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AR-assisted children book for smart teaching and learning of Turkish alphabets

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Abstract Background Augmented reality (AR), virtual reality (VR), and remote-controlled devices are driving the need for a better 5G infrastructure to support faster data transmission. In this study, mobile AR is emphasized as a viable and widespread solution that can be easily scaled to millions of end-users and educators because it is lightweight and low-cost and can be implemented in a cross-platform manner. Low-efficiency smart devices and high latencies for real-time interactions via regular mobile networks are primary barriers to the use of AR in education. New 5G cellular networks can mitigate some of these issues via network slicing, device-to-device communication, and mobile edge computing. **Methods** In this study, we use a new technology to solve some of these problems. The proposed software monitors image targets on a printed book and renders 3D objects and alphabetic models. In addition, the application considers phonetics. The sound (phonetic) and 3D representation of a letter are played as soon as the image target is detected. 3D models of the Turkish alphabet are created by using Adobe Photoshop with Unity3D and Vuforia SDK. **Results** The proposed application teaches Turkish alphabets and phonetics by using 3D object models, 3D letters, and 3D phrases, including letters and sounds.

Keywords Human computer interaction; 5G; Augmented reality; IOT; Turkish alphabet; Smart teaching; AR assisted book

1 Introduction

Information and communication technology (ICT) plays a significant role in education because it can improve student understanding while also allowing teachers to employ more effective teaching techniques. Similarly, there are numerous augmented reality applications available, though they are not always geared toward the educational sector.

With technological advancements, it is reasonable to apply technology to all aspects of life when appropriate. Education is a domain where more technological applications are required. Using alternative techniques in the learning process is in high demand, and once students have practiced and maximized the use of technology in education, they are better prepared to study and gain knowledge.

Playing and learning are essential components of childhood. When considering educational techniques for children, keep the following two points in mind: 1. Educators and parents should design and deliver lessons that emphasize fun and playfulness[1]. Removing such elements will bore children, who will eventually stop paying attention in class; 2. The alphabet is the foundation of all languages. The two previously mentioned elements are taken into account when developing the app to ensure that the children who use it enjoy the learning process.

Augmented reality or also known as AR is a technology that allows virtual items to be merged with real-world photos or videos[2,3]. AR systems must recreate 3D models and compute the camera pose for each frame to make virtual objects appear genuine. "Augmented reality is considered one of the fastest-growing branches of ICT that is visible in our everyday lives." According to experts, AR, or a combination of VR and AR, enhances learning efficiency and promote positive emotions[4–9]. Virtual elements (e.g., 2D photos, videos, 3D models, and animations) that merge into a real-life environment can be added to the physical world with the help of AR. Virtual objects are presented and generated using a computer screen, mobile phone, or a specific head-mounted device, and the technology is halfway between the real and virtual worlds[9]. "Mobile devices (i.e., smartphones) generally have cameras and IMU (inertial measurement unit) sensors, which are ideal for localization."[10] In 5G mobile communication networks, deploying cache and computing resources is seen as a major element in decreasing network transmission latency and redundant content transmission and increasing content distribution efficiency and network computing processing capabilities[11].

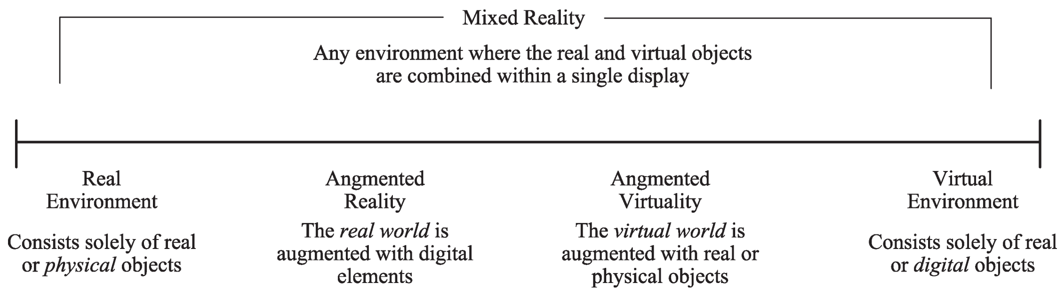


Figure 1 Reality-virtuality continuum[12].

Augmented reality and virtual reality exist between the real and virtual worlds, and they together give rise to mixed reality.

Previous applications developed using augmented reality were task-specific and limited to certain languages. To fill this gap and make the experiences of augmented reality applications in the educational field available to Turkish language learners. Another limitation of the use of modern technologies is that they are not tailored to educators in that environment. Non-English-language countries often need the technology they understand. Specifically, technology is directed towards children.

In this paper, we propose an AR-assisted children's book for smart teaching and learning of the Turkish alphabet:

1. The development of this AR-assisted book is unique. No previous AR-assisted book for smart teaching and learning of the Turkish alphabet has been developed for this purpose using the cloud database. This increases the significance and contribution of this study and the motivation for designing such an application.

2. We created 3D model representations for each example containing a specific letter, not just sample models, but each having a unique example model.

3. For the process of learning, we did not rely solely on having augmented information of the sense of

sight. However, we also applied it to other senses, such as hearing, by playing sounds when displaying the 3D models.

4. By developing these new technologies, we provide more space to the educational sector to be able to apply the technology in their curriculum of studies or that parents use with their children.

