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DEVELOPMENT OF MOBILE APPLICATION FOR OPTIMIZING TRAFFIC FLOW THROUGH GAMIFICATION

Abstract

Technology does not stand still and plays an important and decisive role in our daily lives, constantly creating new and unique opportunities to improve various areas, including transport and urban infrastructure. Our project is aimed at actively introducing advanced augmented reality technologies into the daily lives of consumers to optimize traffic and improve the overall safety of drivers. The mobile application we are developing combines unique elements of augmented reality (AR) and gamification, offering users rewards and bonuses for compliance with traffic and safety rules. This innovation contributes to the formation of more responsible behavior on the roads and helps to reduce the number of violations, as well as contributes to the reduction of accidents. The use of augmented reality technologies provides convenient and intuitive navigation, imposing visual clues on the surrounding world, which helps drivers to better navigate difficult areas. This allows the driver to make more informed decisions and improve driving skills. Our goal is to make these innovative and useful technologies available to every user, so that their trips become not only safe, but also interesting and exciting, turning ordinary trips into new experiences. The project is especially relevant for major cities of Kazakhstan, such as Almaty, Astana and other megacities, where serious problems of traffic accidents and constant traffic jams require new, effective and modern solutions.

Keywords: augmented reality, gamification, mobile application, traffic optimization, driver safety, game-based learning, navigation.

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РАЗРАБОТКА МОБИЛЬНОГО ПРИЛОЖЕНИЯ ДЛЯ ОПТИМИЗАЦИИ ТРАФИКА С ПОМОЩЬЮ ГЕЙМИФИКАЦИИ

Аннотация

Технологии не стоят на месте и играют важную и решающую роль в нашей повседневной жизни, постоянно создавая новые и уникальные возможности для улучшения различных сфер, включая транспорт и городскую инфраструктуру. Наш проект направлен на активное внедрение передовых технологий дополненной реальности в повседневную жизнь потребителей с целью оптимизации дорожного движения и повышения общей безопасности водителей. Разрабатываемое нами мобильное приложение сочетает в себе уникальные элементы дополненной реальности (AR) и геймификации, предлагая пользователям вознаграждения и бонусы за соблюдение правил дорожного движения и безопасности. Данное нововведение способствует формированию более ответственного поведения на дорогах и помогает снизить количество нарушений, а также способствует снижению аварийности. Использование технологий дополненной реальности обеспечивает удобную и интуитивно понятную навигацию, накладывая визуальные ориентиры на окружающий мир, что помогает водителям лучше ориентироваться на сложных участках. Это позволяет водителю принимать более обоснованные решения и совершенствовать навыки вождения. Наша цель - сделать эти инновационные и полезные технологии доступными для каждого пользователя, чтобы их поездки стали не только безопасными, но и интересными и захватывающими, превращая обычные поездки в новые впечатления. Проект особенно актуален для крупных городов Казахстана, таких как Алматы, Астана и других мегаполисов, где серьезные проблемы дорожно-транспортных происшествий и постоянных пробок требуют новых, эффективных и современных решений.

Ключевые слова: Дополненная реальность, геймификация, мобильные приложения, оптимизация дорожного движения, безопасность водителя, игровое обучение, навигация.

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ГЕЙМИФИКАЦИЯ АРҚЫЛЫ ТРАФИК АҒЫНЫН ОҢТАЙЛАНДЫРУҒА АРНАЛҒАН МОБИЛЬДІ ҚОСЫМШАНЫ ӘЗІРЛЕУ

Аңдатпа

Технология бір орында тұрмайды және біздің күнделікті өмірімізде маңызды және шешуші рөл атқарады, әр түрлі бағыттарды, соның ішінде көлік және қалалық инфрақұрылымды жақсарту үшін үнемі жаңа және бірегей мүмкіндіктер жасайды. Біздің жоба трафикті оңтайландыру және жүргізушілердің жалпы қауіпсіздігін арттыру мақсатында тұтынушылардың күнделікті өміріне кеңейтілген шындықтың озық технологияларын белсенді түрде енгізуге бағытталған. Біз әзірлеп жатқан мобильді қосымша пайдаланушыларға жол қозғалысы және қауіпсіздік ережелерін сақтағаны үшін марапаттар мен бонустар ұсына отырып, толықтырылған шындық (AR) және геймификацияның бірегей элементтерін біріктіреді. Бұл жаңашылдық жолдарда жауапкершілікті мінез-құлықтың қалыптасуына ықпал етеді және бұзушылықтар санын азайтуға көмектеседі, сонымен қатар жазатайым оқиғалардың азаюына ықпал етеді. Толықтырылған шындық технологияларын қолдану ыңғайлы және интуитивті навигацияны қамтамасыз етеді, қоршаған әлемге көрнекі белгілерді енгізеді, бұл жүргізушілерге қиын аймақтарды жақсырақ шарлауға көмектеседі. Бұл жүргізушіге неғұрлым негізделген шешімдер қабылдауға және жүргізу дағдыларын жетілдіруге мүмкіндік береді. Біздің мақсатымыз-осы инновациялық және пайдалы технологияларды әрбір пайдаланушыға қолжетімді ету, осылайша олардың сапарлары қауіпсіз ғана емес, сонымен қатар қызықты және қызықты болып, қарапайым сапарларды жаңа тәжірибелерге айналдырады. Жоба әсіресе Алматы, Астана сияқты Қазақстанның ірі қалалары үшін және жол-көлік оқиғалары мен тұрақты кептелістердің күрделі проблемалары жаңа, тиімді және заманауи шешімдерді қажет ететін басқа да мегаполистер үшін өзекті болып табылады.

Түйін сөздер: Толықтырылған шындық, геймификация, мобильді қосымша, трафикті оңтайландыру, жүргізуші қауіпсіздігі, ойынға негізделген оқыту, навигация.

