



RESEARCH ARTICLE

An Augmented Reality-Based Approach for Designing Interactive Food Menu of Restaurant Using Android

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Abstract: The food industry is becoming competitive on a daily basis and introducing newer cuisines to the menu in an attempt to rise up the ladder. But they still are not being able to improve their performances because customers often only have the waiters to describe the dishes to them and thus, most of the time results in not fulfilling their expectations. Thus, to allow the customers to visualize their orders more informatively, this paper presents an android application that overlays digital three-dimensional (3D) food models onto a quick responsible (QR) code image marker on a food menu using augmented reality (AR) technology through the camera of the system. Moreover, the price and a detailed list of the ingredients used to prepare the dish, along with the nutritional and calorie content, will also appear beside the 3D food model to keep the customers completely informed of what they will be ordering. This work focused on designing the 3D food models in the Blender 3D tool, which were then imported into the Unity 3D application with the Vuforia software development kit preinstalled, and Figma has been utilized for designing the user interface of the system. The study's outcome is an AR application that provides the customer with a more engaging approach to visualize the dishes in 3D form, which can improve customer sales and restaurant loyalty.

Keywords: augmented reality (AR), QR code, Unity, Vuforia, Blender 3D

1. Introduction

The food business continues to develop at a great rate as the standard of living improves. This is because demand and supply of food are inextricably linked (Mandviwala et al., 2022). Moreover, restaurants that provide foreign cuisine are becoming increasingly frequent as the food industry gets more competitive. However, most of the customers often have to depend on the waiters to describe the dishes on the menu or imagine them just by looking at the images provided on the menu. This results in not meeting the customer's expectations when the meal arrives, and this could lead to the customer forfeiting the food and even the restaurant. Thus, with the advancement of technology, restaurants need to improve their performance by introducing new ways that will allow the customers to view the dishes on the menu in a more realistic and informative way which will in turn aid in the decision-making process and gain their trust, leading to brand loyalty (Koui, 2017). Using new technologies such as augmented reality (AR) in meal ordering can enhance existing

food menus with digital material that provides interactive and adequate visual information on the food dishes in today's digital world (Kiryakova, 2021). This improves the consumer experience, satisfaction, and increases sales (Arioputra & Lin, 2015). The food business has a plethora of options, thanks to AR, and it is now more important than ever to engage in AR technology (Chaurasiya et al., 2019). So, for our application design, we are to create a virtual pathway for displaying food menus using AR and the application will focus on an interactive approach. By scanning the appropriate image target, the application shows an interactable three-dimensional (3D) model of the food menu. This 3D-based marker design provides the user a more convenient experience as 3D models take up to no physical space other than a smartphone and an example has been shown in Figure 1. Moreover, the price, the ingredients, nutritional content, and calorie magnitude can also be displayed for each food item to help the customer health wise. The proposed software uses a Blender 3D, Figma, Unity 3D, and Vuforia in a novel way to address the above challenge.

Typical AR systems recover the 3D model and identify the object to be presented on the scene using a specially defined pattern (the marker) (AlNajdi, 2022). Quick responsible (QR) codes have the benefit of storing a lot of data and resemble AR

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Figure 1
KabaQ – Depiction of a gourmet from a food menu using an application (Sharma & Tiwari, 2021)



markers in look. By merging the QR code with the standard AR technology, more interesting and useful applications may be created (Baruah, 2022) and we therefore intend on utilizing it.

In this paper, we introduce an AR-based approach for viewing the dishes in a restaurant as 3D models using QR codes. The main contributions of this research are

- Development of the android application that can provide the customers with an interactive experience by displaying a 3D model of the dish so that they can easily understand what the food is before placing their order.
- Boost customer trust by providing a detailed list of the ingredients used in the meal and its calorie content, along with its cost.
- Remove the language barrier because the food will be displayed as a 3D model.

Section 2 conducts a brief literature review on different types of AR research for designing 3D restaurant menus done recently. In Section 3, we describe how the AR system was built using different tools, and in Section 4 the experimental results and the evaluation technique used on the system are discussed. Finally, Section 5 concludes the research paper and also mentions plausible future works to improve the application.

2. Literature Review

Recent studies have looked at and analyzed the potential of using AR techniques to present the food menu of a restaurant for improving customer satisfaction. For example, the study undergone by Oh and Kim (2020) proposed an AR-based food menu system that blended AR technology with video material to create a presentation that provides information about menu items. As a result, it offers more realistic and bright graphics than the current menu board, which offers food information in a plain image format. Their added intention was to apply this system in tourist sites, museums, and galleries as a new sort of guide system that goes past text and image-based pamphlets.