The rest of this paper will go through and review past related research on the topic, the techniques they used, and their results. The process of developing the system and the implementation of the augmented reality application are also explained. Furthermore, the paper presents the results and findings, and finally, a conclusion to the accomplished work and suggestions for future research.

2 Related works

Previous work and research on augmented reality apps, interactive books, and augmented reality language learning are addressed. One of the key reasons for the time span of the selected related works shown in 2014 is that augmented reality is relatively new to consumers and has only recently gained public attention.

Gil K and Rhim presented an augmented reality storybook called "AR Petite Theater" in a short-term experiment that allowed role-playing using augmented reality technology. This gave students the opportunity to develop empathy through an interactive reading experience in which they mocked and copied the way the story's main character thought and spoke. They examined the involvement and perception of children's role-play after performing an experiment with twenty-four young children. Empathic behavior was observed in groups where augmented reality technology was utilized, and children who used the technology had fewer disconnected perspectives than those who did not[13].

Later on in 2016, "MyVision AIR" an interactive augmented reality application that aims to increase the interaction between the user and traditional books to improve the reading experience of adult learners was introduced. They enhanced the standard book by using 3D models, animations, music, and videos. According to the authors[14], adopting augmented reality increased user experience with traditional textbooks, and the conclusions were highly favorable. In 2016, another study discussed the process of creating augmented reality-enhanced flashcards for Arabic language learning. Augmented reality was considered one of the platforms that may be utilized to aid students in learning specific information and maintaining their understanding of a language's vocabulary, in this case, Arabic vocabulary. According to the findings of the study, AR-enriched flashcards can assist students in learning the Arabic language by supplementing their knowledge. Furthermore, they discovered that learning is much simpler with the use of AR-augmented flashcards[15]. More recently, in 2016, an interactive augmented reality technology called "TeachAR" was demonstrated for teaching fundamental English to youngsters who do not come from an English-speaking background. The system was "the very first AR language learning tool attempting to teach young children, 4 to 6 years old, about spatial relationships and shapes," according to the inventors. According to the findings, the "TeachAR" approach seems to have a superior learning outcome than the old system. It also showed that employing AR-based strategies was enjoyable for the children. It did, however, reveal a few usability flaws with the "TeachAR" app design, including difficulties with Speech-Input[16]. A group of academics also created an augmented reality smartphone application for the preliteracy kit in 2016. The produced augmented reality app was built around three primary components: content, design, and tools. The results revealed that both children and teachers offered favorable feedback, children enjoyed using the software, and instructors valued including a range of teaching aids after using the pre-literacy mobile app[17].

Two augmented reality educational game systems were built and reviewed a year later in 2017 in an attempt to teach English vocabulary to third-grade children in free and situated environments. Regardless of whether they applied the self-directed or task-based AR educational game system in their studies, the students showed a high learning performance. According to a study[18], students' learning methods played a significant role in their concern about learning a foreign language and their mental efforts. "Arabic", a mobile augmented reality application for teaching and learning the Arabic language, was created in 2017. In its early stages. The program consisted of two primary modules: a learning and exercise module, which included objects, graphics, animation, video, music, and 3D objects, to hold the student's attention. Because of the printed textbook with digital material, and based on user testing, it was discovered that users were highly engaged in "Arabic" and quickly learned the lessons. The authors also stated that this application can assist parents in teaching their children Arabic at home because it is a full learning system that uses the teaching modules in school and includes Malay translation to assist parents[19]. The year 2017 had more to offer AR applications. In 2017, a prototype of an augmented reality application was created to teach kindergarten students English vocabulary in an interactive manner. Using a mobile device, kindergarten students could study English vocabulary at any time and location. They also built a monitoring system to address parents' concerns regarding their children's health. The monitoring mechanism enables parents to monitor their children's usage and remotely disable the program in real-time. This measure would reduce the negative impact on children's health, while still allowing them to enjoy the experience. Because the authors wrote in their research, the application's efficacy was satisfactory in their early assessment[20]. We discovered another AR application built in 2017 as we continued our study. Augmented Reality was used in interactive English phonics learning for kindergarten applications. The goal of their project was to make phonic learning more enjoyable, interactive, and efficient. The marker-based tracking approach used in augmented reality technology allows students to engage with virtual photonic materials through physical manipulation. In this case, the image marker is a photonic card that initiates the tracking process. Their interactive strategies improved their learning experience. The findings of the performance evaluation revealed that students improved their reading skills after utilizing courseware. The authors see it as viable courseware based on SUS evaluations conducted by educators[21].