Main provisions

This study focuses on the development of a mobile application that aims to optimize traffic flow and improve road safety using innovative features such as gamification and augmented reality. The key features of the application include providing optimal route options, road sign recognition based on augmented reality, real-time navigation with animated guides, and image recognition through augmented reality. Additionally, the system incorporates a gamified element that offers rewards and progress tracking, motivating users to adopt safe driving habits.

Introduction

In today's fast-paced world, technology has become an essential part of our daily lives, offered convenience but also posed new challenges. Modern roads, however, face numerous difficulties such as high numbers of traffic accidents and congestion. According to the World Bank [2], around 3,000 people lose their lives and over 30,000 are injured every year due to road accidents in Kazakhstan. This indicates that the risk of death from a road accident in Kazakhstan is 11 times higher than in countries such as Norway. One of the main reasons for this situation is the inability of drivers to resist the urge to use smartphones while driving, leading to inattention and disastrous accidents. Additionally, poor driving habits contribute to this problem, another piece of evidence is represented in Figure 1 below.

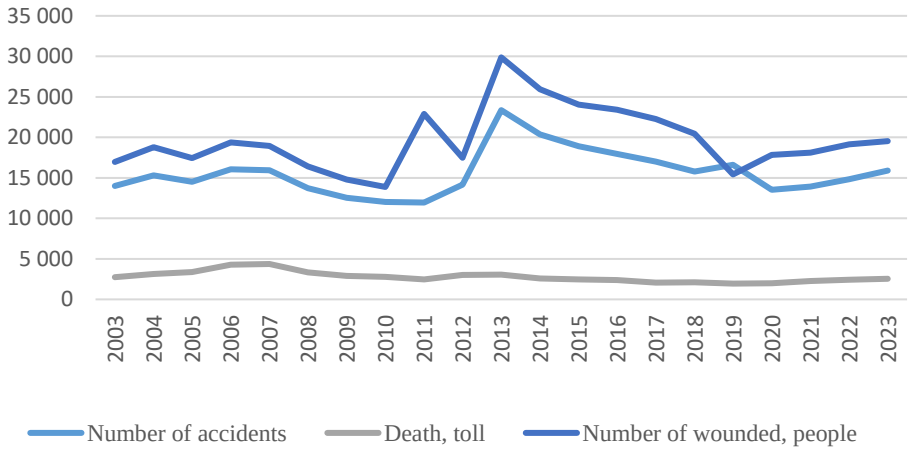

Figure 1. The growth in the number of road accidents in Kazakhstan for 2003-2023 years

According to the Committee on Legal Statistics and Special Accounts of the Prosecutor General's Office of the Republic of Kazakhstan, from 2003 to 2023, the number of road accidents is rapidly growing, and as reported by specialist: One of the main causes of traffic accidents is the low discipline of drivers on the roads of the republic [1].

Our project aims to address these challenges by creating a mobile app that utilizes gamification and Augmented Reality techniques to encourage safe driving behavior among drivers for optimizing traffic flow and enhance road safety by rewarding responsible driving with incentives. By integrating gamification elements and Augmented Reality features into the mobile application, we focus on reducing distractions while driving and promote safer road behavior and believe that this approach will lead to a more enjoyable, safe driving experience for everyone. While there are numerous traffic management and navigation apps available, most of them focus solely on providing directions for drivers [2]. This lack of attention to other aspects of driving safety, combined with an alarming increase in road accidents [3], highlights the need for innovative solutions to promote safer driving habits. In conclusion, the novelty of our app lies in the use of cutting-edge technologies, such as Augmented Reality (AR), which provides navigation information seamlessly to the driver's field of view. We also incorporate gamification elements to promote safe driving behavior. These tools are not currently used in existing traffic applications, despite their potential to engage drivers and reduce distractions that can cause accidents. By addressing this gap, we hope to play a significant role in reducing the risks associated with distracted driving.

Research methodology

The purpose of the project is to develop a mobile application that optimizes traffic by using a gamified approach that encourages drivers to drive safely, as well as providing innovative tools such as convenient navigation tools with Augmented Reality features and other. This Mobile application mainly focusses on reducing traffic congestion, improving road safety and improving interaction between road members [4]. Research question for this study: How can we optimize traffic flow by using gamification, improve driving quality, and enhance road safety with the help of innovative tools integrated into our mobile app? To achieve the objectives of this study, there will be used a mixed approach that includes qualitative and quantitative techniques.

Target audience for this study. According to the priorities of the study, a random sample will be used. For quantitative studies such as performance evaluation, a random selection within the relevant population group will be made to ensure objectivity and representativeness. The target audience for our mobile application is diverse. Thanks to its versatility, we can appeal to a wide range of users, including drivers, novice drivers, members of the community, and travelers. The detailed information about these groups is illustrated in Table 1 below.

Table 1. Key audience groups for mobile application

Who	*Needs*	*Benefits of using app*
Drivers who have their own private car.	*To use efficient navigation, real-time traffic data and reminders for safe driving.*	*The application provides variants of optimal routes, in addition rewards system for safe driving techniques.*
Individuals with limited driving experience like new, young drivers.	*The guidance in navigating complex roads and comprehensive understanding of traffic rules.*	*Due to the user-friendly navigation features with AR, making path easier by building confidence on the road.*
People	*AR navigation assistance and information about landmarks and historical sites.*	*Provide navigation tips with visual elements, making it interesting.*
Travelers	*Enhanced safety measures in new places, monitoring new road conditions.*	*Features help users feel informed and secure themselves in their journeys.*

The table illustrates data about the main groups of people that will use this mobile application, their needs from using this application, in addition what benefits they will receive using this system.

Since everyone can use and evaluate this mobile application, for receiving respectable and valuable evaluation, there will be a random sampling method employed. However, for prototype testing there will be used non-probability method Purposive sampling. Drivers with a lot of experience will be evolved for prototype testing and getting real feedback that will help to identify high quality and relevant data. The study will use both qualitative and quantitative methods, so the sampling approach will fit these approaches. The sample observations will represent specific solutions, which will then be generalized to apply to the general population [5].

