Leveraging augmented reality in a mobile application for effective advertising of educational services: an efficiency analysis

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Abstract

This paper examines the efficacy of a mobile application utilising augmented reality (AR) technology for advertising educational services at the Faculty of Information and Computer Technologies, Zhytomyr Polytechnic State University, Ukraine. The application, developed using Vuforia Software Development Kit in Unity, was deployed during career guidance activities. To assess its impact, data pertaining to applicants who submitted documents, viewed AR advertising, enrolled at the university, and their competitive scores were analysed using descriptive statistics and exploratory analysis techniques. The results demonstrate a notable increase in interest among applicants who interacted with the AR application, affirming its effectiveness in career guidance. The findings suggest that AR-based mobile applications can be a valuable tool for enhancing the appeal and information content of advertising materials, ultimately boosting applicant engagement. Future work aims to extend this application to all faculties within the university.

Keywords

augmented reality, vuforia, descriptive statistics, data analysis, advertising efficiency

1. Introduction

The rapid advancements in human-computer interaction have paved the way for innovative user interface paradigms. The widespread adoption of virtual reality has introduced the related concept of augmented reality (AR) into scientific discourse [1, 2]. While current user interface technologies primarily focus on human-computer interaction, AR leverages computer technology to enhance the interaction between humans and the real world [3, 4].

AR has emerged as a highly relevant research area, describing the process of augmenting existing reality with virtual objects. With the increasing prevalence of mobile devices, AR is poised for significant growth. By 2025, nearly 75% of the global population and almost all smartphone users are projected to be frequent AR users [5].

In the context of education, the majority of institutions currently offer both state-funded and commercial programs. The rising number of private educational establishments has intensified competition, compelling universities to employ relevant marketing tools and instruments to attract students, reinforce their market position, and enhance competitiveness.

The combination of mobile devices and AR technologies presents compelling advantages for advertising educational services, including informing applicants and their parents, creating a positive impression, increasing university recognition, and enhancing the effectiveness of career guidance activities.

This study aims to evaluate the effectiveness of a mobile application, UniAd, developed by specialists from the Department of Computer Science at Zhytomyr Polytechnic State University, Ukraine. The application employs AR technology to advertise the educational services of the Faculty of Information

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and Computer Technology (FICT). The research objectives include analysing data collected during career guidance work, conducting intelligence and statistical analyses across various indicators, and drawing conclusions based on the findings.

2. Literature review

The application of AR technologies in science education was explored at the AREdu 2020 conference [6]. Bilous et al. [7] emphasised the potential of AR application development as a promising research area for students, outlining the essence, directions, and advantages of AR technology in the educational process.

Several studies have demonstrated the current state and relevance of AR [8, 9]. Hordiienko et al. [10] presented a software application that utilises AR to provide a detailed representation of solar system objects, employing scaled dimensions to accurately depict the distances between planets. He et al. [11] reported enhanced English learning outcomes in children through the use of an AR application that displays visual representations of English words using a mobile camera. Vakaliuk et al. [12] showcased the possibilities of AR technology in creating a local history software application, "Monuments of the city of Zhytomyr", which was tested during city tours with elementary school students, resulting in increased interest in studying the history of their native city. Zhou et al. [13] introduced a mobile application that promotes lifestyle engagement in AR, enabling users to combine practical skills and visuals for enhanced multidimensional intelligence development.

The application of AR in contemporary chemical education and its potential for enhancing students' chemistry research projects were investigated by Nechypurenko et al. [14]. Krainyk et al. [15] explored the development of a historical guide based on AR technology, while Hruntova et al. [16] theoretically substantiated the use of AR technology and its features in higher technical educational institutions. The feasibility of AR in STEM education in Ukraine was demonstrated by Bilyk et al. [17].

Beyond the educational context, AR has been employed in various domains. Jung et al. [18] described an application for virtual tours of Jeju Island, enabling users to explore cultural heritage even in remote regions. Wang et al. [19] examined the popularity of AR mobile applications across four categories: games, advertising, videos, and shopping, concluding that AR mobile games are the most frequently used. Ozdemir [20] studied the role of virtual and AR for accessibility and marketing in tourism, highlighting both strengths and weaknesses. Wang et al. [21] analysed the status and benefits of AR technology application in domestic logistics. Osadchyi et al. [22] explored the possibilities of using innovative AR technologies to form the viability of future specialists. Hu et al. [23] investigated the attributes of theatrical performances using AR in theme parks, finding a positive effect on visitors' nostalgia and emotional arousal.

Carmigniani et al. [24] examined the current state of AR technologies, systems, and applications, addressing the challenges and requirements for successful mobile AR systems. Young and Koo [25] discussed the development of university library services using virtual and AR technologies, suggesting considerations for their implementation. Wyss et al. [26] reported a highly positive attitude and interest among students towards AR technologies.

Park [27] introduced ARLooper, an iOS AR application for multiplayer audio and performance, exploring the potential of mobile AR technology in creating new music interfaces and collaborative audiovisual experiences.

Based on the analysis of recent publications and the experience of using AR technologies, it can be concluded that AR has significant potential for application in education, particularly for advertising purposes.

3. Theoretical background and system design

3.1. Augmented reality technology

Augmented reality (AR) is a concept that describes the process of complementing existing reality with virtual objects. AR is evolving rapidly and is poised to become as significant a technological advancement as the Internet or mobile devices. It serves as a powerful tool for brands to attract consumers, enhance communication, and strengthen consumer confidence. The camera transforms AR from a gaming technology into a comprehensive experience that enriches people's lives. AR is already widely recognised as both interesting and useful, promoting rapid implementation and growth, with untapped demand for an increased number of AR applications [5].