Moving to 2018, for children's education, an interactive augmented reality android application of the "Hijaiyah" alphabet (letters used in the Qur'an) was created. Smartphones and markers were used as media for the application. "Hijaiyah" can appear as 3D objects on the marker, and each virtual button can play a sound dependent on the button picked by the hand. By pushing the virtual button on the marker, the user can learn and grasp the shape and sound of the "Hijaiyah" alphabet. One of the limitations of this program is its dependency on light: if it is dark or there is insufficient light, the application will not function[1] for the personalized Arabic vocabulary learning for non-native students of "Universiti Sains Islam Malaysia" (USIM). The findings suggest that AR-augmented flashcards assist in supporting information about the study of Arabic vocabulary. The study also revealed that the augmented reality application could be regarded as a personalized learning platform that can be used to assist students in memorizing specific information, maintaining their knowledge of Arabic vocabulary, and creating different sentences using the target vocabulary more than half of the time[22]. Subsequently, in 2018, MacCallum K and Kumar conducted a study on augmented reality in mobile apps for early childhood literacy learning. The prototype they created used markers for tracking purposes in the form of cards representing a letter of the alphabet with an accompanying graphic illustrating that letter, to activate and monitor the content. The program displays a 3D animation of the item and displays the phonetic sound of the letter. The method they utilized provided the children with an environment for familiarity with the sound of a given letter while pronouncing it phonetically[23]. Another "augmented reality application based on markers for kindergarten children in Trujillo" was developed in 2018[24]. The scenery was designed in such a manner that when concentrating on a marker using the smartphone app's camera, the picture shown in augmented reality is mirrored. For example, using a marker with a picture of a number would display the 3D object of that number on the mobile application, and the same is true for vowels[24].

In 2021, Afnan et al. conducted a comprehensive study on the effectiveness of augmented reality as a tool for primary school children's education. They used portable marker-based AR technology for elementary school students' education. They created a package of four programs for learning the English alphabet, decimal numbers, animals, and global learning. They carried out various types of learning activities using various learning methods and assessed students' learning performance. Their comparative research on these activities demonstrated that AR-based learning approaches have a positive influence on children. Students exhibited a favorable attitude and conduct toward the AR learning technique. Compared with traditional learning techniques. They scored higher on the ARCS motivational model components than students in other traditional learning groups. Furthermore, instructors and parents responded well and complemented AR learning approaches[25].

The proposed AR-Assisted Children's Book for Smart Teaching and Learning of Turkish Letters was created in this study. It teaches children Turkish letters and provides an example of a letter being applied to a word. Once the marker picture is discovered, it displays 3D objects of the Turkish alphabet, followed by the sound of the letter's pronunciation, and an example of a 3D object of a word containing that letter. Following up on past and recent studies, it was discovered that there is a high need for augmented reality in the educational sector, particularly for teaching children.

It was also discovered that there has been no previous research or application for teaching children the Turkish alphabet using cloud-based AR-assisted technologies.

3 Methods

In this section, we discuss the creation of the suggested AR-based application in detail. In terms of technology, we chose AR approaches to produce the learning and teaching content. AR technology satisfies all the educational demands of students for them to study efficiently. Students view virtual learning content in the actual environment and can interact with it in real-time using AR techniques, whereas students in conventional teaching methods can only visualize the learning content.

Regarding tracking, AR applications are fundamentally divided into two types: marker-based and markerless. The marker-based methodology uses a camera and a visible indication (e. g., an image or a shape) to serve as the target to be tracked, whereas the markerless method uses the mobile device's global positioning system and compass positioning information to track and place virtual objects[26].

Maker-based augmented reality applications work by scanning a marker, which triggers an augmented experience (such as an object, text, music, video, or animation) to be displayed on the device. It generally involves the use of software in the form of an app that allows users to scan markers from their device's camera feed. It compares the live feed from the camera to the database's stored image targets (the cloud database, in our case). Once the target image(s) have been identified, the program retrieves the digital object/3D model from the cloud database and places it in the actual world on the screen[27].

3.1 System development

To create the desired application, different tools are used for both the software and the design of the image targets. Figure 2 shows all the tools used in the development of the augmented reality application.

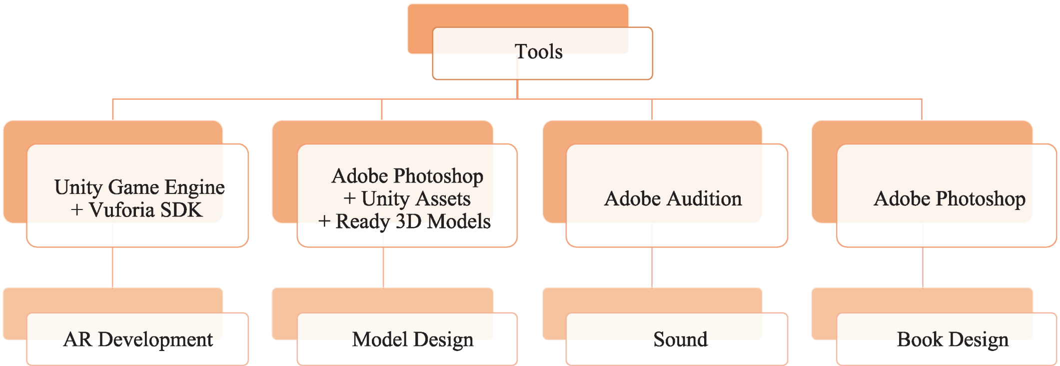


Figure 2 System development tools.

There are five steps in the system development process.

Step 1: Adobe Photoshop was used to create model 3D letters and prepare relevant 3D objects.

Step 2: Adobe Photoshop is used to draw and create image targets for the book.

Step 3: Using Adobe Audition to prepare and edit sound.

Step 4: Augmented reality system programming using the Vuforia SDK and Unity Game Engine as the system development environment.

Step 5: After using Unity as a system development platform and integrating it with Android SDK, the finished product application becomes ready for downloading and installation.

3.2 Architectural system design

The AR application is designed using Vuforia SDK, which can store up to 1 million image targets remotely on the Vuforia cloud recognition service. These targets were then queried and retrieved using an HTTP connection. To achieve immersion, 3D objects are placed in real life through a screen display after tracking the image targets and successful detection. Figure 2 shows the design of the AR application architecture.

