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ServAR - An Augmented Reality System for Visualization and Portion Estimation of Restaurant Food Items

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Abstract:- Augmented reality is an interactive experience of a real-world environment wherein a computer-generated image is superimposed on the user's view of the real world, providing an exciting visual experience. Today, even with the advancements in technology in recent times, there is still a gap between the amount of information available to us and the real world in which we apply it. While most of the data remains trapped in two dimensions, reality is in three dimensions. Augmented reality aims to bridge this gap between dimensions. We propose an Augmented Reality solution to revamp the food industry. Through this application, the customers will be able to visualize the restaurant menu items in three dimensions, which gives them a gist about the portioning, ingredients and presentation of the food items.

Keywords:- *Augmented Reality (AR), 3D modelling, Mobile Application, Unity, REST API, Blender, Vuforia, MongoDB.*

I. INTRODUCTION

Virtual and Augmented reality are widely regarded as the technologies with the highest projected potential for growth. These are new and upcoming technologies, and their potential has not been fully explored yet. They can be used in a variety of applications, such as gaming, healthcare, education, etc. Reference [1] gives us an overview of the applications of Augmented Reality (AR) in real life.

In the current scenario, with the widespread pandemic, the food industry is undergoing a major transformation. There is a great rise in food delivery applications and services, and the need for these services is increasing day by day. Contactless ordering and delivery is essential during these times.

In today's time the world is coming closer. Cuisines all over the world are now available at almost every restaurant as against a few years ago only a few five star restaurants served international cuisine. This makes it difficult for the consumer to visualize the various dishes available at the restaurant by their mere names.

Moreover, it is very difficult for the customers to estimate the portion sizes of the food served just by looking at the two dimensional menu images. Some restaurant menus contain only item names and descriptions, which are not adequate enough to help visualize the food items.

Hence, we integrate the food industry with an AR application, wherein users can scan the restaurant menu to visualize the food items in three dimensions on their phone screens. Using this system, users can view food items that they have never heard of prior to actually placing the order. The users are also able to place orders within the application itself, without any human interaction. The three dimensional (3D) visualization also helps the user in gauging the portion size or the food quantity present in the serving. The use of AR in our application helps in increasing user engagement throughout the food ordering process [2].

II. BACKGROUND INFORMATION

In a survey conducted [3], in which it was observed that about 35.3% of the respondents cannot envision what the food looks like just based on the ingredients mentioned in the menu, and only 14.7% are able to envision the portion size served accurately. About 63.6% people believe that most meals they have eaten were not worthy of their price. These results highlight the need for accurate visualization or representation of the food items present in the menu.

Apart from these, users are also more likely to try out new restaurants or foreign cuisines if they get an idea about the ingredients present in the item, or if they can visualize what the item will exactly look like. Augmented reality opens a new door in solving the problems mentioned above.

III. RELATED WORK

When researching for the various nuances about the food industry, we discovered a disconnect between the menu card representation and the actual food representation. Hence, we decided to combine real and virtual objects in an AR environment in real time and mobile mode aligns real and virtual objects with each other. This virtual augmentation is based on dynamic, 3D objects (e.g. interactive, deformable virtual characters) these systems vary in display type, reality, immersion, and directness of interaction.

One of the widely used approaches we came across was explored in "Mobile augmented reality as a Chinese menu translator" [4]. The paper presents an application which translates Chinese menus into English. The system runs on an Android device. Image recognition is used to trace and register AR markers. The Chinese words in the menu work as marker images. It creates a database of the restaurant menu items using Features from Accelerated Segment Test (FAST) implemented by Vuforia Library. The system checks the database, and after matching it with the marker texts, will generate the image of the food using the Unity 3D game engine. The other benefit it offers is that many times it happens one cannot gauge the ingredients of the dish just by the mere name here is where the application comes in handy. The application helps when the restaurant menus are written in a foreign language, and no standard translation of the dishes in English is available. The English names could be very obscure, and does not help identify the ingredients of the dish.