The sample size for the quantitative component will be larger to use statistical analysis around 200-250 participants. Participants will be randomly selected from demographics to involve a balances representation of age, gender, experience, and geographic location. It will be beneficial for the calculation of significant statistics, to make accurate about user needs, benefits about application.

For the qualitative component, the sample size will be smaller, it mainly focuses on in-depth interviews and prototype testing with approximately 20-25 drivers with extensive experience. Online surveys: It will be widely distributed on social networks, forums for drivers, taxi drivers and large communities. This approach will help reach a broad audience, making results more exact.

Moreover, as mentioned before there is no limitation about the target audience of mobile applications, because even if the kids use navigation apps to get somewhere, consequently there are no strict inclusion criteria. In contrast for prototype testing of navigation system, participants must meet the following criteria: Aged 18 years/older. They have their own vehicle and have more than 4 years' experience in driving. So, including both purposive and random sampling approaches ensure the accurateness of this study by exact data.

Data collection methods. For the study, it is planned to develop a mobile application with the integration of a navigation system using augmented reality (AR) and gamification. The application will be aimed at optimizing traffic and improving driving safety.

The planned technologies that will be used in the application include:

1. GPS and real-time navigation: GPS technologies are supposed to be used to determine the user's location in real time, which will allow providing accurate routes considering the traffic situation.

2. Integration with the Mapping API: The API will provide up-to-date traffic and route data, helping users choose the best paths considering road conditions and congestion.

3. Augmented Reality (AR): AR will be used to display information about road signs and buildings on the device screen, helping drivers navigate the roads. AR will also provide visual cues along the route (such as arrows and pointers), improving navigation quality.

4. Cloud storage and data analysis: it is planned that all data on user movement, route selection and interaction with the system will be uploaded to the cloud storage for subsequent analysis. This will allow you to evaluate the effectiveness of the system by collecting data on user behavior, their preferences in routes and the success of gamification to improve security.

5. Gamification and collection of user interaction data: The system will collect data on user behavior, including compliance with traffic regulations, choosing optimal routes, as well as participation in game mechanics (for example, awarding points for safe driving). This data will be analyzed to assess the impact of gamification on driving quality and safety.

Planned data collection methods:

Quantitative methods: it is planned to collect statistics on the use of routes, compliance with traffic regulations, driving time and participation in game mechanics through the application, which will allow a quantitative analysis of user behavior [6]. Qualitative methods: it is planned to conduct interviews and surveys of users to collect qualitative data that will help us to better understand the experience of using the application, the perception of gamification and identify possible improvements in the system. The work process about AR functions shown in Figure 2 below.

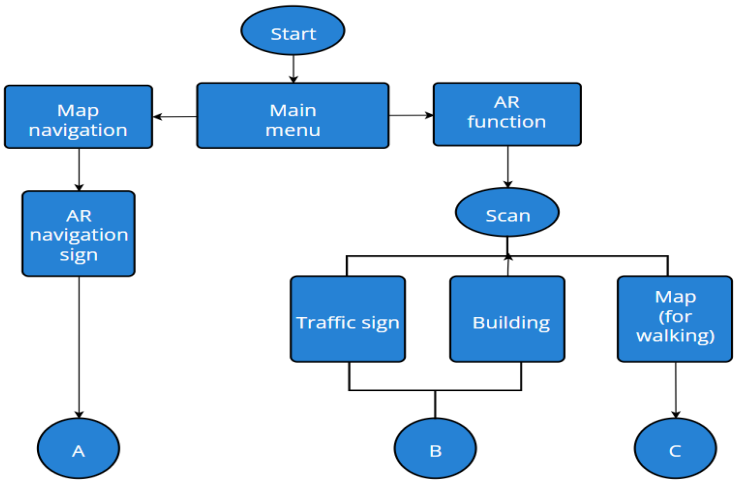

Figure 2. Flowchart for AR navigation system

According to Figure 2, when a user selects the "Map Navigation" option, the application uses a mapping API to load routes and provides real-time information about traffic conditions. This allows the user to follow the optimal route and receive updates about road closures and traffic jams [7].

The map interface shows the direction of travel and any traffic disruptions, functioning similarly to a traditional navigation system but with additional features provided by augmented reality (AR) and cloud-based mapping data. AR functions offer various interactive options such as map navigation, object scanning, and walking navigation, which are explained in more detail in Figure 3. About Map Navigation and AR walking Navigation for pedestrian navigation, they are similar in working process but differ by the use. AR for Map Navigation displays signs for drivers in the map, while AR walking Navigation is focused on the pedestrian navigation by involving extra properties [8].

The option of AR Scanning for Objects allows users to scan markers (such as traffic signs or buildings) using their device's camera. The app then renders the object in augmented reality, displaying additional information from a connected database, like descriptions or images. After viewing, users can return to the previous screen or main menu. Together, these technologies and data collection methods form the foundation for a system that improves traffic flow and promotes safe driving using gamification and Augmented Reality features [9].

Prototyping and Development Process. There are different types and styles used for mobile applications. In this case, this app optimizes traffic flow and promotes responsible driving by incorporating two main features such as gamification and Augmented Reality elements.