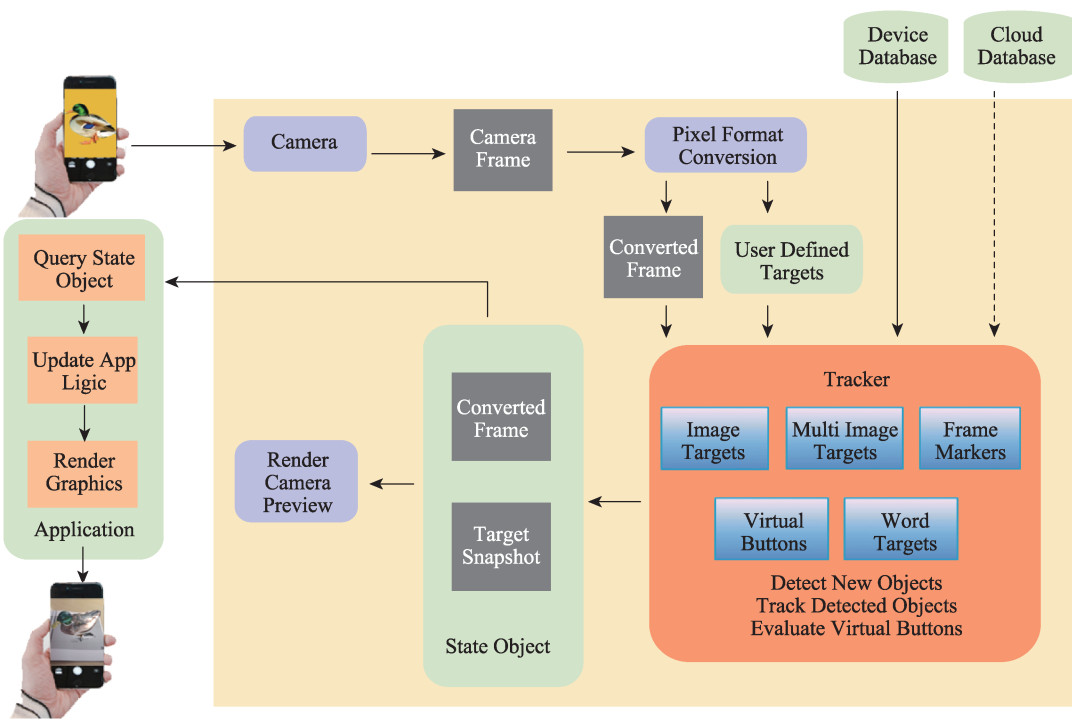


Figure 3 Vuforia Core Components of the developed AR application.

The user opens the application to detect an image target using the camera, which then captures the preview frame and passes it to the image tracker. The image converter uses a pixel format convertor, converts the default format of the camera, and changes it to a suitable format for openGLES rendering and tracking. The tracker detects and tracks real-world objects in the preview frame of the camera using image recognition algorithms, and the results are then stored in the state object that is passed to the video background renderer. The camera image stored in the object state is rendered, and the virtual objects are augmented on the real-world display on the camera screen of the user's device. All retrieving occurred in real-time from the cloud database.

3.3 Implementation of AR application in Unity3D with Vuforia SDK

Vuforia is an augmented reality SDK that enables app developers and companies to quickly create high-quality, mobile-centric, immersive AR experiences. Vuforia AR SDK employs real-time computer vision to recognize and track image targets and 3D objects. If 5G is adopted, developers and enterprises can insert and orient virtual items more easily. It enables them to add 3D models and other content to a real-world environment, such as 2D films or photographs, without having to worry about latency or the time it takes to recognize an image target. Virtual items are overlaid on top of a real-world scene and can be viewed using AR-enabled devices, such as smartphones or tablets[28].

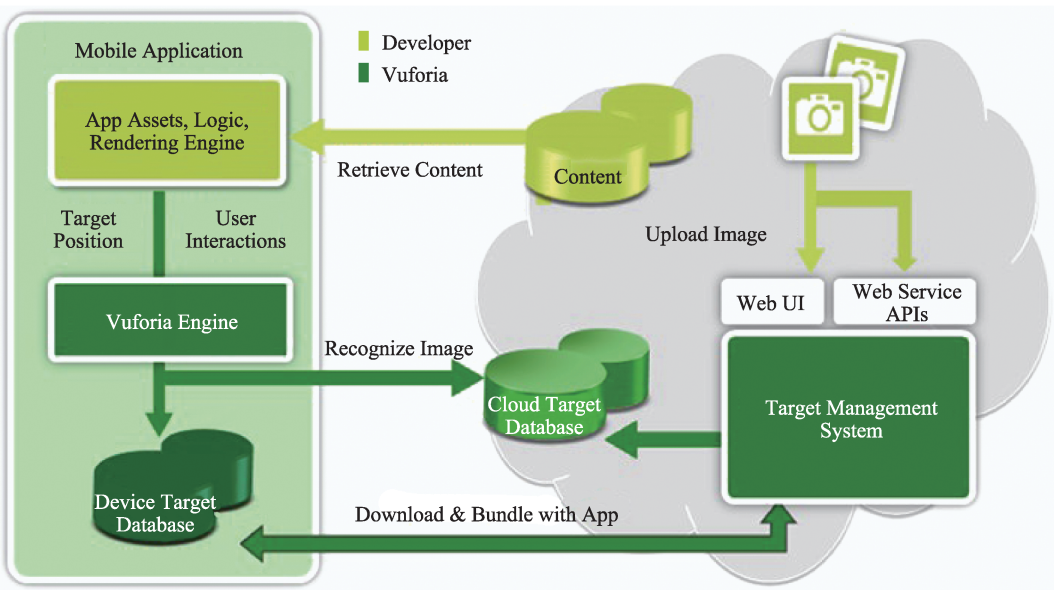


Figure 4 Diagram of the process of application development platform Vuforia[29].