Another aspect that drew our attention was the focus on actual portions served when the food item is ordered. Estimating the portion or amount of food which will be served is a difficult task. Reference [5] demonstrates potential as a practical tool to support the accurate serving of food for portion control. The paper proposes an android tool which would render a 2D model after hovering over the menu card. However, 2D models do not accurately grasp the aesthetics of the food item.

We also decided to add additional features apart from the ones listed above. Our aim was to build a complete restaurant ordering and rating system, along with other features which enhance the user experience. Users can visualize the different items in 3D, choose the dishes that they like the most, place orders and review the dishes within the application itself.

We also conceptualized a prototype to implement the rating and review mechanism in 3D. Once the marker images are scanned, the prototype shows a small 3D model of the food item, and its ratings and reviews are also displayed alongside it.

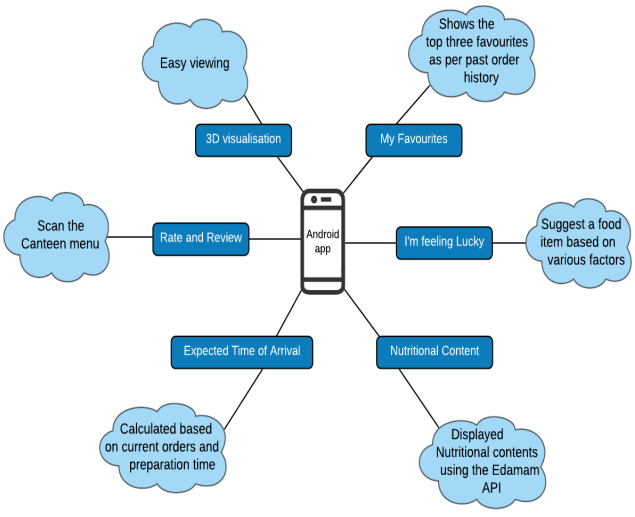

Fig. 1. System model

Fig. 1 shows the final system model of our application. This model represents all the major features of our system.

IV. PROPOSED MODEL

A. LOGICAL FLOW

Our system adopts an approach wherein markers are used as triggers to show 3D models of food items.. Augmented Reality markers or AR-markers are objects or images which are trained so that they can be recognised later easily and act as triggers to display certain virtual information. Reference [6] proposes a marker-based system which can be used for mobile devices.

For our system, we use small icons which represent the food items being served as marker images. Whenever a user scans these markers using his mobile device, the respective 3D model of the food item is shown on the screen.

All marker images are added to the Vuforia database. Then, we download the database and import it within Unity. The 3D models of the food items are created using Blender. These models are converted into the .fbx format and imported into the Unity application. The markers from the Vuforia database are then mapped with the appropriate 3D models within Unity.