AR can be implemented using applications for smartphones and tablets, AR glasses, stationary screens, projection devices, and more. The essence of AR technology lies in combining the real image with its virtual complement and outputting the final image on a visualisation device.

The foundation of AR technology is an optical tracking system. There are several options for using AR technology: marker-based and markerless. Marker-based technology is easier to use, as it is simpler for the camera to recognise and provides tighter binding to the location for the virtual model. This technology works almost seamlessly, often using a sheet of paper with a special image as a marker. The type of image can vary greatly and depends on the image recognition algorithms employed.

In this work, the advertising booklet of the Faculty of Information and Computer Technologies of Zhytomyr Polytechnic State University, Ukraine, is used. Before using the booklet, it needs to be marked with Vuforia to activate the application. The booklet image must be less than 2 megabytes in size, with a clear picture or photo. It is uploaded to the Vuforia website to obtain a rating. A rating of 1-2 stars is not recommended, as the speed and quality of recognition will be very low, potentially leading to incorrect program reviews. The booklet used in this study has a rating of 4-5 stars, indicating that recognition in the software application does not require much time and will accurately display the reproduced information about the specialty.

Marker technology using Vuforia creates static markers and uses them to enable object activation (figure 1).

3.2. Creating 3D objects

To create the UniAd mobile AR application, a number of graphics were developed using Blender. The main, albeit most time-consuming, model is the university building. In addition to the main facility, several other objects were created, including trees with animated leaves that move in the wind, walking human models with gait animation, benches, lanterns, and a fountain model located at the main entrance to the university (figure 2).

Furthermore, a number of 2D models serving as buttons were added to the mobile application, allowing users to select certain actions (figure 3).

3.3. Design and implementation of individual system modules

The Unity engine was used to create the program, leveraging its component-oriented system for working with objects. Interactivity and gameplay in Unity are based on three fundamental blocks: GameObject objects, components, and variables [28]. Any object in the application is a GameObject, including characters, light sources, special effects, scenery, and more. Components determine the behaviour of game objects to which they are attached and control them.

Figure 4 presents a precedent diagram demonstrating possible user actions when using the mobile application. The precedent corresponds to a separate service of the system, determines one of the options for its use, and defines the typical way of user interaction with the system. Usage parameters are commonly employed to determine system requirements.

An activity diagram was used to describe the behaviour of the mobile application (figure 5). The diagram reflects the dynamic aspects of system behaviour, essentially serving as a flowchart illustrating

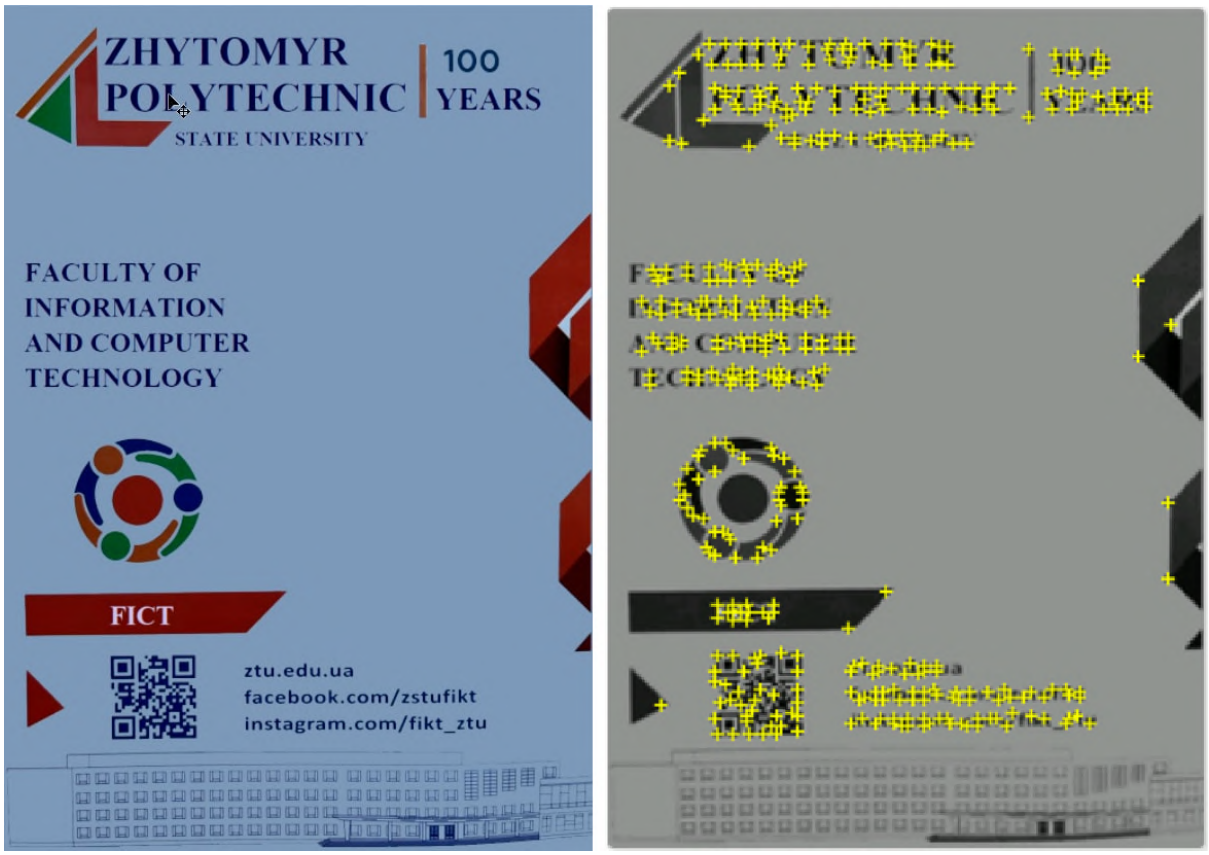

Figure 1: Creating targets on the booklet for the UniAD application.