Another similar work was attempted by Mali et al. (2021) where with the aid of an interactive 3D model and visuals, they created a smart menu card and a recipe for culinary items which could be displayed using a smartphone. The main feature of their project was that each restaurant would have its own unique sticker (image target) containing the logo of the restaurant which would display the restaurant menu according to categories when scanned. According to

the users' preference, they would select the food item's name, and accordingly, the 3D model of the food would render on the sticker. Moreover, the ingredients used, their nutritional value, and a 360-degree visualization of the item are provided, making the whole food choosing menu engaging and informative.

The purpose stated by Mali et al. (2021) for developing this system was to remove the language barrier which would in turn attract more customers and bring greater brand visibility. Arioputra and Lin (2015) developed a mobile application that can be used to translate the Chinese menu into English and display a 3D model of the desired food item. The image marker in the system was Chinese words which were processed as inputs using features from accelerated segment test implemented by Vuforia Library. The proposed system will match the marker and generate the 3D model of the food accordingly using Unity 3D. The novelty of the system was that up to five 3D models and translations of the dish can be performed in real time, and these will be rendered near the Chinese word.

Most of the existing restaurants are still dependent on the manual note down of customer orders which include the problem of taking the wrong orders or making incorrect calculations due to human error. As a result, many researchers have attempted to solve this issue by making the whole process automated and the most recent study was done by Gupta et al., (2020). Here, the clients have to order their food using this application and its Graphical User Interface (GUI) includes images of the items available, which makes the decision-making process easier. On the restaurant management side, they view the orders and accordingly prepare them without having to face any communication error.

A very recent study conducted by Mandviwala et al. (2022) proposed an application named FlavARsome which utilizes AR to present a 3D food model over a QR code image marker when it is scanned by a phone camera. It also allows the user to check the ingredients used and the nutritional level, and also customize their desired toppings, and finally display their preferred item through AR. The application was developed using Unity 3D software with Vuforia software development kit (SDK), and the 3D food models were designed using Blender 3D. Their aim was to utilize this app to improve customer satisfaction, and current sales, and to bring a new perspective to the current restaurant business strategy with the next generation of online food ordering.

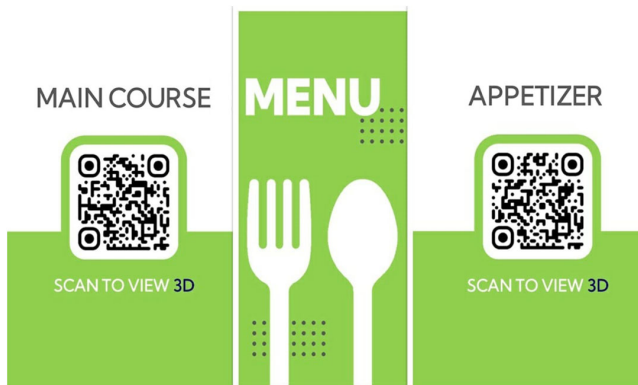
The aim of this project is to build an AR system that allows the customers to view the food available on the restaurant menu as a 3D model by scanning a QR code. As a result, this aids them to make the decision-making process easier, giving a better experience and improving customer satisfaction.

3. Proposed Methodology

The proposed method provides an efficient environment that innovates the food ordering process. Its goal is to use AR to present 3D food courses, allowing customers to see food items in greater detail than they can in standard meal menus. The system is QR marker based which let the customers view the 3D model of the real items in front of them by scanning the QR code on the menu using the camera of a smartphone. Moreover, the price and a detailed list of the ingredients used to prepare the dish, along with the nutritional and calorie content, also appear beside the 3D model to keep the customers completely informed of what they will be intaking. The view of our AR menu containing the QR codes can be seen in Figure 2.

Our system is a QR-based AR application built using powerful tools such as Unity and Vuforia, and the whole designing process has been elaborated and illustrated in Figure 3.

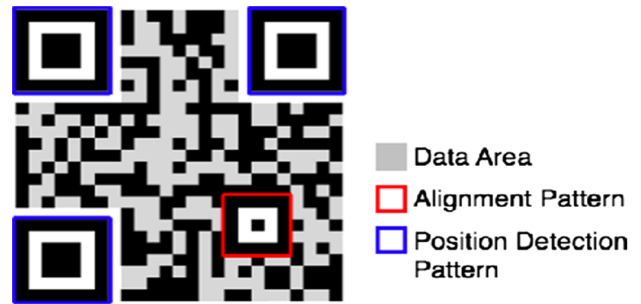
Figure 2
The augmented reality menu of the proposed model



Android smartphone: Android smartphones have added multimedia capabilities such as camera and internet connectivity (Kaur et al., 2014). So, the camera receives a live video streaming of the image target as an input and provides it to the AR application for processing and augmenting the 3D food model.

