Enhancing User Interaction Through Augmented Reality Interfaces

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***Abstract*—This paper presents an Augmented Reality (AR) system designed to enhance educational card games by recognizing cards and providing real-time word explanations in Azerbaijani. The system integrates AR for object detection and an API to fetch and display word meanings dynamically. The proposed method demonstrates its potential in language learning and interactive education through engaging and adaptive user interfaces. Using the OCR-based approach, the system achieves over 95% accuracy in Azerbaijani educational cards.**

Keywords—augmented reality, educational games, intelligent system, serious games, word recognition, gamified system, learning system

I. Introduction

Augmented Reality (AR) technologies are commonly employed to automatically recognize cards and extend augmented data to that [1]. Different solutions such as educational cards available in the literature for teaching purposes [2]. However, their physical limitations restrict the incorporation of long explanations and adaptive content. AR technologies are favored for their capacity to overlay interactive content and extensive information. This approach allows AR-based solution to bridge this gap, enabling card recognition and word explanations in the Azerbaijani language using backend integration. While physical methods are effective, they suffer from the following drawbacks:

- limitation to quantity of information: Physical cards constrain their capacity to offer lengthy explanations or additional data;
- static nature: They are not flexible because changes need new printouts, so they are not good for fast-paced learning situations;
- no interactivity: Physical cards don't have interactive features, so they can't offer unique learning experiences;
- language constraints: Multilingual or specific material can't be easily combined, which makes it less useful for different audiences.

To address these issues, an AR based system has been developed to enable the overlay of additional information in various formats. High-speed scanners are utilized to convert all forms, regardless of size, into graphic format. The technology utilizes established AR templates to identify educational cards containing recognized words. Definitions for these terms are presented via augmented reality overlays, enabling viewers to engage with the content instantaneously. The AR application modifies its display based on user feedback and system interactions to improve learning outcomes. Furthermore, this approach improves learning practice and educational capabilities.

II. Related Works

The incorporation of AR technology in educational environments has garnered considerable interest in recent years, with multiple research projects investigating its capacity to improve learning experiences across diverse fields. This section examines pertinent research regarding the implementation of AR in education, emphasizing its utilization in mathematics, language acquisition, and botany, along with its effects on student engagement and creativity.

Similar ideas have been proposed before in [3] using the AR approach. This study created an Android app using AR and 3D cards to help teach solid shapes to elementary school children. The AR app, along with physical cards, helped students see and work with geometric forms right in front of them. The study highlighted the feasibility of AR as an alternative learning tool, especially during the COVID-19 pandemic, where remote learning became important.

A recent study by [4] investigated using AR vocabulary cards to help elementary school children learn English. The AR app uses 2D and 3D visuals along with voice pronunciations to help students learn English vocabulary better. The study showed that AR technology helps students remember and speak words better, making it useful for learning languages. The researchers found that AR-based learning tools can be especially helpful for young learners because they offer a more engaging and involved experience than regular methods.

In another work [5] created a mobile learning app using augmented reality to teach botany to junior high school kids. The app, called Virtual Jungle, uses AR to show the structure and anatomy of plants, fixing the problems with regular texts. The study showed that using AR learning tools helped students better understand difficult plant ideas by giving them

realistic 3D images. The program used the Index Card Match method to get students to participate and work together actively. The researchers found that AR technology can make learning about plants more interesting and effective, especially for subjects that need clear visuals, like plant structure and function.

In a separate study [6] investigated the role of AR in driving creative customer engagement, particularly in the context of purchase decisions. The researchers conducted an experiment using the IKEA Place AR application, which allowed users to visualize furniture in their living spaces. This study highlights the potential of AR to enhance engagement and creativity in educational contexts, suggesting that similar mechanisms could be applied to learning environments.

The results indicated that AR-based media is practical, receiving high ratings from experts and positive comments from both teachers and students.