A developer uploads an input image to track a target. The mobile application has two methods for accessing the target resources.

- It can be accessed from a cloud target database using web services (the ones used in this study).
- It can be stored in a device target database and used in conjunction with a mobile application.

3.3.1 Configuring Vuforia into the project

A license key is required to utilize Vuforia in the application. A license key is copied from the Vuforia developer portal and pasted into the Unity program.

To create a new database, you need to go to Vuforia's developer portal website, go to the target manager, click on the add database, give it a name, and choose the type of database. Finally, click create.

After creating the cloud database, we added image targets to the database. While using the developer license key, a user can upload up to 1000 image targets. Once the image targets have been uploaded, the interface shows the recognition rate. These recognition rates were based on the feature points of each image target uploaded to the cloud database. How accurate will it be when searching for an image target and how many feature points do an image target?

The access keys are specific to each cloud database. Do not share your access keys with an untrusted party, and take the necessary steps to protect them within the application code. Two types of keys can be used for your application: client access keys and server access keys. The client access keys must be passed to the Vuforia library within the application to authenticate itself with the server. Use the server access keys to upload and manage images in the cloud target database via REST interfaces.

3.3.2 Development in Unity3D editor

Add Vuforia and AR assets to your Unity project

• Unity incorporated the Vuforia Engine for the easy building of AR experiences, starting with Unity version 2017.2.

• Right-click on an empty area in the hierarchy area and hover over Vuforia Engine; a list will appear; click Add camera; ask you to import certain required assets; click Import.

After importing the Vuforia Engine, these "Game Objects" need to be added to the project.

• Add AR camera

• Add cloud recognition

• Add image target

From Vuforia's developer portal, copies the license key and passes it to the project in its dedicated area, which is the "AR Camera" in Unity. Attach the "Simple Cloud Handler" script to the "Cloud Recognition" element. The "Simple Cloud Handler" script is responsible for accessing the image targets from the cloud and displaying them while they are found. Grab the image target and place it into the image target template for cloud recognition.

Now, we add the 3D models to our image targets, as shown in Figure 5.

• Load your project-related 3D models into Unity

• Place the objects/3D models on top of the image targets by dragging and dropping them.

• Use the scale tool if the model is too large or too small

We edit the script and add sound to each image target after we add our 3D models to them so that when an image target is found, the phonetics of that letter are also played.

• Go to your desired script editor and double-click the "Default Trackable Event Handler".

• This will take you to your preferred script editor.

• When adding sound, the written script performs the following: if an image target is identified, it will activate the sound file; otherwise, it will continue to wait until an image target is located.

When the project is finished, we must compile the project with Android because we are going to export it to an Android application.

To switch the platform to Android, you need to go to the file, build settings, and then choose Android. Before beginning the development process, it is recommended that the Android SDK be loaded onto the PC to ensure that the project runs without any undesirable issues.

3.4 Implementation of the application

The augmented reality program was created using the Turkish alphabet, and for each letter, the visual