Marker: We present an AR system using QR code as the marker for android smartphones. We generate the QR codes for each dish using an online QR generator <https://me-qr.com/>. QR code-based AR uses a QR code as a trigger for augmenting the 3D model in the real world (Kan et al., 2009). QR codes are 2D matrix barcodes with a distinctive design, as shown in Figure 4. In the three corners of a QR code, there are three enormous square patterns (within each is a small black square surrounded by white bars). For position detection, these three square patterns are required. We intend to use an AR solution for android smartphones that uses QR code as the marker. The technique recognizes the QR code and extracts the information embedded in it to layer a 3D food model on top of it. The most important is that the marker must have a high contrast between itself and its background for the camera to recognize it easily. Therefore, we chose a bright green color as the background for the QR codes.

Figure 4
QR code structure (Kan et al., 2009)



Traditional AR systems are fiducial marker based and therefore tend to have the shortcoming of being able to display only a limited amount of AR information. Therefore, we chose to utilize QR because it does not have the limitation of displaying only a specific amount of information as it has the ability to access remote repositories. The comparison made by Kan et al. (2009) between QR codes and fiducial markers has been given in Table 1.

Blender: Blender is a free and open-source 3D modeling program that can handle almost every facet of 3D modeling (Hartmann et al., 2020). A prototype of one of our food models built in Blender has been illustrated in Figure 5. The creation of 3D food models in Blender 3D software was the first step in the development process. Food models are created using multiple meshes, and various textures and materials are applied to give them a realistic look using Blender’s shading, edit mode, and UV editing tools as shown in Figure 6. The completed 3D food model was then exported to Unity 3D in .blend format.

Vuforia SDK: It is an AR SDK that aids the developers to insert virtual objects into the real world through a camera and adjust the position of 3D objects in the real world in front of the camera lens by using the feature of computer vision technology to identify and capture flat images or 3D objects in real time (Liu et al., 2018). It also adds the image target into the Unity database. Therefore, we establish the image marker, which in our case are the QR

Figure 3
The block diagram of the proposed methodology

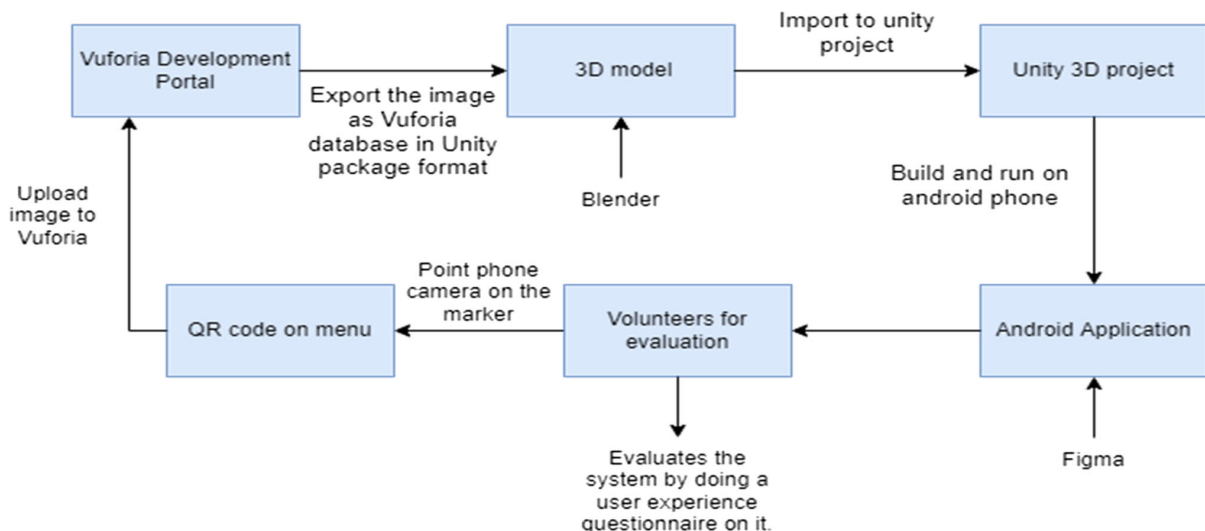


Table 1
Comparison of QR codes with fiducial markers
for AR systems (Kan et al., 2009)

	QR codes	Fiducial markers
Need to pre-register	No	Yes
Model storing	Internet	Local
Number of markers	Large	Small

codes, using the Vuforia Development Portal. It is used to generate a licensing key for our AR application and add our image target to a database. The SDK recognizes and tracks characteristics in the QR code, which are subsequently matched to a database of known target resources. This database is then downloaded as a Unity package which is then imported and utilized in Unity 3D.

Unity 3D: Unity 3D is a multi-platform game production tool, which includes a fully integrated professional game engine, which includes rendering, physical engine, and script engine, lighting mapping, and scene management. The camera presents and controls as stated in the situation (Li & Tang, 2019). In Unity 3D, development starts with a project, which is then filled with packages obtained from Vuforia. By selecting the proper frame, 3D food models are subsequently inserted into the QR code targets as seen in Figure 7, where we set up the virtual object's overlay location on the target picture (QR code). A 3D food model generated from Blender is then placed on the target image from the Unity warehouse to be displayed as a registered item in the application.