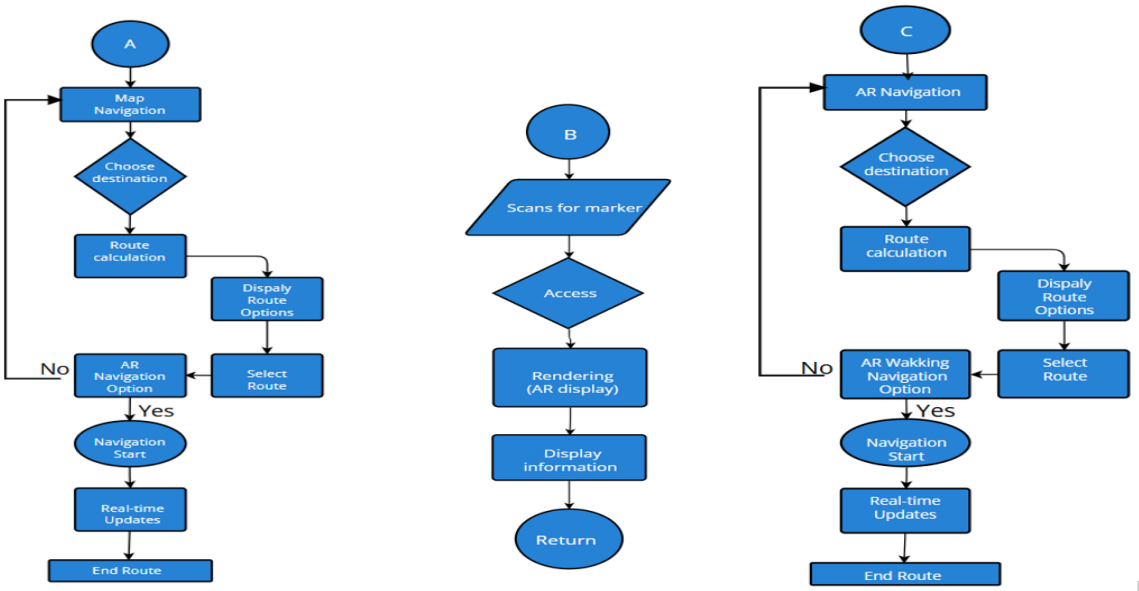

Figure 3. Flowchart for AR functions system

Gamification: The goal of integrating a gamified driving system is to encourage safe driving by motivating users through a game-like experience. Users earn points for following safe driving habits, traffic rules and can exchange these points for prizes or discounts. Additionally, various animations will be presented to help users navigate and stay focused, as shown in Figure 4 below. Each user will have their own animated character that will assist them with navigation and encourage safe driving. By combining fun with education, we aim to create a system that engages drivers and helps them develop better driving habits, ultimately reducing the number of accidents on the road.

Figure 4. The gamification features

1. Augmented Reality: While the integration of the AR system will provide real-time visual guidance (arrows on the road, road signs), it provides convenient navigation tools with augmented reality functions, helping the driver not to be distracted and making the trip livelier without letting the driver get bored on long trips [10]. In addition to map navigation using AR, functions will also be included for road signs and for buildings, as shown in Figure 5 below.

- Augmented Reality Road Signs: Recognizes Road signs and provides additional information.
- AR markers for buildings: Allow the user to point the camera at buildings and get information about them, such as the name or historical data.
- Animated Augmented Reality Character: Pedestrians can use a character to guide them along the route in augmented reality mode.

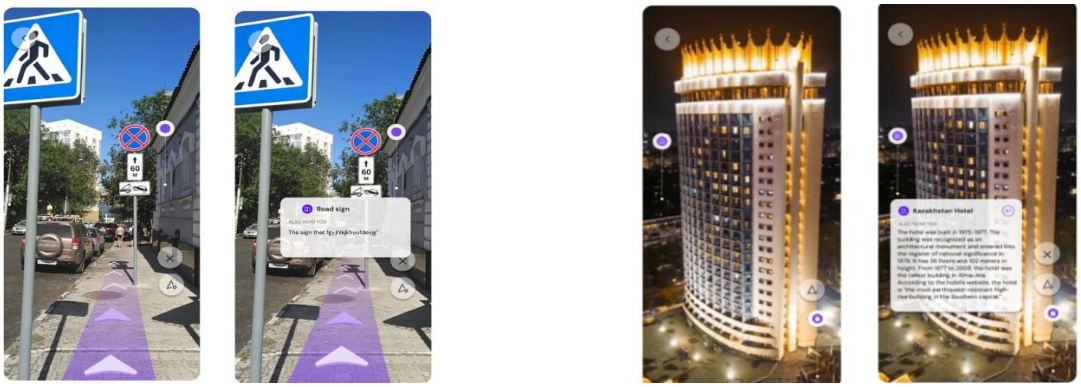

Figure 5. AR functions in application

To develop this mobile app that includes maps, navigation, Augmented Reality (AR) functions for displaying extra information about traffic signs and buildings, there are used such instruments tools as. The main platform for development of AR – Unity Engine.

- AR Foundation – the built-in Unity library.
- Vuforia-image recognition.
- Google ARCore for Android AR.
- Visual Studio Code IDE.
- Android Studio – to build an application.
- Mapping service – Google Map.
- Datasets for navigation, traffic signs, buildings information, etc.
- Flutter, Dart programming languages.
- PostgreSQL, Postman.

The use of Unity, AR Foundation, Vuforia is significant, because of their popularity and ease of use in the developing AR based system. Furthermore, other tools that also play a crucial role in the development of mobile applications that aim to optimize traffic flow through gamification elements. Ethical considerations. The study was conducted in accordance with ethical principles requiring the informed consent of all participants before data collection [11]. The study has identified several potential limitations that can be eliminated in the future:

Using standard mobile devices

- The current Augmented Reality navigation system was designed to work on conventional mobile devices, which limited the use of more advanced technologies such as smart glasses or Bluetooth beacons. In the future, with the development of technology, it is possible to integrate such solutions, which will improve the accuracy and quality of navigation.
- Lack of personal support.
- During the experiment, users did not receive assistance from the staff, which could cause some difficulties and disruptions in the visiting process. In the future, the use of automated prompts or interactive assistants may solve this problem and improve user convenience.
- Limited applicability of the results.
- Since the study was conducted in the specific context of an outdoor exhibition, its results are difficult to generalize for all types of AR navigation systems. However, with the improvement of augmented reality and GPS technologies, in the future such systems will be able to be adapted to a wider range of conditions.