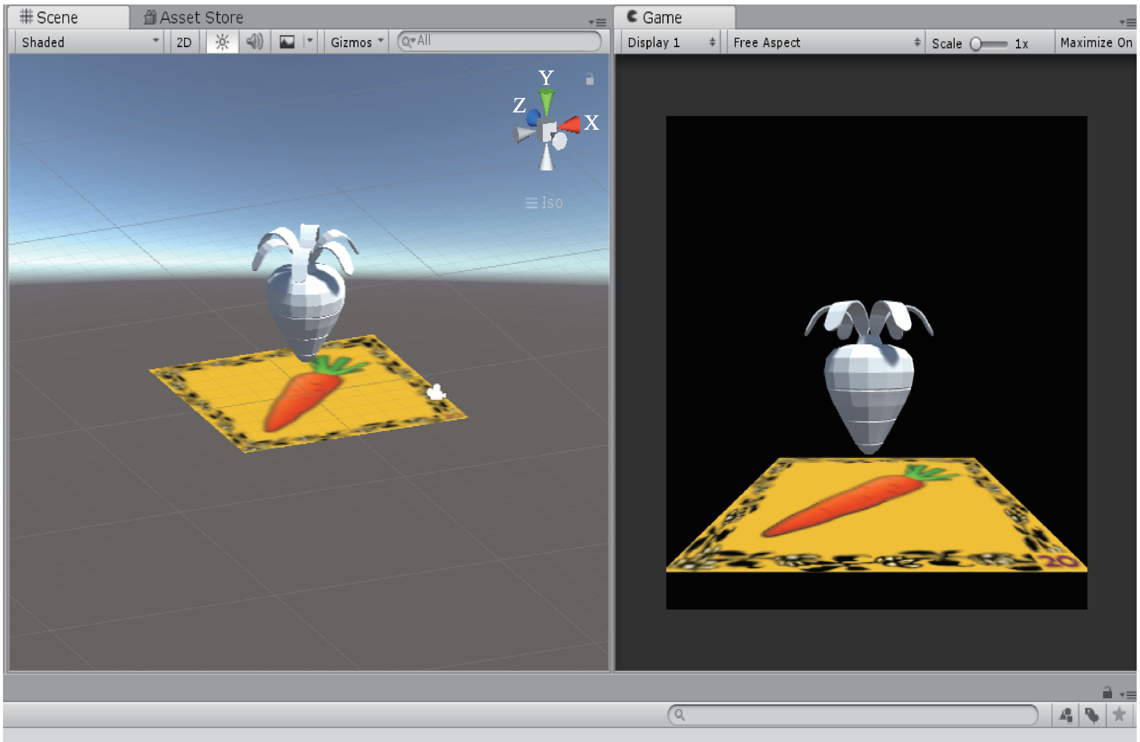


Figure 5   Adding 3D model objects to our image targets.

representation of the letter was shown as a 3D model along with the word that contained the letter as an example. When the camera identified an image target, it displayed the 3D model/object of the image target on the screen. When an image target is detected, a sound is played that pronounces the associated letter in the alphabet or any 3D object. Then, with the 3D object, the entire text of that example is displayed on the image target. Figures 6a and 6b show that when 5G technology is used, detection speed increases. Figure 6c shows another example of the operation program. Because two picture targets may be seen simultaneously in the book when it is opened, the application has been configured to track only two targets at a time. This saves resources because it will not hunt for another object to find after it reaches the maximum number of objects shown simultaneously. Although the letters and the example can be tracked simultaneously, for a better learning experience, the user should direct the camera to only one page and interact with it.

4   Results

Making a new augmented reality application that teaches young children the Turkish alphabet is the significance of this paper.

R1. Make 3D models of the letters of the Turkish alphabet.

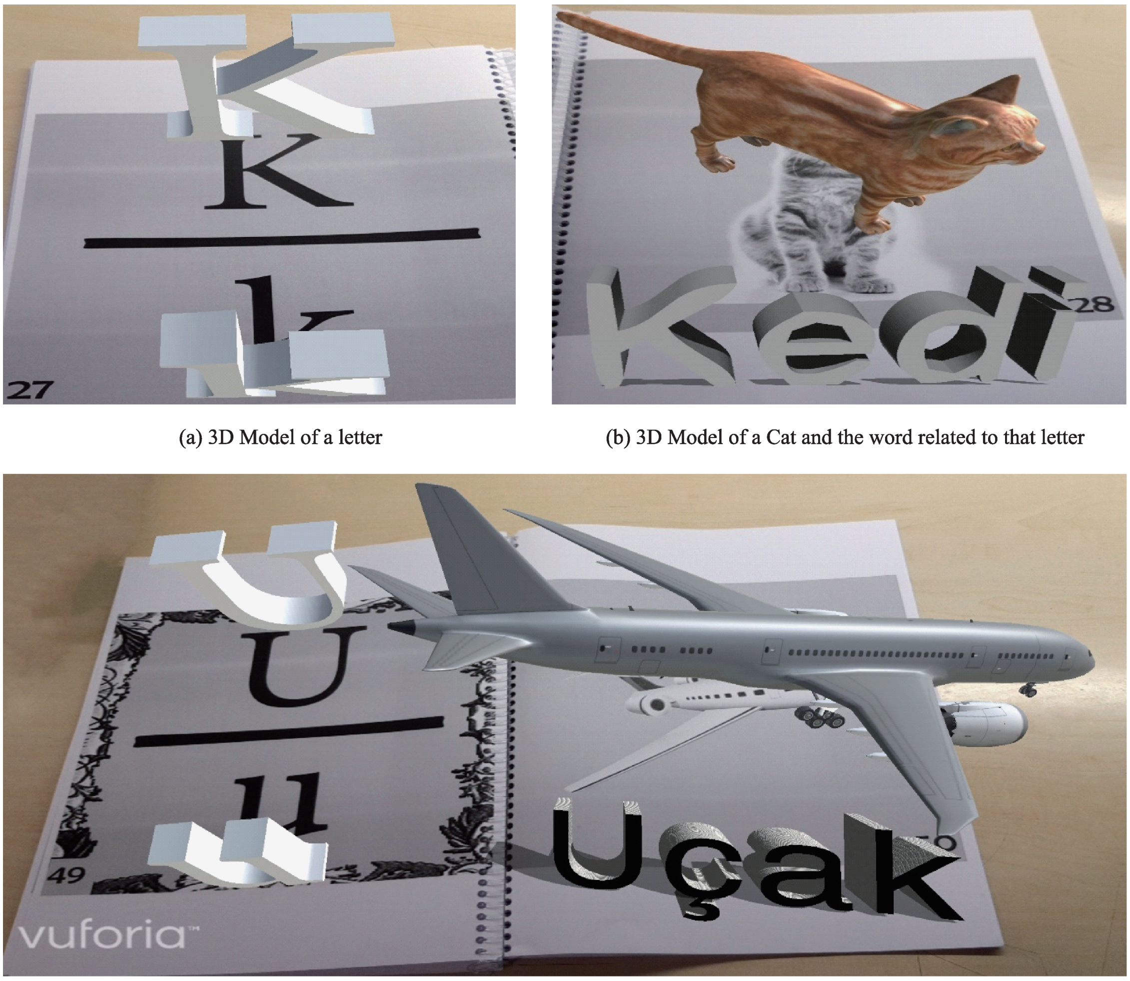
R2. Create 3D models of samples for each letter of the Turkish alphabet.