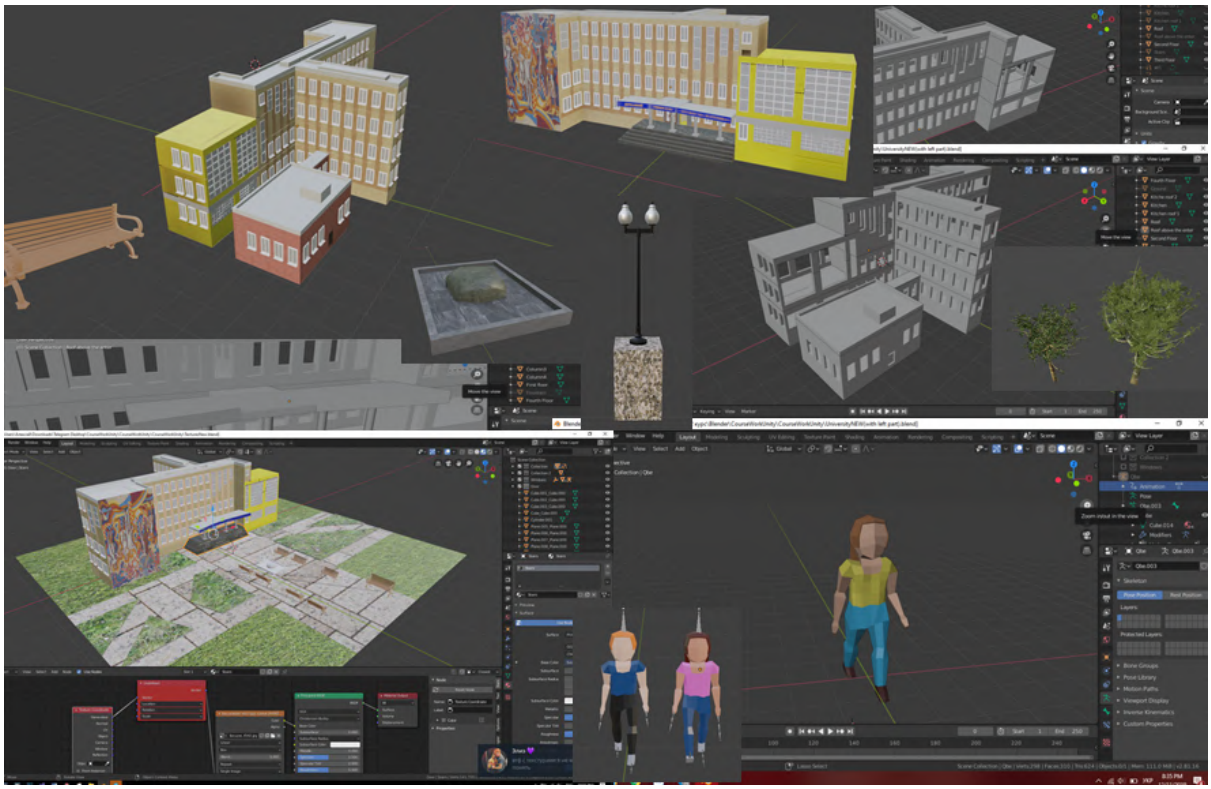

Figure 2: 3D models developed in Blender.

Figure 3: Buttons.

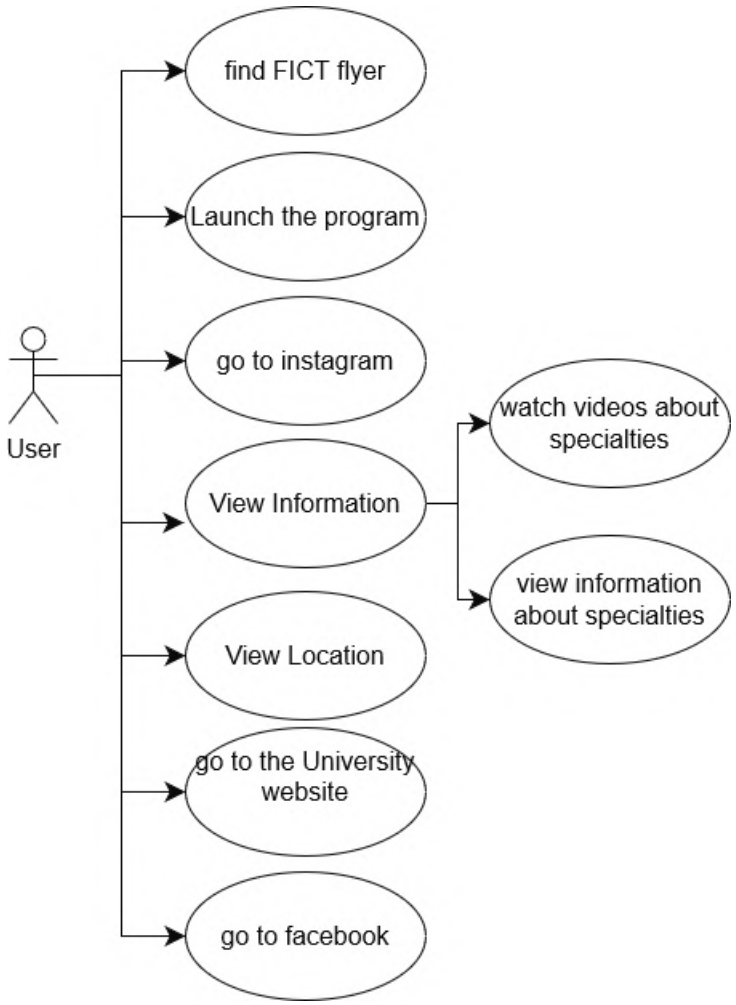

Figure 4: Use case diagram of the mobile application.

how control flow moves from one activity to another.