The development of a mobile application with the integration of Augmented Reality (AR), gamification technologies represent an innovative approach to optimizing traffic and improving driving safety. AR allows you to create interactive elements that make the navigation process more intuitive and convenient. By superimposing virtual hints on the real environment, users can navigate the roads more easily, which minimizes the risk of errors and increases safety. Thus, the application makes navigation more convenient for users and increases road safety. The project is relevant for large cities of Kazakhstan. The introduction of such technologies will help create a safer transport

system [12]. Drivers will be able to easily plan their routes and participate in the game elements of the app, which will make them more involved and responsible on the road.

Results of the study

Upon starting this application, according to the main goal of this mobile application, there are main, and first page is map, such as navigation page with the menu bar that provide access to other functionalities like play Augmented Reality functions, profile, and chat page, shown in Figure 6. In the top of this map page, there are windows about *What are you going to?* by clicking to this user build road directions from, to address. In addition, on the map page, users can also choose various transport, type to go. As mentioned before, the mobile application for optimizing traffic flow shows variants of routes with the explanation and differences vary them with different colors.

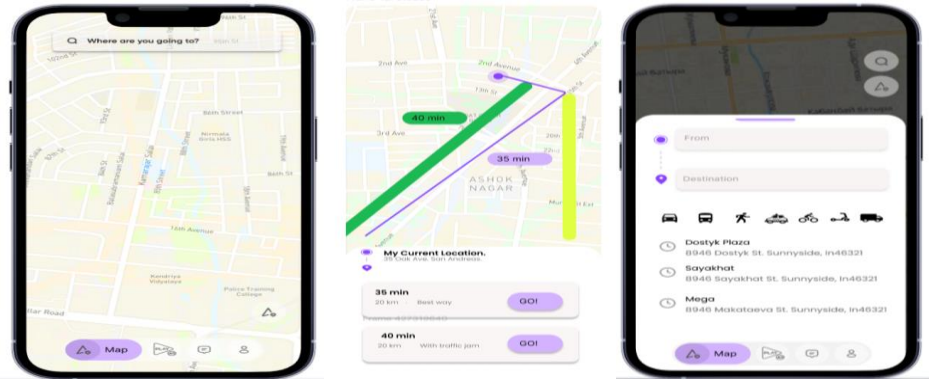

Figure 6. Interfaces of Map Navigation function in mobile app.

To draw the road line for users' destination. There represented only the initial examples about map components. Additionally, in navigation of users this application will display navigation elements in AR form making it easy, and interesting without distracting the user, by supporting to be focused on the road signs and don't get distracted. *The System Architecture* of this application is outlined in the UML class diagram for traffic optimization that incorporates gamification and Augmented Reality (AR), below in Figure 7.

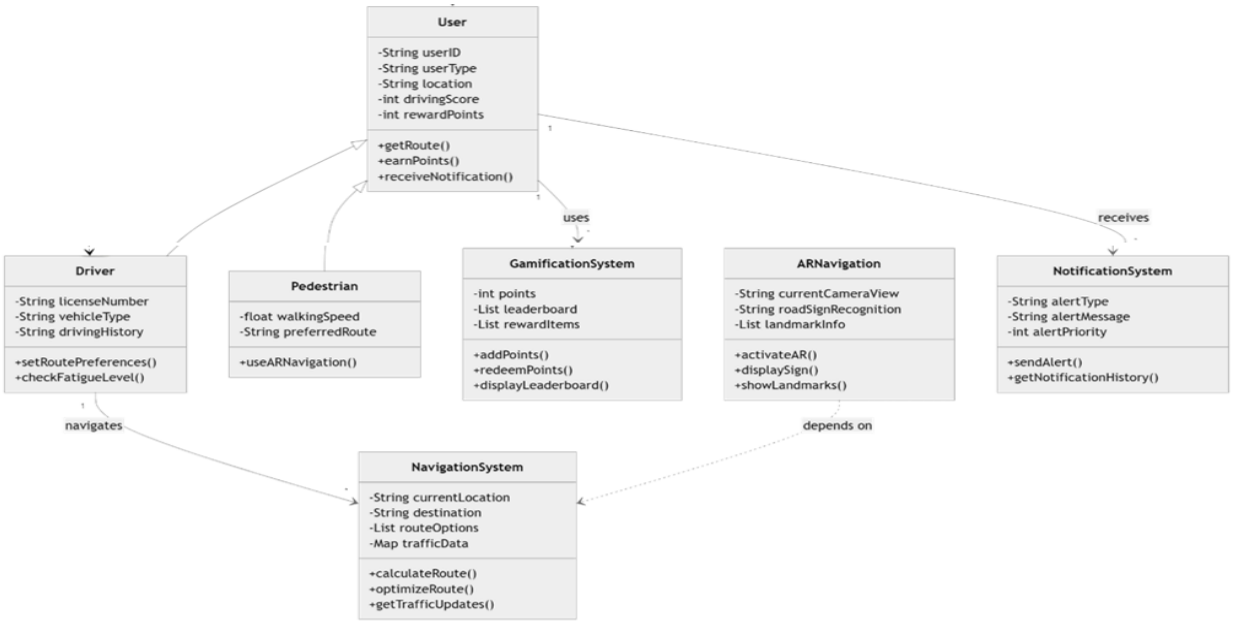

Figure 7. UML class diagram for the application

It defines the main classes that are responsible for the application's features and how they interact, offering a safe and engaging navigation experience through AR, and promoting safe driving. First, there are 7 classes including User class that interacts with other classes such as Driver, Pedestrian, GamificationSystem, ARNavigation, NotificationSystem and NavigationSystem, with appropriate methods of each of them.

