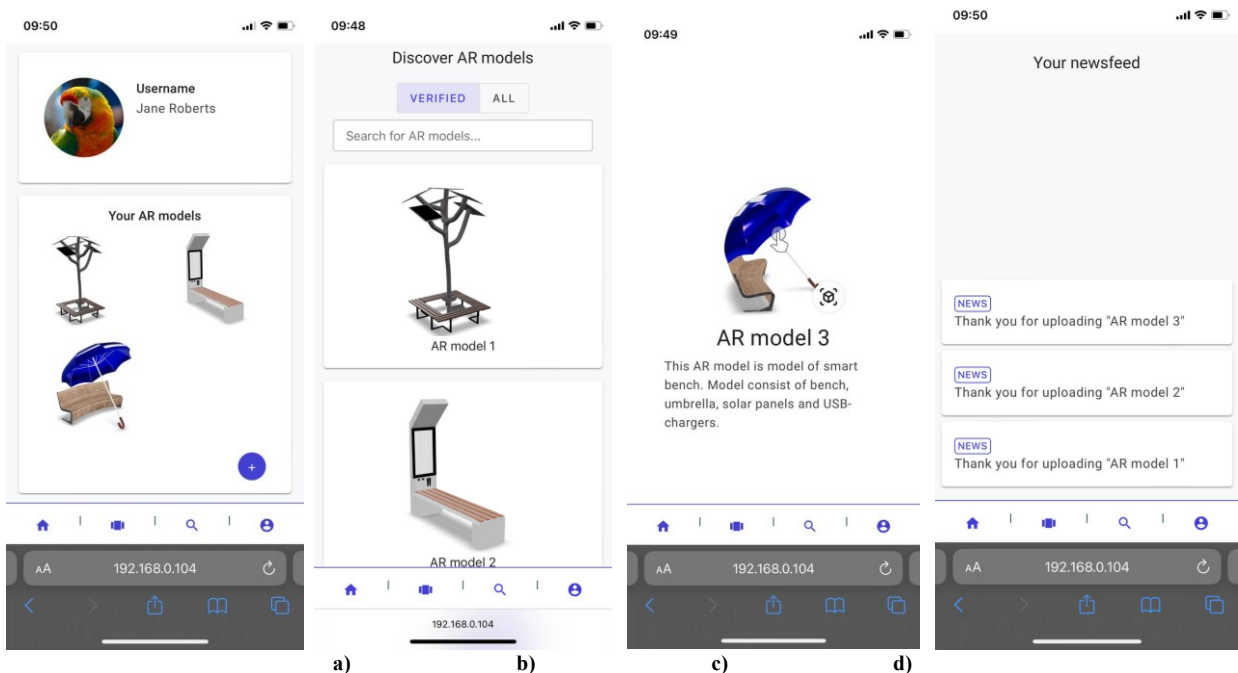


Fig. 7. Interface screens of Information Technology for 3D objects models visualization (User Profile Interface; b) Set of the available AR models; c) Preview of the selected model with the description before the visualization; d) The process of models uploading)

The results of the experiments are presented as a set of photos taken with the smartphone camera (Fig 8). The objects on photos are placed in the environment (Khmelnyskyi National University campus and Botanical garden) in real size.



a) the Bench and the Smart Umbrella



b) the Smart Bench with the Information Screen



c) the Solar Tree Art-object

Fig. 8. The experiment results on 3D objects models visualization in AR

Conclusions

Augmented reality has always been an object of interest as scientists as business industry representatives. The prospect of this technology application for various areas of industry and social life is proved by the numerous research works as well as the increasing number of commercial program products.

During the study the conducted literature analysis and the analysis of already existing AR-based mobile applications provided the conclusions that currently there are no ready-to-use solutions that provide reproducing a three-dimensional model of an object in augmented reality, so this is currently an urgent task from both a scientific and a practical point of view.

Therefore the information system for 3D objects models visualization in augmented reality was developed in the form of cross-platform mobile application. The proposed information system uses a device camera as a mean of object visualization and provides quick reproduction of the selected from the application's database model in augmented reality in real size and in real time.

The developed application works quite well, has a user friendly and intuitive interface and allows user to add own models, that makes this tool multipurpose. The further efforts of the authors will be directed to improving the existing algorithms for extending the current functionality of the proposed tool for 3D objects models visualization in

augmented reality and application of the developed tool for real-life needs, such as digitization and visualization of museum exhibits and archaeological artifacts of Khmelnytskyi region.

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