Figma: Figma is a vector graphics editor and prototype tool. Its main feature is that it is accessible both online and as a desktop application. One can design anything using Figma such as a user interface for websites and vector graphic images (Sharma &

Figure 5
The designing process of the 3D model of a chicken salad in Blender

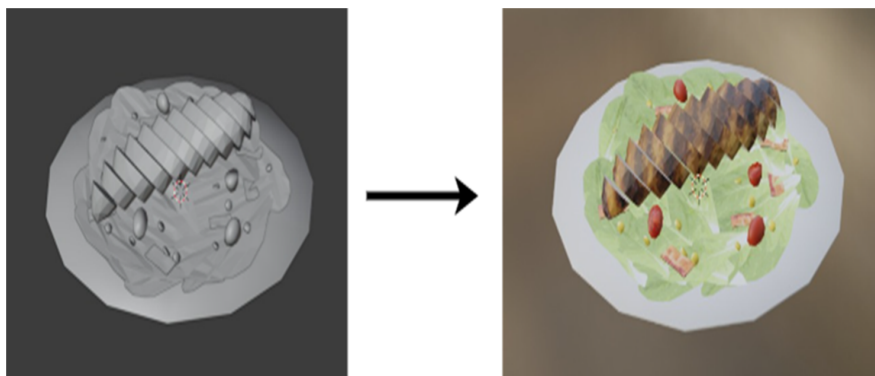


Figure 6
3D food models designed using Blender

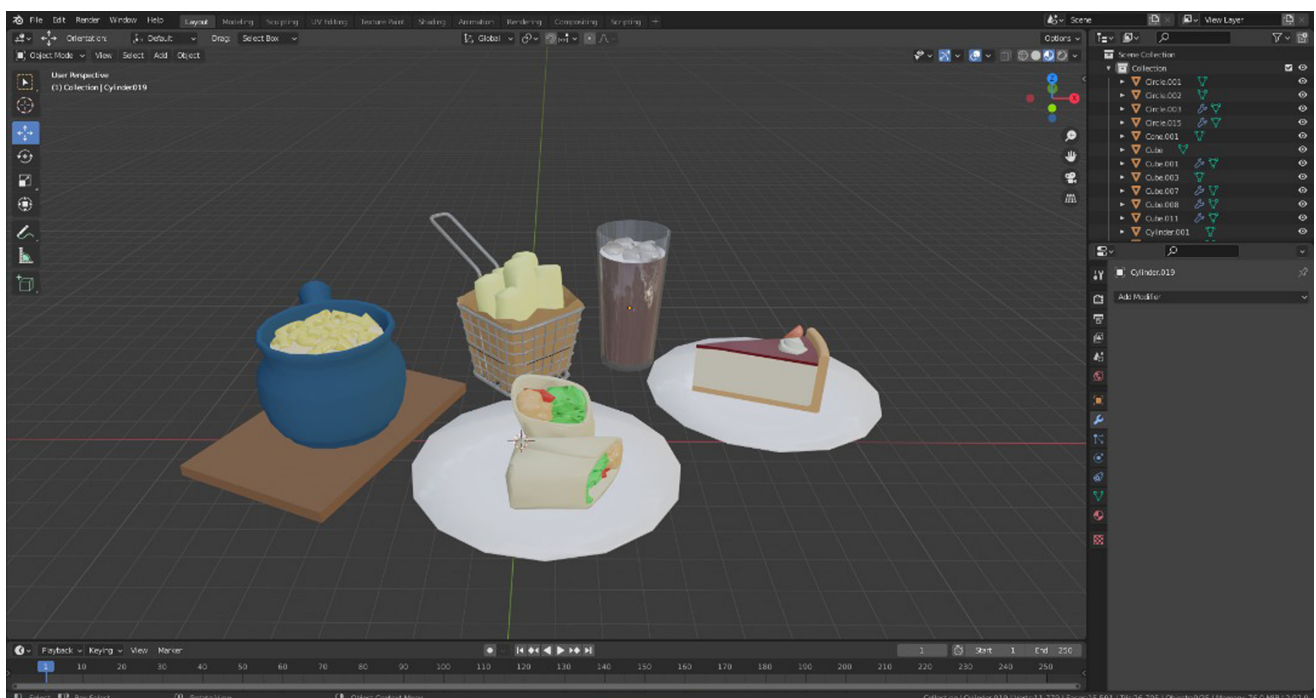
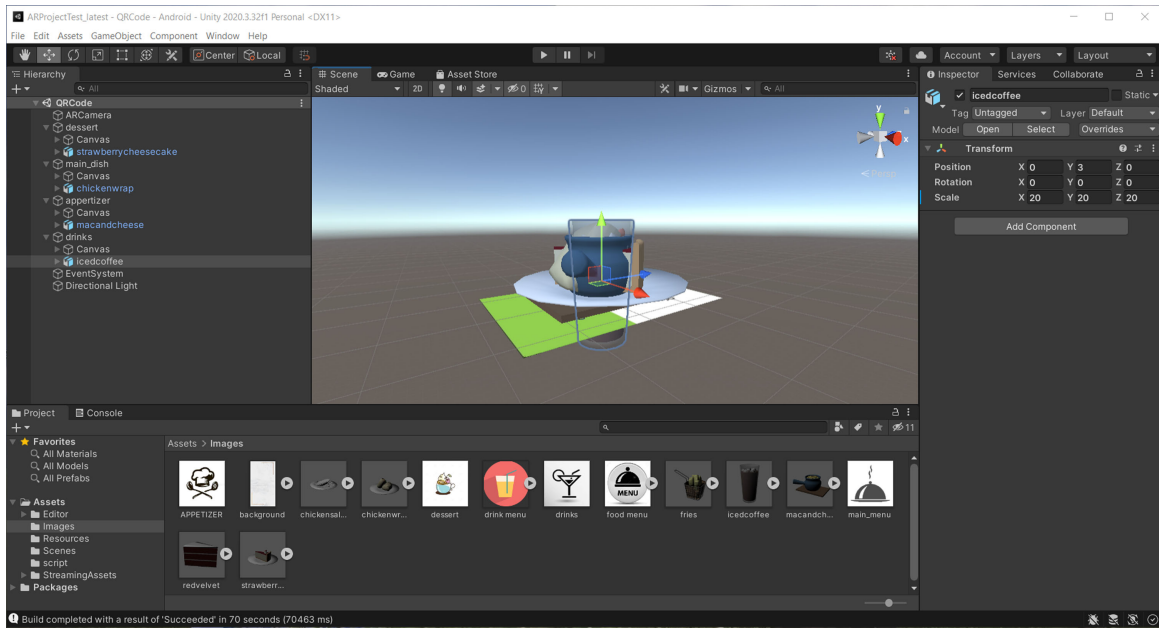