All components/classes are demonstrated in this class diagram communicate through a database, ensuring consistency in data. For instance, the main User class contains information about userID, userType, location, drivingScore, rewardPoints with methods getRoute() for drawing road for navigation(destination), earning points by maintaining good behaviour on road, and receiving notification about possible harm or challenges. Users of application receive alert notifications from NotificationSystem class which contain information about alertType, alertMessage, alertPriority and methods for sending alert message and getting notification history. While GamificationSystem class is used by users to earn points, to browse leader board and reward details. In addition, another class called Pedestrian class is displayed there, as mentioned earlier, it uses an animated AR character for a pedestrian using the useARNavigation() method.

On the other hand, Figure 8 shows a diagram of the use cases. The diagram shows how specific actors (player, system, pedestrian) interact with a mobile application for navigation and traffic optimization. The first goal of the mobile app is to motivate users to maintain good driving habits, and in this case, by following the rules and warning messages, users earn points that can be exchanged for other rewards in the future. At the same time, the system displays several options for the best route options from the request of users. While the system displays optimal variants of routes by the request from users. In addition, an actor called pedestrian in diagram, that handles Augmented Reality functions to recognize road signs and buildings, animated character for navigating user while navigating user to their destination by giving directions with AR features.

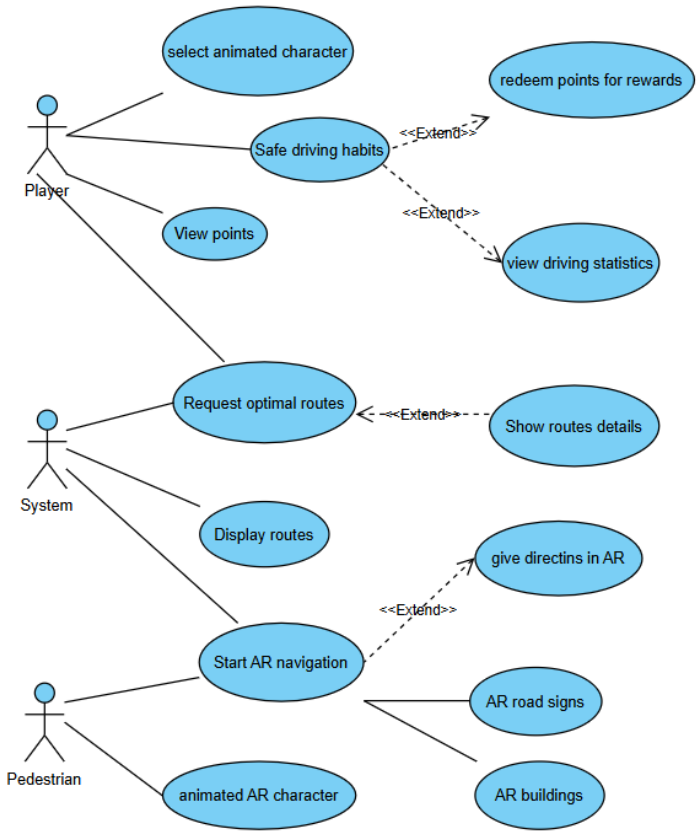

Figure 8. The Use case diagram for a mobile application

The uniqueness of this mobile application lies in the combination of advanced technologies, gamification and augmented reality. Augmented reality (AR) technology plays an important and valuable role in the effectiveness of the application, so here it illustrates a sequence diagram in Figure 9, that displays augmented reality functions in the application according to the interaction of objects such as the User, ARNavigation, map, road signs, recognition of buildings and augmented reality animated character.

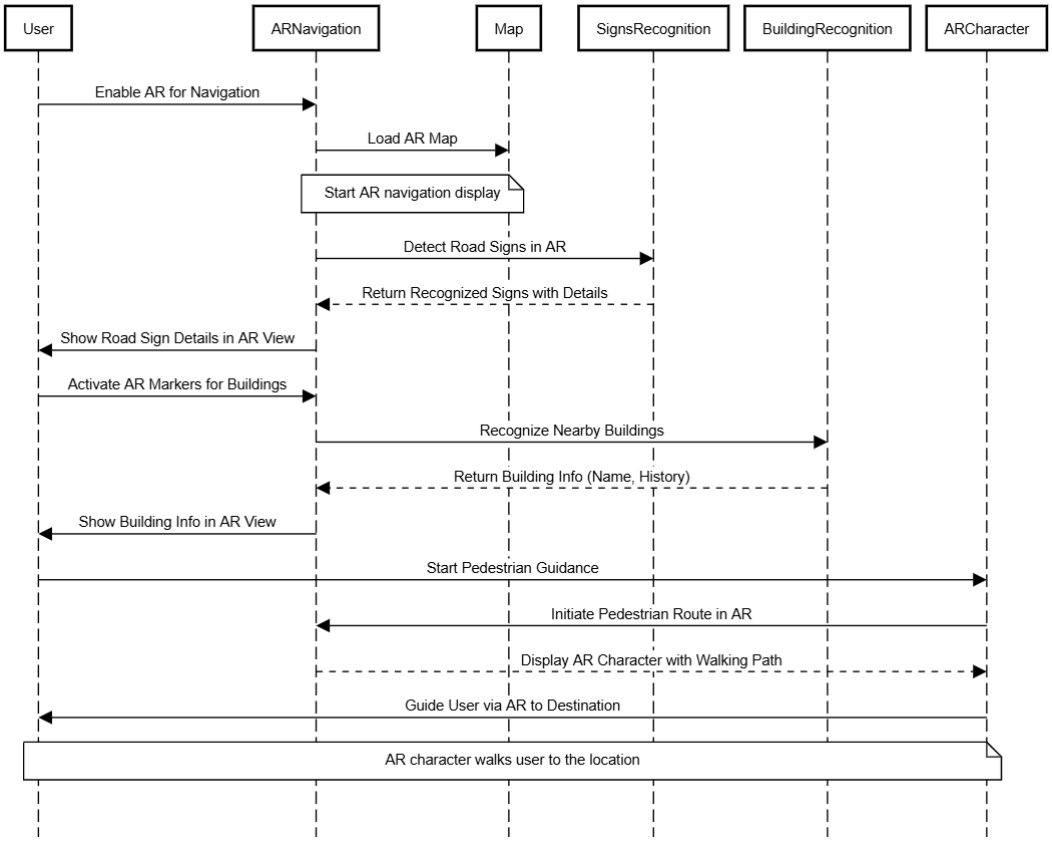

Figure 9. Sequence diagram for AR functionalities

With the camera, users can scan road signs that have been detected and returned with detailed information, and activate AR markers for buildings that recognize and return building information in AR mode in the app. In addition, a sequence of actions is displayed according to an animated AR character who guides the pedestrian to their destination using AR elements. In general, the purpose of this sequence diagram is to show how users use the application and the sequence of functions, how it starts and how it returns a response, displaying augmented reality objects in the application view mode with all the augmented reality functions in the mobile application.