3D application simulation was created using the Blender development environment. The main model is the university building, with auxiliary objects such as bushes, benches, trees, and a fountain, some of which are partially animated. Many animations were created in the mobile application, including a 360-degree rotation of the university building, bone animation of student 3D characters moving near the university, and leaf movement on trees simulating wind. The Animator Controller, created by Unity, allows managing a set of animations for GameObject and switching between them when certain conditions are met.

Figure 6 illustrates the general algorithm of the system. Using an AR camera, focus is placed on the booklet of the Faculty of Information and Computer Technology. If the appropriate markers are found in the image, the “Start” button is displayed.

Unity supports C# scripting, following either the traditional object-oriented approach or the information-oriented approach.

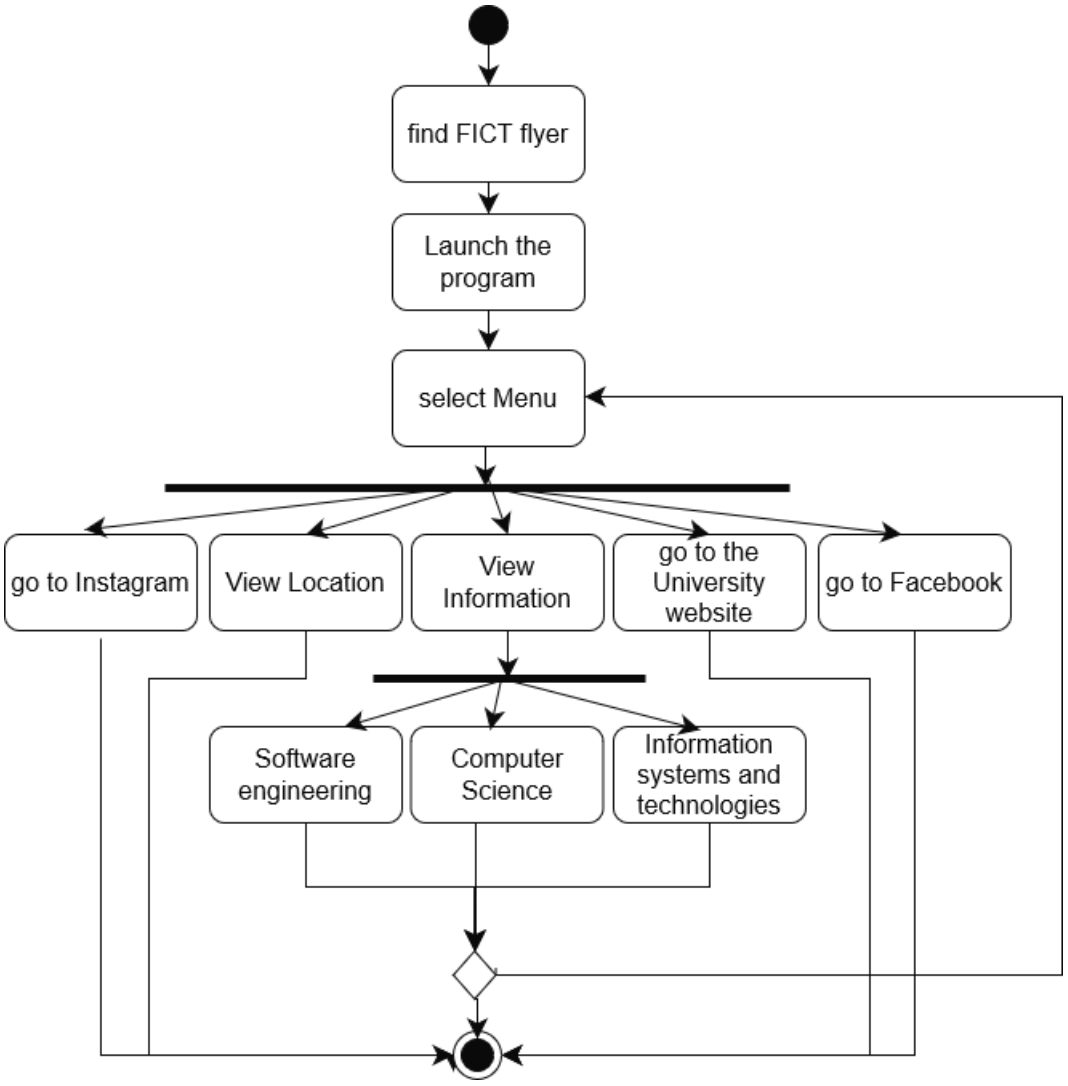

Figure 5: Activity diagram.

3.4. Mobile application interface

The application, implemented using Unity and Vuforia, can be used on devices with Android operating system version 10 and higher, requiring 210 MB of free memory. The interface is quite simple, with management carried out using the smartphone camera and the faculty booklet on which the user points the camera.