Figure 7
Integrating 3D food model with the image marker (QR codes)



Tiwari, 2021). Therefore, the user interface of our model was designed using Figma which also includes the buttons for checking the price and displaying the ingredients, calories, and nutritional information. This layout is then imported to Unity using Mixed Reality Toolkit (MRTK) Figma Bridge and the whole project is assembled together. All the above steps resulted to an AR-based android application that could be used to view and scan the QR codes to trigger it into displaying the required 3D food models.

The inside workings of the assembled AR android application when implemented have been elaborated below and shown in Figure 8.

Camera: The camera module receives a real-time live video feed from the smartphone camera.

Image capturing module: We configured the camera of the smartphones to be the Vuforia ARCamera for Unity to use. This

module examines the live video stream from the camera by examining each frame. This module creates binary pictures, which are digital images in which each pixel has only two potential values – black and white. The image processing module receives these binary pictures as input (Saif, 2020).

Image processing module: To detect the AR marker, the binary pictures obtained from the preceding module are processed in the Vuforia Engine. The detection of an AR marker, in our case the QR code, is necessary for determining the location of the virtual item. The position of the AR marker is supplied as an input to the tracking module once it has been discovered.

Marker tracking module: The marker tracking module is the AR framework’s main engine; it determines the camera’s relative posture in real time. Vuforia Engine uses the Device Pose

Figure 8
Detailed AR system design

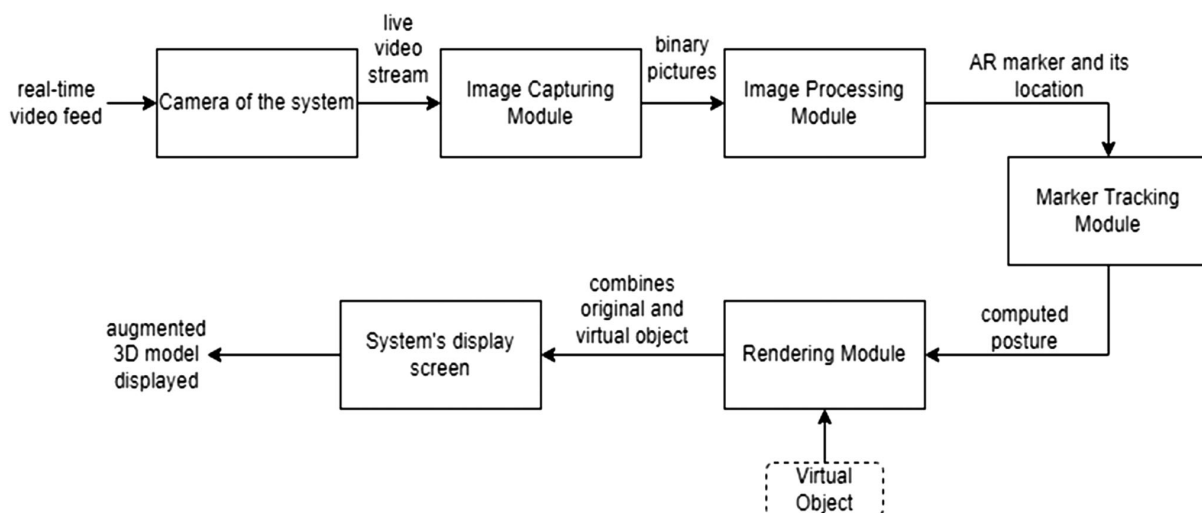


Figure 9
QR code used for displaying main course



Observer to provide precise tracking (Cheng et al., 2017). The six degrees of freedom position, i.e., the 3D location and 3D object orientation, are referred to as pose (Lin et al., 2021). The rendering module receives the computed posture as an input.