Fig. 2. Example of a marker image

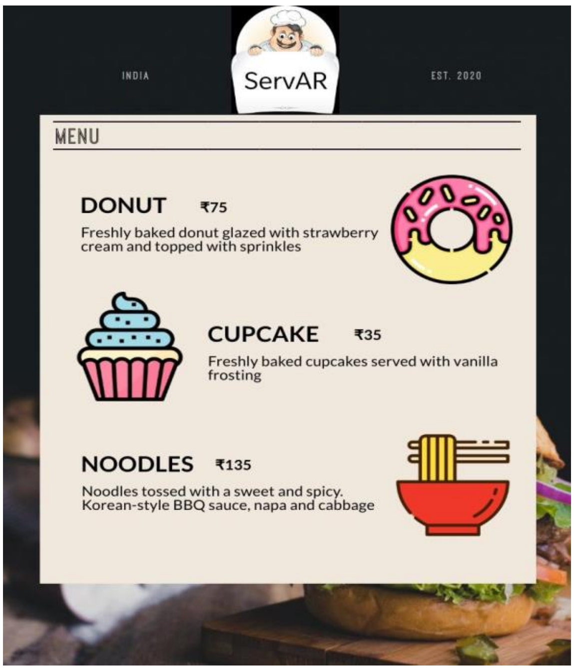

Fig. 3. Marker images used in making the menu card

B. SOFTWARE ARCHITECTURE

The proposed system employs a mobile application with Unity engine to create the frontend. All the tasks such as scanning marker images, viewing the menu, placing the orders, etc is done using the Unity UI. The backend is created using Flask REST(representational state transfer) API(application programming interface). All requests are passed between the application and backend by making API calls. The REST API connects to the MongoDB database, which is used to store user data, as well as all other application related information.

The application also has several other features, such as an in-app menu for placing orders, user favourites, 'I am feeling lucky' feature, Expected time of arrival (ETA) calculation, etc. All computations are done on the server side using the REST API.

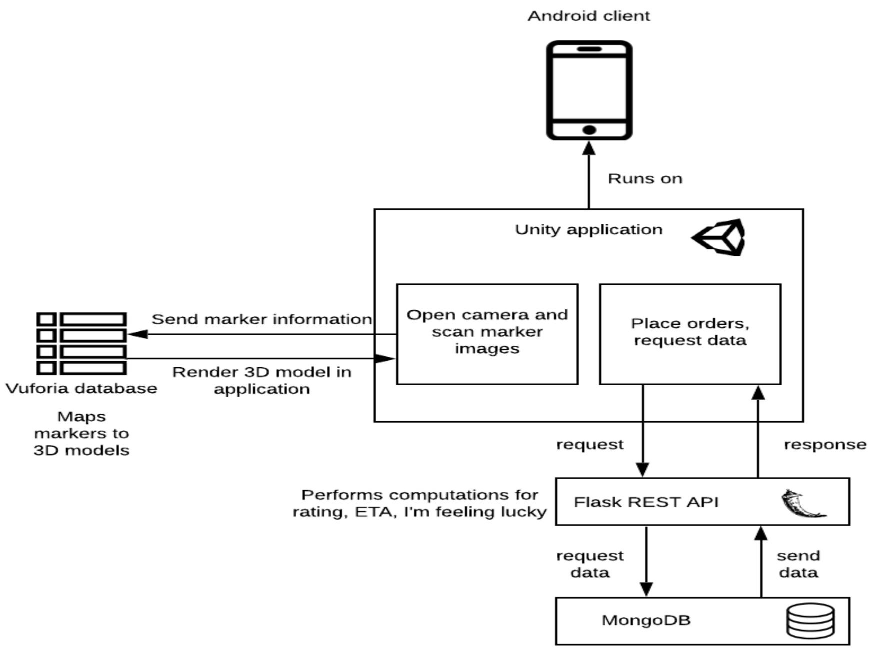

Fig. 4. Flow diagram of the system working

C. ADMIN PANEL

The system also consists of an Admin panel, wherein the restaurant admin can view the pending as well as the completed orders, as shown in Fig. 5. All new orders are displayed on the dashboard as pending orders. The dashboard uses data from the MongoDB database to display the orders placed by the users.

Once the order is fulfilled, the restaurant admin can press the 'Delivered' button to mark the order as completed.

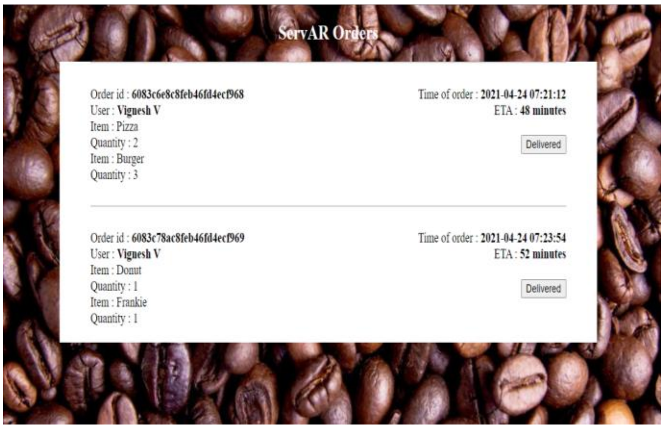

Fig. 5. Admin dashboard to view pending orders

V. IMPLEMENTATION

A. VISUALIZATION OF FOOD ITEMS

Once the user has logged in, Customers will be able to visualize his/her menu in 3D. This will be implemented using 3D models in Blender software. The customer will have to hover the phone over the marker text in order to view the 3D models of the food items.