After launching the mobile application and pressing the "Start" button, calm music starts playing, and the animation of the university's appearance begins. Near the university, there are people walking, trees with rustling leaves, benches, lanterns, a fountain, and an inscription above it. Another "Menu" button appears on the screen. Figure 7 shows the program's image after clicking the "Start" button.

Users can view the university model by rotating the paper advertisement, as well as enlarge or reduce the institution's image. They can also open a drop-down menu to access additional university resources, such as the main university website, Instagram, Facebook, and Google Maps, indicating the location of Zhytomyr Polytechnic State University, Ukraine.

Pressing the "I" button opens seven cards, each representing a separate specialty at the faculty (figure 8). The cards display the specialty name, number, preferences, subjects, or interests. At the bottom of each card is a "View animation" button, which, when pressed, replaces the card with sprite animation related to the main activity studied in that specialty. Figure 8 shows an animation depicting an IT professional creating software, reflecting the essence of the specialty 121 "Software Engineering".

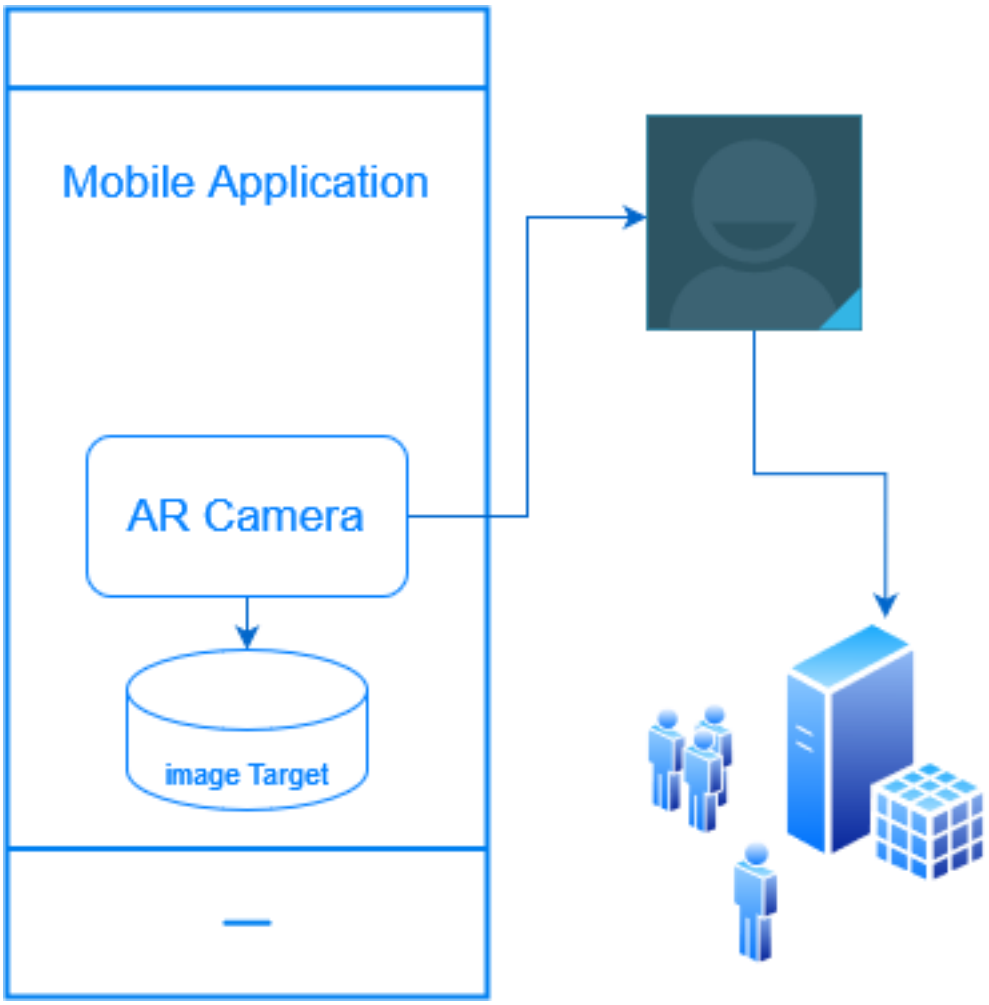

Figure 6: Scheme of project elements and their functionality.

By swiping the screen to the left, users can see all the animations and cards. To close the card view, the user must click on the "I" icon again.

When the user moves the camera away from the paper advertisement, all objects, music, and sounds are lost. To view the program again, the camera needs to be pointed at the paper advertisement once more.

4. Results

The application was intensively used during the career guidance work of the Faculty of Information and Computer Technology in 2021. During this process, a set of data was accumulated, which formed the basis for the analysis.

The data set, in CSV format, contains 1086 records represented by the following fields: submitted documents, saw AR advertising, entered the university, and competitive score. Among these, three fields are categorical data (0 or 1, saw advertising – 1, did not see – 0) (figure 9).

Descriptive statistics were used in the initial stages of the analysis. Measures of central tendency revealed the following indicators: the minimum value for the competitive score is 125 points, and the maximum is 200 points, with a range of 27 points. The arithmetic mean indicates that the "typical" score in the dataset is approximately 160.76, suggesting that most applicants have a fairly high competitive score. Spearman's rank correlation established a connection between competitive score and admission, as well as a small relationship between admission and ad viewing. The distribution of observations

Figure 7: General view of the program after pressing the Start button.