Rendering module: The estimated posture from the tracking module and the virtual object to be enhanced are the two inputs to the rendering module. The rendering module uses the computed posture to mix the original picture with the virtual components and generates the augmented image on the mobile device's display screen (Mandviwala et al., 2022). In order to guarantee that rendering in respect to a target's posture in the real world is always in sync with the video backdrop image, Vuforia Engine offers its features.

4. Experimental Section

To evaluate the proposed software, we consider QR code as input for generating 3D view for the menu and other details of dish items. The whole section is divided into three subsections, namely Section 4.1 discusses dataset collection and nature of the data. Implementation details are presented in Section 4.2. Statistical analysis for validating the proposed software is discussed in Section 4.3. Section 4.4 describes the limitation of the proposed system.

4.1. Dataset description

For validating the proposed system, the input that is chosen is QR code, and this is the image marker for augmenting the 3D food models in the real world. We generate the QR codes for each dish using an online QR generator <https://me-qr.com/>, and a sample is shown in Figure 9. The generation of the QR codes does not take much time because they are done online, reducing the complexity of collection. The most important thing is that the marker must have a high contrast between itself and its background for the camera for recognition. Therefore, we chose a bright green color as the background for the QR codes. 3D food models are then subsequently inserted into the QR codes using Vuforia. The system's camera scans the QR codes and matches it with the contents in the database in Vuforia, after which the information embedded on it is extracted to layer a 3D food model on top of it.

4.2. Implementation details

In this section, we assembled the whole project together and experimented on it to check if it performed according to the requirements. The .apk file was installed into an android smartphone and after setting it up, its camera was used to scan the

QR codes on the AR menu. Accordingly, it was seen that the 3D models of the dishes render over the image marker along with buttons for checking price, showing ingredients, and the nutritional values of the items. The images of how the 3D food models appear along with the detailed information have been shown in Figure 10. The demonstration of the whole process from scanning the QR codes from the AR menu to the displaying of the 3D food models to the viewing of the information has been illustrated in Figure 11.

4.3. Evaluating the proposed system

AR is being utilized to solve the issue of customers during ordering food and not being able to visualize the dish, and this, in turn, will help meet the customer demands faster (Yuan, 2018). This can create added value for the customers and, as a result, increase sales of the restaurants using this technology. Unfortunately, organizations often face the challenge of evaluating commercial AR mobile applications in user experience. Therefore, we evaluate the customer experience after using our AR system by asking some volunteers to fill out a user experience questionnaire – the link of which is <https://forms.gle/XMtVyi3aqajFhEGK7>, and the results were accessed.

The reason for choosing this evaluation method is that it is able to represent the whole user experience of the product being assessed (Davidavičienė et al., 2020). The questionnaire focuses on how this new technology affects consumer acceptability when compared to factors such as attractiveness (general view of the AR system being assessed by the user), perceptiveness (the ease of using the user interface and navigate through), efficiency (the quick and efficient use of the system), dependability (response time of the system), interactivity (the interest and excitement to use the application and increase motivation to continue using it), and the information quality.

The overall user experience evaluation of the AR platform is favorable, according to the evaluation data which have been illustrated in Figure 12. The AR application can be used by downloading the .apk file of our project into an android smartphone. So, we provided the .apk file to 15 participants and asked them to first use the application and then complete the questionnaire. The responses received were evaluated and the percentage for each of the assessment criteria was manually calculated. The results from this assessment prove that the AR system has the ability to interactively and effectively provide a 3D view of the dishes on a restaurant menu; thus, it has the potential to aid customers with the decision-making process during ordering the foods. This would in turn bring customer satisfaction, improving the restaurants' performance and potentially increasing sales and customer loyalty.

To justify the user experience evaluation result of our proposed system, we asked the same set of volunteers to fill out the same user experience questionnaire for two other similar systems designed by other researchers. The applications chosen to compare the results against were the work by Mandviwala et al. (2022) and Mali et al. (2021). The .apk files of these two systems were downloaded from github repositories and given to the volunteers to use them and then complete the questionnaire. The overall user experience evaluation data of the two systems have been illustrated in Figure 13. Although most of the evaluation criteria gave satisfactory outcomes, the attractiveness of Mali et al. (2021) and the efficiency of Mandviwala et al. (2022) fell short when compared with our system. Therefore, we can state that our system achieved better assessment scores from the volunteers when compared with two other similar designs.