R3. Create Image Targets and upload them to the cloud database.

R4. Once a picture has been identified for pronunciation, it plays the appropriate sound.

The application features 3D representations of letters from the Turkish alphabet created from the ground up. The program was built using 3D models of the samples for each letter of the Turkish alphabet. This program has also proven to be successful in incorporating sound. The letter or the corresponding sound of the example is played after each successful recognition of an image target.

Based on the image's feature points, the image target representing the letter A is unlikely to occur, as



(a) 3D Model of a letter

(b) 3D Model of a Cat and the word related to that letter

(c) Two Image targets with their respective 3D Models being presented

Figure 6 App in use when directed to the image targets.

noted in the table below, and its algorithm assigns a score of 0 out of 5 stars, although this is not accurate based on the findings after running the program.

The second example is the red car. While the system works with both black and white pictures, the color of the image does not influence the performance. The system can only recognize an image target by observing its feature points. This example received a four-star rating from the system, suggesting a strong likelihood of identifying the image target.

When comparing these findings to the results of the developed application, it is clear that letter A is always identifiable when pointing the camera to the relevant image target, unlike the percentage offered by Vuforia's algorithm. Additional test results demonstrate that updating the image tracker is recommended after a low recognition rate is reported. A poor recognition rate does not always imply that the image tracker is not recognized.

Our findings revealed that D had a hard time recognizing the visual target at first, but after a few trials, it succeeded. A defter likewise struggles until it is identified, and once it is identified, the 3D model shakes, which is thought to be related to the object's complex features and size, as well as the rendering time. Even though the S-letter image target has been updated, the letter's lack of distinguishing traits makes it difficult to detect. It occasionally misrepresents it as Ş, and other times it accurately identifies it as S. Image Targets were forced to be in a precise shape and design since the program was designed to interact with a real book. Many problems can be avoided if the designs are just for the goal of detection, and nothing else.