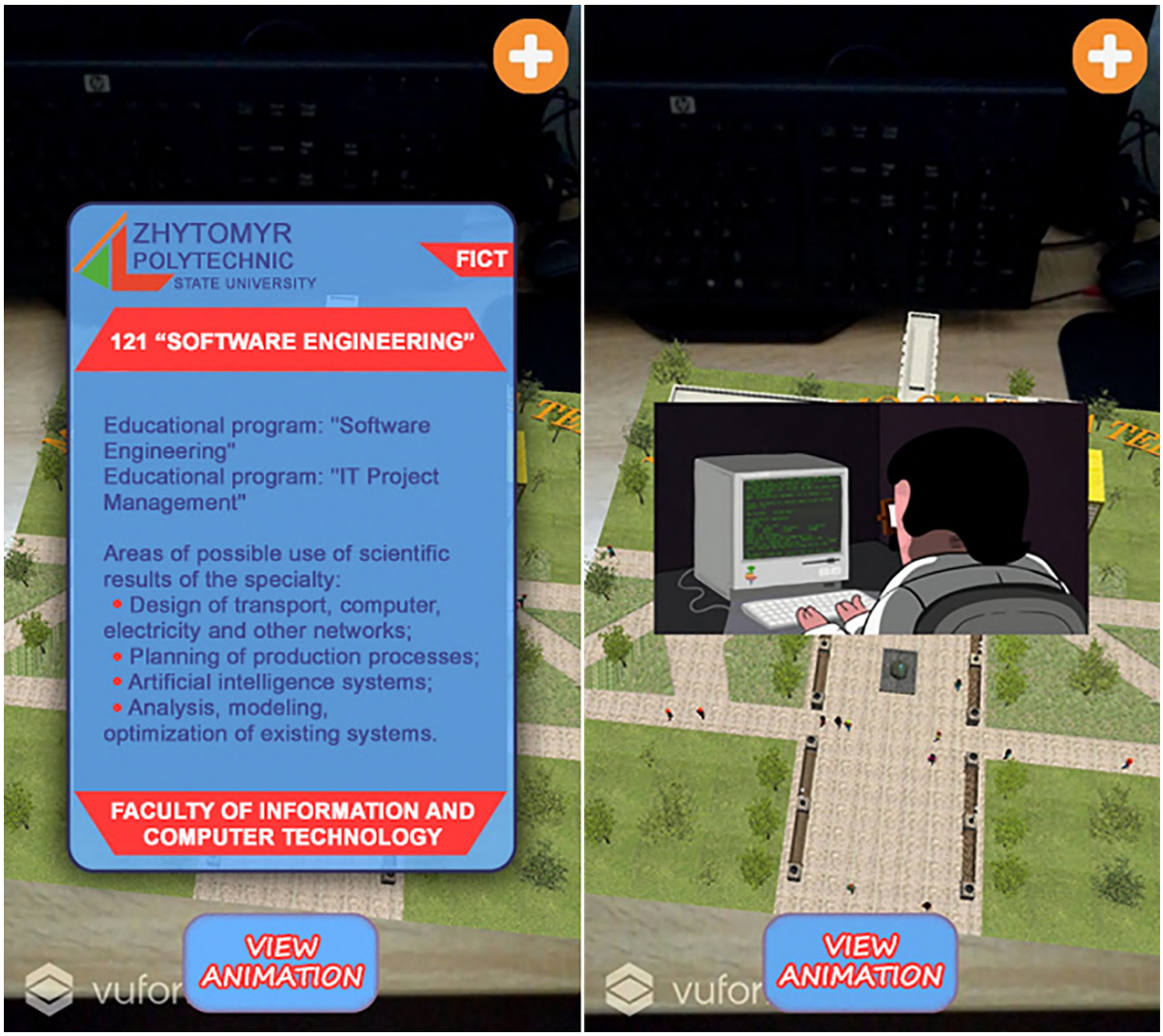

Figure 8: The result of pressing the "I" button.

	video_pres	sex	entered	competitive_ball	speciality
0	1	1	1	175	125
1	1	1	1	172	125
2	1	1	1	175	125
3	1	1	1	162	122
4	1	1	1	165	125
5	1	1	1	183	125
6	0	1	0	145	122
7	0	1	0	149	125
8	0	1	0	144	126
9	1	1	1	142	121
10	0	1	0	182	121

Figure 9: Fragment of the data set.

showed the following data: the first quarter is 152, the second quarter is 162, and the third quarter is 166. The standard deviation of the competition score is 13.32.

After profiling the file, it was determined that out of all applicants who submitted documents, 630 (58%) saw advertising. The majority of applications (60% or 652) were submitted for specialty 121 "Software Engineering", followed by 23.8% (259) for specialty 122 "Computer Science", 6.9% (75) for specialty 125 "Cybersecurity", 5.5% (60) for specialty 123 "Computer Engineering", and 3.7% (40) for specialty 126 "Information Systems and Technologies".

Out of all the applicants, 374 became students of the Faculty of Information and Computer Technology of Zhytomyr Polytechnic State University, Ukraine.

Figure 10 shows the general schedule of all applicants, those who enrolled, and those who saw the advertisement. The results indicate that not everyone who used the mobile application enrolled at the Faculty of Information and Computer Technology of Zhytomyr Polytechnic State University.