Figure 10
 Display of how the 3D food model along with the information appears

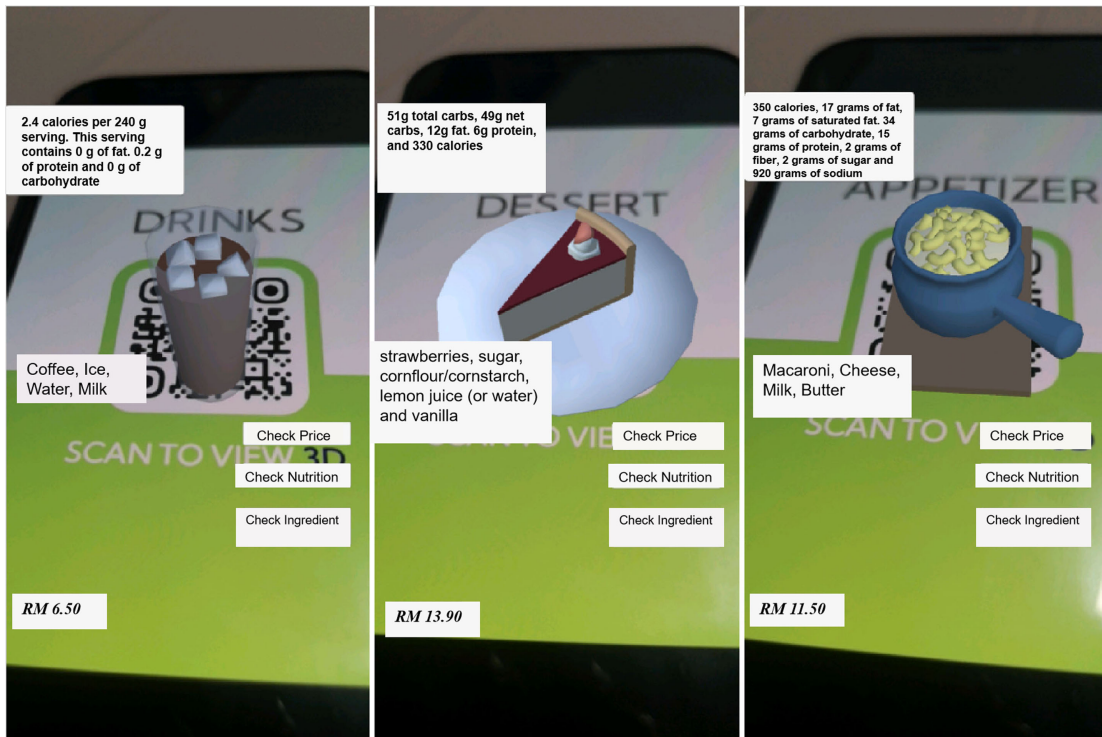


Figure 11
 The demonstration of the 3D model viewing process of appetizers and main course