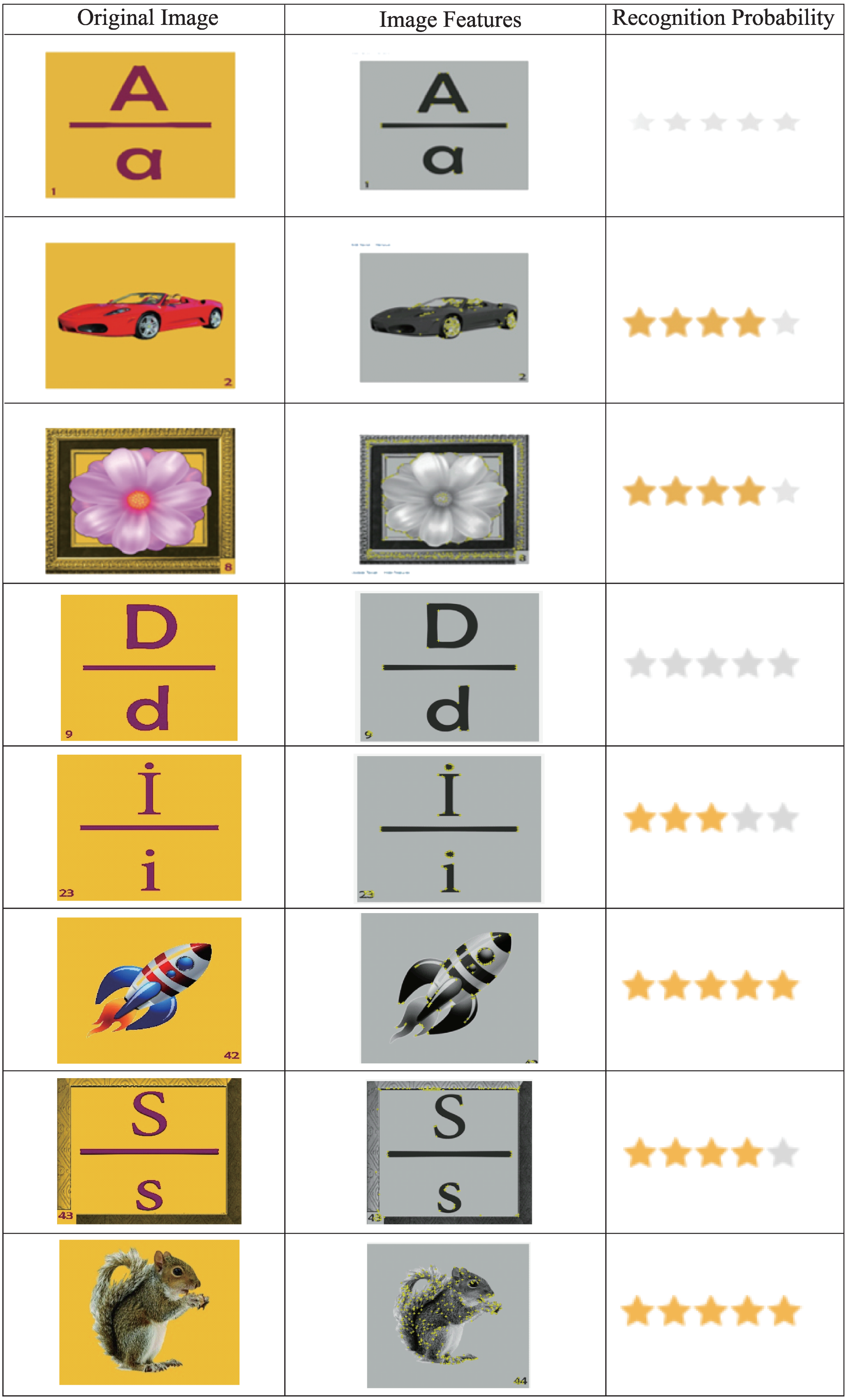


Figure 7 Recognition Probability based on Vuforia's engine.

Table 1 Image targets recognition test results

Image Targets (Letter)	Recognized	Notes	Image Targets (Example)	Recognized	Notes
A	Yes	None	Araba	Yes	None
B	Yes	None	Balloon	Yes	None
C	Yes	None	Ceket	Yes	None
Ç	Yes	None	Çîçek	Yes	None
D	Yes/No	The model of the letter D struggles until it gets recognized	Defter	Yes/No	Struggles until it is identified; this might be due to the 3D object's size or high detailed features.
E	Yes	None	El	Yes	None
F	Yes	None	Fil	Yes	None
G	Yes	None	Güneş	Yes	None
Ğ	Yes	None	Ağaç	Yes	None
H	Yes	None	Havuş	Yes	None
I	Yes	None	Irmak	Yes	None
İ	Yes	None	Înek	Yes	None
J	Yes	None	Jöle	Yes	None
K	Yes	None	Kedî	Yes	None
L	Yes	None	Lamba	Yes	None
M	Yes	None	Masa	Yes	None
N	Yes	None	Nar	Yes	None
O	Yes	None	Ot	Yes	Struggles until it is identified; this might be due to the 3D object's size or high detailed features.
Ö	Yes	None	Ördek	Yes	None
P	Yes	None	Pencere	Yes	None
R	Yes	None	Roket	Yes	None
S	Yes/No	"At times, instead of recognizing S, it recognizes Ş because of the shape similarity"	Sincap	Yes	None
Ş	Yes	None	Şemsiye	Yes	None
T	Yes	None	Tavşan	Yes	None
U	Yes	None	Uçak	Yes	None
Ü	Yes	None	Üzüm	Yes	None
V	Yes	None	Vişne	Yes	None
Y	Yes	None	Yıan	Yes	None
Z	Yes	None	Zil	Yes	None

When the camera is pointed at the image targets, all other letters and objects are identified immediately. According to the data above, only 10.34 percent of the image targets encounter problems when attempting to be identified, resulting in an 88.66 percent accurate identification rate.

5 Discussion and applicability to 5G-IoT scenarios

Augmented reality is an interesting and effective technology that combines virtual objects with real-world environments. This technology provides endless ideas and innovations in different areas. In terms of network performance, this is critical for both AR and VR applications. Disruption has a detrimental influence on the user's experience. This is because integrating and syncing the real world and the user's actions with a digital world requires a large number of graphics rendering operations. Such intensive rendering operations can only be handled correctly with 5G, whose fast and dependable network connection can ensure a string of device functions in real-time and cut the cord linking numerous VR headsets to PCs, with the cloud performing heavy lifting. Applications operating on screens may acquire even better resolution images from the cloud by employing a superfast, low-latency (very short lag time) 5G connection. In scenarios using head-mounted displays such as HoloLens from Microsoft or Magic Leap, it can enhance the user's experience and has the added benefit of including location-specific data[30].

In this paper, an augmented reality application was presented, this AR application teaches children the Turkish alphabet with phonetic examples.

The developed system is the first AR-Assisted Children's Book for Smart Teaching and Learning, attempting to teach children aged 5 to 7 using 3D objects, 3D letters, 3D words that contain that letter, and the pronunciation of each target.

If the design of the book is unified, some image targets have few feature points and edges and might slow down the recognition rate. To avoid that, each image target should be unique with its own features for a fast recognition rate.

Achieving the desired outcome of the study bridges the gaps and requirements discussed at the beginning of the paper.

We can do great things using the newest technologies, such as virtual reality, augmented reality, 5G, and IOT. Technology is built to make our lives easier, and we need to find ways to harness it.

6 Conclusion

We used smartphone marker-based AR technology to teach elementary school students an effective learning strategy in this study. We developed an application to assist students in learning the Turkish alphabet. The proposed AR-assisted children's book teaches children the Turkish alphabet and demonstrates how to use each letter in a word. The marker image depicts 3D objects of the Turkish alphabet and the sound of the letter's pronunciation, and an example of a 3D item of a word containing the letter, with the word itself shown on the image target. According to previous and recent research, augmented reality is in high demand in the educational sector, particularly for educating children.

We recommend adding more than one language to the proposed application for future work (e. g., English, Arabic, Kurdish, Spanish) to make it a multilingual application that reaches more than a single demographic area. We can also add animation and movement to the 3D models used in the application for better engagement.

Declaration of competing interest

We declare that we have no conflict of interest.

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