AR Development and Testing process. According to the functions relating to AR, as mentioned before, right now we work in Unity Engine to develop the application that uses AR technology. The first task about AR was about the capturing image or marker that after recognizing and displaying necessary information, details. Using the camera of Android phone, we can see that only in case there appeared any image on camera AR is activated and showed little elements saying that it is work and find image. In that case, Unity's AR Tracked Image Manager used to detect when an image from Reference Image Library is recognized by the camera, below, represented the example of this system in Figure 10. Using Unity as the main platform for augmented reality (AR), the application for Android phones is now integrating AR images of road signs and building elements into the mobile app. This allows users to capture these images with their phone's camera and view additional information in a new layer.

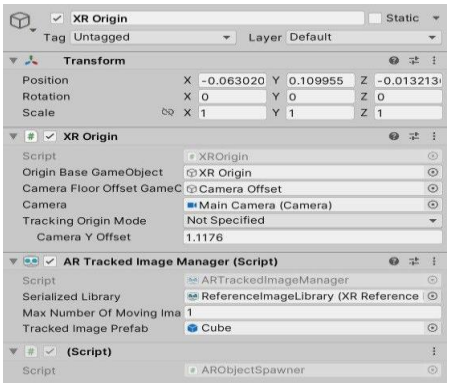

Figure 10. Example of working with Unity's AR Tracked Image Manager

In Figure 11, we see the first test of handling images using the camera. As you can see, the mobile app detects, recognizes, and shows details of the markers.

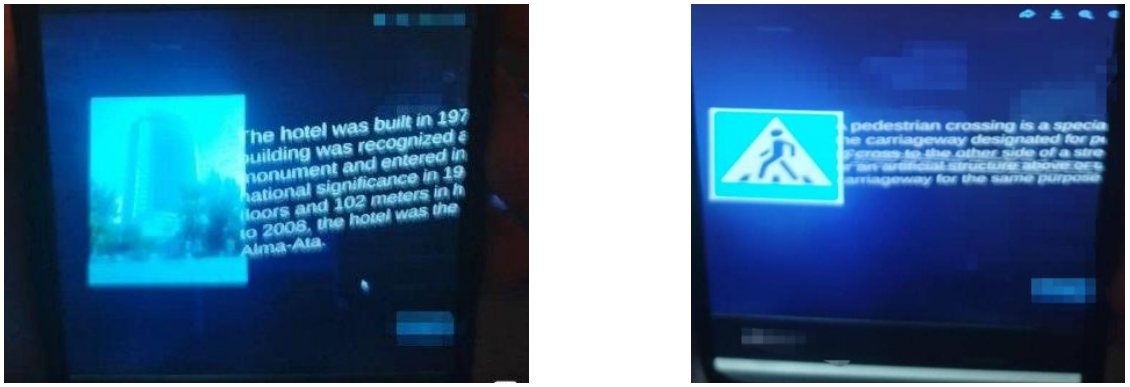

Figure 11. Initial test on AR functions

So, to detect and display these images we used Vuforia and AR Foundation, along with other tools, to capture various elements, such as traffic signs and building information, in our case, there are demonstrated the example of working with AR Tracked Image Manager, as shown in Figure 12.

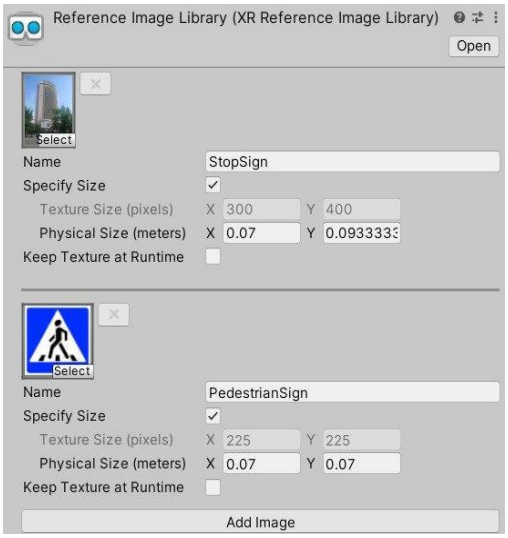

Figure 12. Example of working with AR Tracked Image Manager.