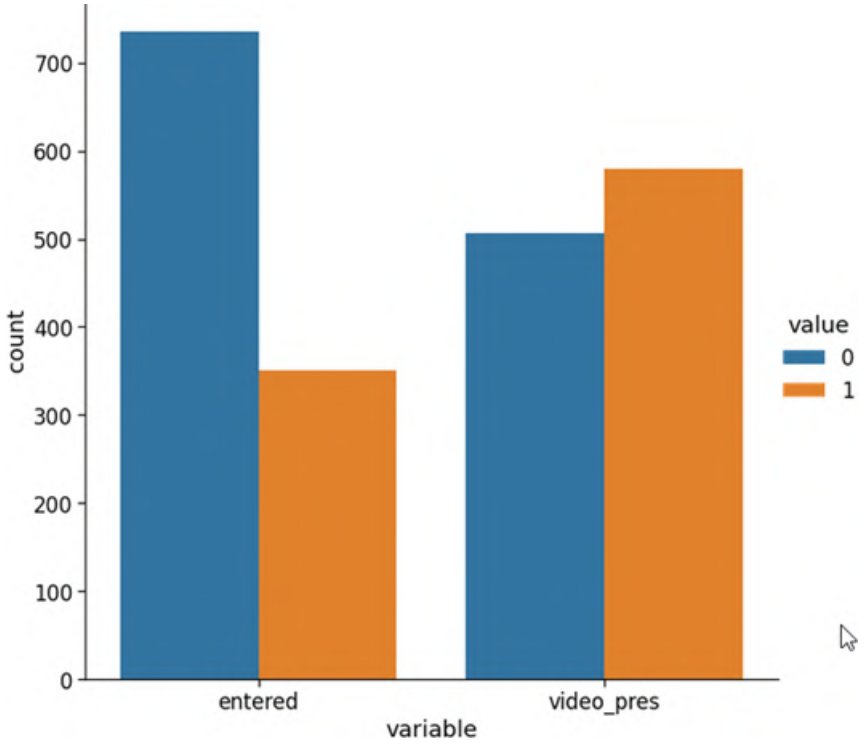

Figure 10: General schedule of all applicants, those enrolled, and those who saw the advertisement.

Figure 11 presents the data for the target variable "entered". Sample elements according to the value of the target variable are divided into two graphs, showing the number of applicants who did not enroll in FICT but saw advertising and those who saw advertising and enrolled in FICT. The schedule demonstrates that for both values, the number of applicants who saw advertising is higher, indicating increased interest in specialties at the university due to the search conducted before admission.

Figure 12 presents a histogram showing the data on advertising views using the application and the number of students enrolled in terms of FICT specialties. Interestingly, in specialty 122 "Computer Science", the number of enrolled applicants is higher than those who viewed the advertisement, despite the specialty's focus on augmented reality technology, which forms the basis of the created and researched UniAd mobile application. A more detailed analysis of the data for specialty 122 revealed that a significant number of students came from regions other than Zhytomyr (Lviv, Luhansk, Kyiv, Khmelnytsky, Rivne regions) and did not have the opportunity to use the application, thus not being reflected in the collected statistics. The coverage of a larger number of geographical regions in Ukraine has a significant influence.

The results show a significant number of applicants who saw the advertisement but did not enroll, which can be attributed to various factors, such as a low competitive score (figure 13). The passing score

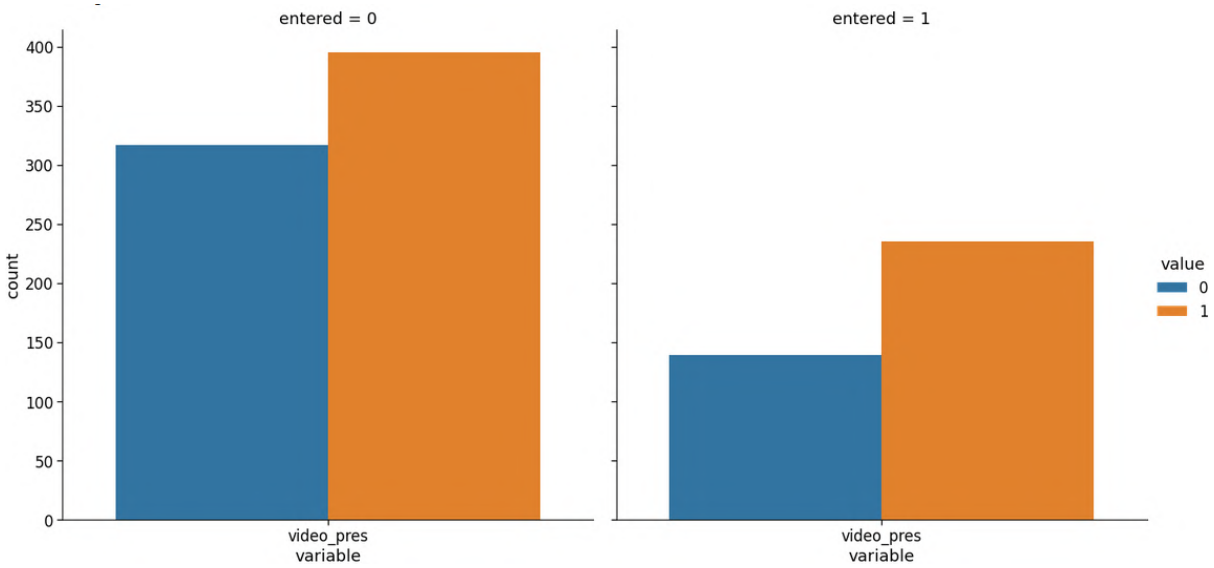

Figure 11: Data on the target variable “entered”.