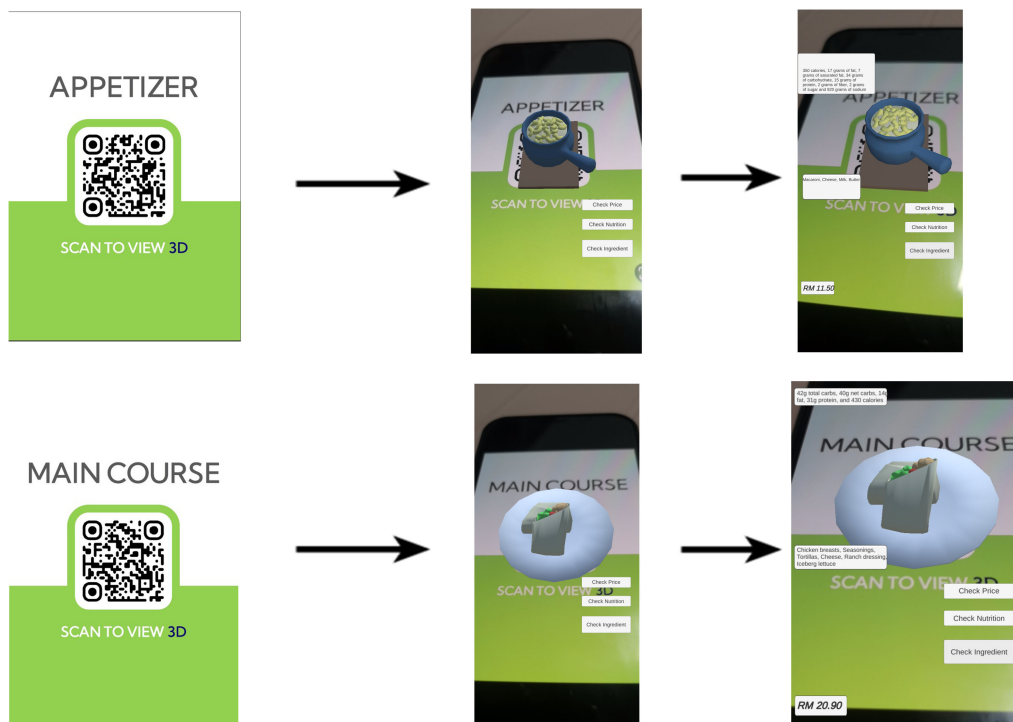


Figure 12
Evaluation of the proposed AR application using the user questionnaire

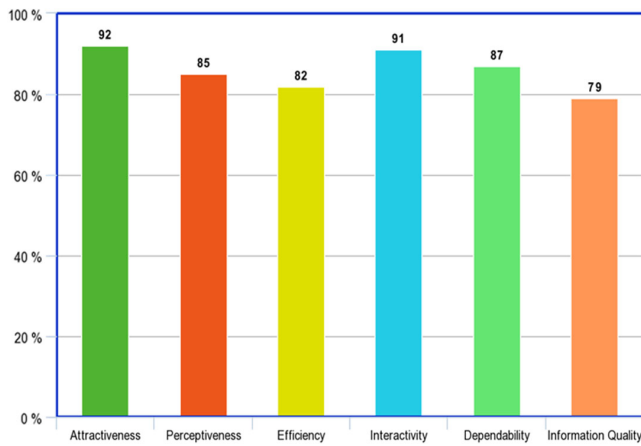
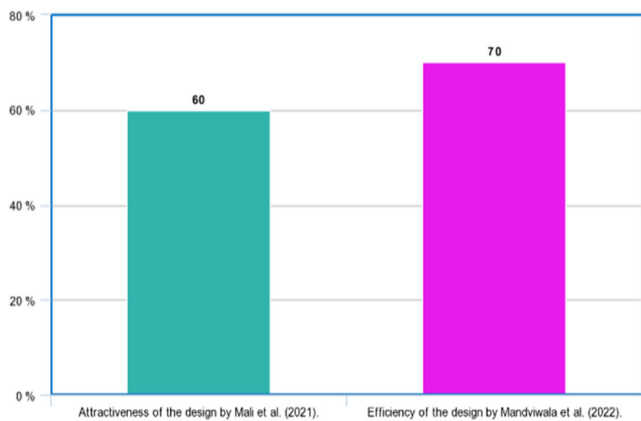


Figure 13
Evaluation of the two AR applications chosen for comparison using the user questionnaire



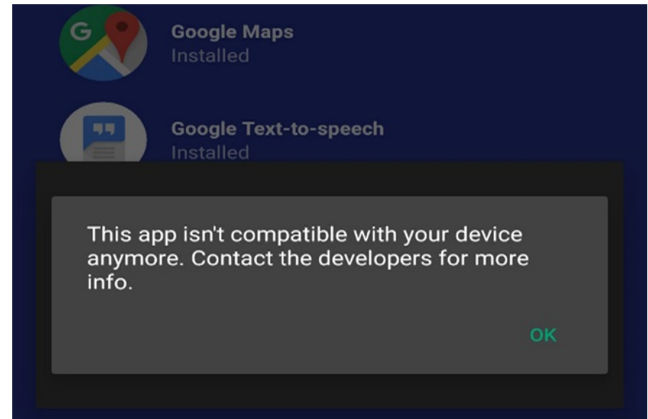
4.4. Limitation of the proposed system

Although the proposed AR system is able to meet its objectives, there were a few issues that we found during the experimental stage. There was an application compatibility issue when the system is tried out using backdated smartphones as shown in Figure 14. Moreover, the system is seen to lag when used in some smartphones and also there are phones which could not run the system because they lacked enough RAM to run an AR-based application. Also, some phone cameras had inefficient autofocus which resulted in a longer time to detect and scan the QR code.

5. Conclusion

The proposed approach is an AR application that integrates virtual reality to real life by utilizing the recent advances in the android operating system. The employment of AR technology is a marketing approach for attracting a diverse consumer base and brand loyalty improves as a result of increased user involvement. The technology allows the client to preview the real visualization of a meal, allowing the restaurant to acquire the customer’s trust and so grow the number of users. In the future, we hope to increase the

Figure 14
Application compatibility issue in backdated devices



number of features in the application like speech and gestures to increase customer interaction. Moreover, the system could be upgraded to make it markerless, and also the present application could be expanded to add an online order placement feature with a payment gateway to make the whole process more efficient.

Conflicts of Interest

Palaiahnakote Shivakumara is an Editor-in-Chief and Ramachandra Rahavendra is an Advisory Board Member for Artificial Intelligence and Applications, and were not involved in the editorial review or the decision to publish this article. The authors declare that they have no conflicts of interest to this work.

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