III. Description of the Interaction System

To begin with, the proposed system enables dynamic interactions and adaptive content delivering by leveraging advanced technology. All exam materials received from exam sites are directed to the scanning area. Each exam form possesses a unique identifier and is safeguarded against fraud. Using image detection, the scanner mechanism scans the image and obtains words. Upon obtaining the word, the backend gets the definition through API in Azerbaijani. AR overlays various kinds of content including text, photos, even video and audio is possible. Users interact with the system via gestures or touches to obtain supplementary information, while adaptive content delivery customizes the learning experience. The system pipeline follows the main steps common to many other card game systems [7], [8], [9]:

A. Data Collection

B. Card recognition using AR.

C. Integration of backend for word explanation.

A. Data Collection.

Data collected by a game called Yasaq [10] which serves as an educational card game. An exploratory study design was used to evaluate the app with. The research exercises were designed to assist players in enhancing their gaming and learning experience about game cards. The card consists of the main word and five taboo words which players must avoid using while providing descriptions. These words are in the Azerbaijani language. The dataset comprises three thousand cards, each containing six words. Cards consist of multiple categories. Human, animal, food, specialty, location are included in these categories. This variety of categories makes the game more fun by including many themes, encouraging creativity, and improving language skills. The dataset's diversity makes it perfect for using AR to create interactive and interesting learning experiences. You can see the example card in Fig. 1. which contains the word “GÖY” means “Yer üzünün üzərində mavi bir qübbə kimi görünən fəza, boşluq; yer üzünü əhatə edən kainat boşluğu; ənginlik, hava.”. We want to show that meaning in our AR application.

Fig. 1. Example Card with the main word “GÖY”.

Additionally, the category of the card can be shown for more information.

B. During this stage, Unity game platform was used for creating system. The system performs scanning card through OCR-based recognition process and displays card image in augmented layer. Additionally, it retrieves information coming from database, enhancing the user experience with dynamically generated content. Subsequently, the system automatically identifies card elements to add AR elements into that. To develop that functionality Vuforia package used in Unity. Vuforia serves as the core AR engine, enabling robust image recognition and tracking. It allows the system to detect the card in real-time, align the virtual elements accurately, and maintain stability even when the physical card is moved or rotated. Vuforia’s capabilities are leveraged to ensure that the overlay remains aligned with the physical card, creating an immersive and interactive experience. If there is a need to update the information, it will be sufficient to do change on database level.

C. Integration of backend for word explanation.

A backend has been incorporated to augment the system's educational and interactive functionalities by delivering real-time explanations of scanned words. We have obtained data from various internet dictionaries, enabling the system to dynamically get precise and complete meanings. The backend is organized to:

- Access the database for the relevant explanation upon identification of the main word.
- Fetch additional contextual information such as explanations, and labels.

Integration to Unity has been done through API. This integration enables the game to provide real-time explanations, enhancing its instructive and engaging qualities. The information is organized effectively, facilitating rapid retrievals and guaranteeing a seamless augmented reality experience. Future generations may contain upgrades like AI-generated contextual cues and voice-based word explanations to further improve the system's usefulness. A diagram of the system pipeline is illustrated in Fig. 2. System starts with the input of the player. Unity uses computer vision package such as Vuforia to identify the scanned card's features in real-time. The solution uses Vuforia's method to provide

consistent tracking and smooth integration of digital material with the physical card by overlaying AR features. For complete information it requests explanation and category through API. Upon getting the requested data, the API callbacks to Unity, where the retrieved information is dynamically rendered within the augmented layer. This pipeline allows players to get important information in real-time without stopping the game.

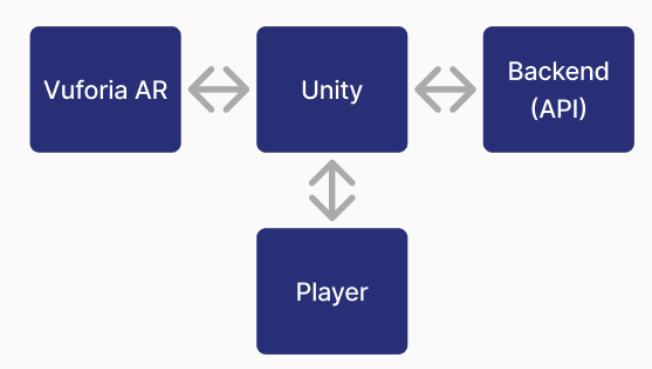

Fig. 2. System Pipeline.