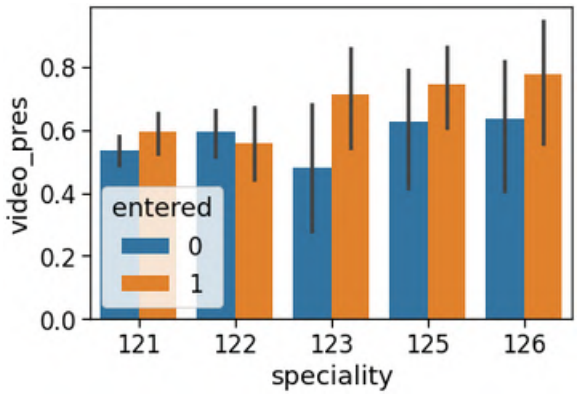

Figure 12: Histogram of advertising views and specialties entered.

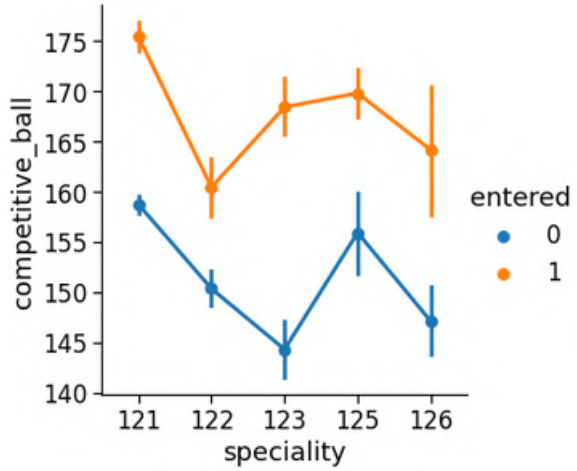

Figure 13: Data on the competitive score of applicants by specialties.

for admission was quite high and varied for each specialty, creating significant competition. The graph in figure 13 establishes the relationship between categorical and continuous variables, with vertical segments indicating the data portion for a particular category.

Another factor influencing admission is the lack of government-funded places for new specialties, leading applicants to seek other specialties or universities.

Considering the data in the context of gender, as shown in figure 14, a much smaller number of female applicants to technical specialties can be observed. In contrast, the girls' competitive scores vary between 154-176, which is above the mean, with a lower standard deviation compared to the total. It should also be noted that girls show more interest in specialties 121 "Software Engineering" and 122 "Computer Science".

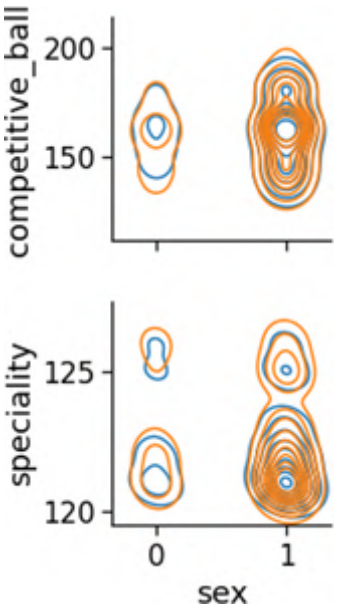

Figure 14: Diagram of advertising views by gender.

Based on the analysis of the data set, it can be concluded that advertising services using a mobile application based on AR technology are effective. Such applications attract applicants by providing information about specialties in an interesting way. Textual information is not always perceived qualitatively and in full, whereas the information presented in animated videos briefly represents the essence of the specialty, improving perception.

Methods of descriptive statistics and exploratory analysis were used for the analysis, implemented using the Python programming language, specifically the NumPy, Pandas, Seaborn, and Matplotlib libraries.

5. Conclusions

This study investigated the effectiveness of a mobile application for advertising educational services at the Faculty of Information and Computer Technologies of Zhytomyr Polytechnic State University. The analysis was conducted using data collected during career guidance work, with metrics including the number of applicants who submitted applications by specialty, the number of applicants who used the mobile application, competitive scores, and the number of enrolled applicants.

The results of the study demonstrate the appropriateness of using the developed mobile application. This is evidenced by the increase in first-year student enrollment across all specialties of the faculty in 2021, with the number of submitted applications exceeding the licensed volumes by specialty [29].

Therefore, we conclude that the use of augmented reality technology is suitable for promoting the educational process and advertising educational institutions. This approach undoubtedly increases applicants' interest and enhances the level of information perception about faculty specialties, achieved through diversity, interactivity, and visual presentation of information.

The mobile application was tested at the Faculty of Information and Computer Technologies of

Zhytomyr Polytechnic State University, Ukraine. In the future, it is planned to expand the application for use by various faculties and publish it in the Play Market.

Moreover, the effectiveness of the AR application in conveying information about specialties suggests that it can serve as a powerful tool for career guidance [30]. By presenting educational content in an interactive and visually appealing manner, universities can help applicants make more informed decisions about their future academic paths. This is particularly crucial in the context of technical specialties, where the complexity of the subject matter may deter some students from considering these fields.

However, the study also reveals some challenges that need to be addressed to maximize the impact of AR in education marketing. The lower number of applicants who viewed the advertisement for specialty 122 "Computer Science" compared to those who enrolled highlights the importance of expanding the geographical reach of such initiatives. Universities should strive to make their AR applications accessible to a wider audience, perhaps by exploring remote access options or collaborating with schools and educational institutions in different regions.

Furthermore, the gender disparity observed in the data underscores the need for targeted efforts to encourage more female applicants to pursue technical specialties. While the higher competitive scores of female applicants indicate their strong potential, universities must work towards creating an inclusive environment that nurtures and supports their interests in these fields.

Declaration on Generative AI: The authors have not employed any Generative AI tools.

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