As you can see, right now our system is in the process of integrating and working in main functions of AR to capture elements by camera of the phone and displaying other extra information in the mobile application by creating new layer that user captured by themselves. Furthermore, there to develop and manage all these AR Foundation libraries in Unity Engine, there used Programming Language as C#, which is the main in Unity Engine Platform. In addition, there are displayed the peace of code implementations on Unity Engine platforms, in Figure 13 below.

```
using UnityEngine;
using UnityEngine.XR.ARFoundation;
using UnityEngine.XR.ARSubsystems;
using System.Collections.Generic;

public class ARObjectSpawner : MonoBehaviour
{
    public ARTrackedImageManager trackedImageManager;
    public GameObject cubePrefab;
    public GameObject spherePrefab;


    private Dictionary<string, GameObject> spawnedObjects = new Dictionary<string, GameObject>();
    void OnEnable()
    {
        trackedImageManager.trackedImagesChanged += OnTrackedImagesChanged;
    }

    void OnDisable()
    {
        trackedImageManager.trackedImagesChanged -= OnTrackedImagesChanged;
    }
    void OnTrackedImagesChanged(ARTrackedImagesChangedEventArgs eventArgs)
    {
        foreach (ARTrackedImage trackedImage in eventArgs.added)
        {

            string imageName = trackedImage.referenceImage.name;


            if (imageName == "PedestrianSign")
            {
                Debug.Log("Contains");
                SpawnObject(trackedImage, cubePrefab);
            }
            else if (imageName == "StopSign")
            {
    }
    foreach (ARTrackedImage trackedImage in eventArgs.updated)
    {
        if (spawnedObjects.ContainsKey(trackedImage.referenceImage.name))
        {
            Debug.Log("Contains");
            spawnedObjects[trackedImage.referenceImage.name].transform.position = trackedImage.transform.position;
        }
    }
}
```

Figure 13. "ARObjectSpawner" code for image recognition.

All these current tests and developments demonstrate how the work process is rapidly progressing and improving towards achieving the goals of the mobile app. Now, this AR function detects images captured by the camera and displays additional information about road signs and buildings. However, we should remember that this is only an initial test, so the interface of the mobile application will become more user-friendly and easier to understand for users, as shown in Figure 7.

Regarding Unity Engine, as previously mentioned, for all aspects of integrating Augmented Reality features, programming language C# will be used, while for implementing other functionalities of the application, we will use platforms such as Android Studio and a significant API for maps.

Discussion

The development of our mobile application, which combines elements of gamification and augmented reality (AR), offers a new approach to solving problems on the roads, such as traffic jams and dangerous driver behavior. The app motivates drivers to follow safety rules by offering them rewards for proper behavior, and helps improve traffic on the roads. Using augmented reality for navigation makes the driving process easier and more interesting by providing drivers with useful information in real time without distracting them from the road.

How gamification affects driver behavior. Gamification is an important element that affects how drivers behave. Rewards for following traffic rules and responsible behavior increase user motivation. Research shows that gamification helps make everyday tasks more fun, and in our case, it helps

drivers learn and follow safety rules. The points system, ratings and bonuses motivate users to drive safer and increase their engagement.

Augmented Reality to improve navigation. One of the key features of our app is the use of AR to improve navigation. AR adds navigation information directly into the driver's field of view, which helps to be less distracted by the phone or map. The app also recognizes road signs and shows information about buildings and other objects. This turns our app not only into a navigation tool, but also into an assistant for the driver, providing useful data. On the other hand, for mapping, Google APIs will be used to capture maps. This is due to their ease of use and accessibility. There are numerous platforms and systems available for navigation, including those that use AR in their maps, such as Pogo Map. Pokémon Go Map, developed during the popularity of the Pokémon Go game, uses AR only as game components to prevent boredom. While it has more functionality than other platforms in this area, there is also research on Zombies on the Road: a holistic approach to balancing gamification and safe driving. Moreover, in our country, when it comes to navigation tools, most people are familiar with only a few popular apps. All these popular apps focus on providing directions to users.

Data collection and user feedback. We use two methods of data collection: quantitative and qualitative methods. Quantitative data, such as driving habits and route selection, allows you to assess how well the app is working. Qualitative methods such as surveys and interviews help to understand how satisfied users are with the application and what can be improved. This information will help us make the app better based on real user reviews.

Limitations and challenges. Despite the innovativeness of our project, there are some limitations. For example, the capabilities of standard mobile devices may reduce the accuracy of AR functions. There are also challenges related to maintaining user interest and data protection. Since the application collects behavioral data, it is important to ensure high security of users' personal information.

The mobile application, which combines elements of gamification and augmented reality (AR), is an innovative solution aimed at improving the traffic situation and improving driver safety. Gamification helps to increase the motivation of users to follow the rules of the road, making the driving process more responsible and interesting. Augmented reality facilitates navigation by providing useful information in real time without distracting the driver from the road. Despite existing limitations, such as the technical capabilities of mobile devices and the need to ensure data security, our application has significant potential to improve the traffic situation and increase user satisfaction. The quantitative and qualitative data collected will allow us to optimize the operation of the application, focusing on real user feedback.

Conclusion

Our mobile application is an innovative solution aimed at improving road safety and optimizing traffic flows. Combining augmented reality (AR) technologies and gamification, it allows users to learn the rules of the road in an exciting way and apply them in practice. Users receive rewards for following the rules, which contributes to the formation of a culture of safe and responsible driving. At the initial stage of the project, we focused on creating basic functionality, including AR navigation, a traffic sign recognition system and a system for calculating points for correct behavior on the road. The first tests confirmed that the application is able to improve the interaction of drivers with the environment, making trips more convenient and safer. We have also received feedback from users who emphasize the usability and the need for such technologies in real life.

One of the key features of the application is its adaptation to the road conditions of Kazakhstan. We take into account the specifics of the local infrastructure, such as the condition of roads, the presence of signs and the general congestion of the transport network. This allows you to create a tool that not only helps drivers comply with the rules, but also helps to reduce traffic jams and improve the overall transport situation. An important stage of the work was the study of user behavior. The analysis of the data collected during the testing process allowed us to identify areas for further

improvements. For example, we plan to optimize navigation algorithms and expand AR functionality to make the process of interacting with the application even more convenient and intuitive.

Despite the successes achieved, we face challenges to improve user data protection, increase the accuracy of AR modules and integrate additional functions. In the future, we plan to expand the application's capabilities by adding, for example, information about local attractions and services, which will make it useful not only for drivers, but also for tourists. The project demonstrates how modern technologies can become an effective tool for solving urgent transport problems. We are convinced that the developed application will contribute to improving road safety, improving driving culture and developing Kazakhstan's digital infrastructure.

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