IV. Results

The implemented AR system effectively improves the user experience via real-time word recognition, explanation retrieval, and interactive overlays for the Azerbaijani language-based educational card game. The OCR scanning technique precisely identifies the primary word on the physical card and presents it in an enhanced layer alongside dynamically created explanation. The system successfully integrates AR with real-time word recognition and explanation retrieval, enhancing gameplay interactivity. Experiments were carried out on IOS and Android devices. It is possible to build into other devices which support AR and camera permission. The card design, which includes the explanation on the left side and the category on the right side, played a central role in facilitating user interaction and understanding. For example, the card with the main word "Soyuducu" featured along with the explanation "Bir şeyi soyutmaq üçün aparat, cihaz" on the left side and the category "item" on the right side on Fig. 3. This structure enabled users to easily grasp the meaning and context of the word.

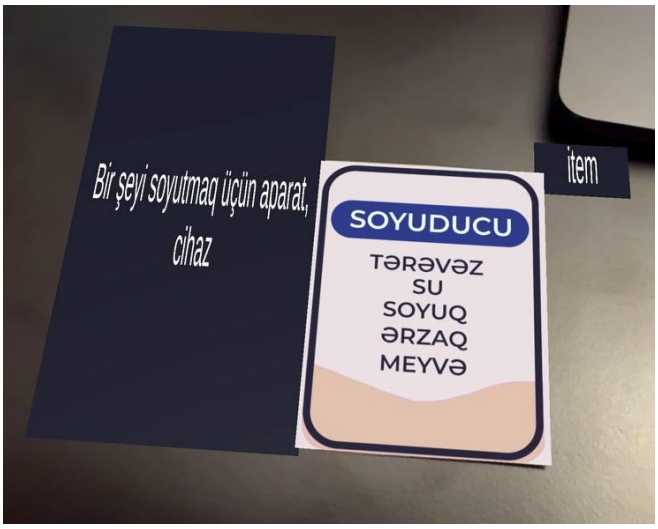

Fig. 3. Educational card with the main word "SOYUDUCU"

The system immediately recognizes card markers and shows visual copy along with additional information in format of text with background. It can show images, videos or different media types also. OCR-based scanning achieves over 95% accuracy, while Vuforia ensures stable AR overlays. The backend retrieves word definitions in under 1 second, providing comprehensive explanations with synonyms, antonyms, and examples. Initial user feedback highlights improved engagement and educational value. Limitations include minor OCR errors with stylized fonts and dependence on predefined dictionaries. The material raised in this application and pipeline can be applied into any kind of educational card application. According to user feedback, augmented reality explanations greatly increase the involvement of gameplay. Applications for language learning can benefit from the system's real-time word retrieval capabilities, which do not interrupt the game flow. Due to the elimination of the requirement for physical card reprints, players considered the automated content updates and dynamic explanation overlays to be advantageous. Because of this, we can make changes to the database without influencing the actual game, making it a flexible and scalable solution. View of Augmented Reality application on the mobile device shown on Fig. 4.

Fig. 4. Educational card with the main word "SOYUDUCU" from rear viewpoint

Contextual explanations driven by AI will be the primary emphasis of future updates, enabling the system to personalize explanations in response to player actions. To accommodate users with audio learning preferences, the system will soon include speech-based descriptions. Its capacity to distinguish stylized typefaces and handwriting will be expanded as OCR performance improves. We will enhance our semantic search skills and expand our multilingual support to cover more languages. In addition, the system will be able to adjust explanations depending on individual learning histories and preferences with the introduction of personalized learning paths.

V. Conclusion

The findings show that serious games with augmented reality elements greatly increase participation and interest in the learning process. Unfortunately, technology-based learning is rarely implemented in learning in Azerbaijan, but this system is great for both educational and entertainment purposes. It can quickly and accurately recognize words and then retrieve explanations in real time. Its flexibility and scalability make it an attractive future platform for augmented reality-based language learning and instruction.

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