The user who visits the restaurant can download the application on their phone. Once the application is opened the user will be presented with an option to use the camera to view the restaurant menu items.

On hovering the application over the menu card, the Vuforia plugin will notice the image targets which are present in the menu card and effectively map the target to its respective 3D model. (This Image target and 3D model mapping is done in the Unity project itself by establishing parent child relationship between the Image target and the model). Similarly, these image targets within the menu card are uploaded beforehand to the Vuforia Target manager database and downloaded within the Unity Project assets. Fig. 6 shows the rendered 3D model of the cupcake marker image in Fig. 2 displayed when the user scans the menu card.

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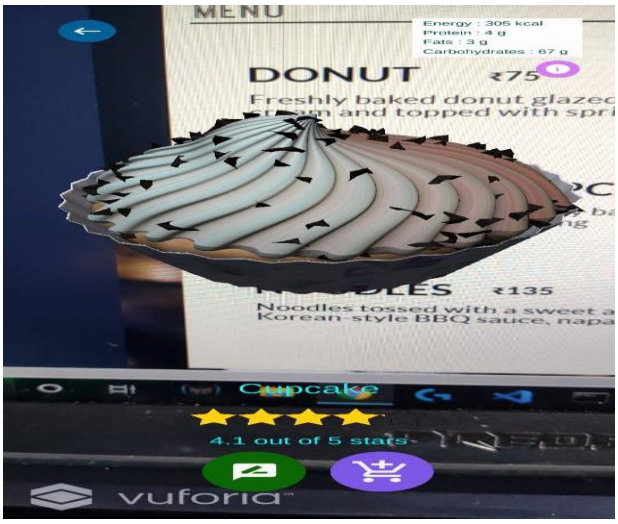

Fig. 6. 3D model visualization

B. RATING AND REVIEW

Customers will be able to rate (only after placing the order) and view other's reviews of the dishes. The customer will have to hover the phone over the marker text in order to view the ratings and review of the food items scanned.

The ratings are calculated based using the Bayesian Rating model. This model takes into account both the average rating as well as the number of ratings. This method helps us in comparing food items with very few ratings, to items whose ratings have a high level of certainty. Bayesian ratings also help us in condensing the various ratings with different numbers of ratings to relative range, which makes it easy to compare any two or more ratings.

The formula used to calculate the Bayesian adjusted rating:

$$\text{Bayesian Adjusted Rating}_i = ((\text{Number of Ratings}_i * \text{Ratings}_i) + \sum_i (\text{Number of Ratings}_i * \text{Ratings}_i)) / (\text{Number of Ratings}_i + \sum_i (\text{Number of Ratings}_i))$$

Fig. 7 shows the reviews and ratings of users about donuts. The date and time of the review, the stars given by the user is displayed along with the description.

Fig. 7. Viewing the reviews of an item 'Donut'

C. ORDER PLACEMENT

The user can add items to their cart by either scanning the restaurant menu using their device, or using the in-app menu. Once the items are added, the user can view the ETA and order total in the cart before placing the order. The orders placed are also shown on the admin portal of the restaurant. Once the orders are fulfilled, the restaurant can mark orders as delivered.

Fig. 8 shows the user cart with items added in it. Fig. 9 shows the order details once the order has been placed.

D. EXPECTED TIME OF ARRIVAL (ETA) CALCULATION

The ETA module is based on certain assumptions:

- Number of cooks in the restaurant will be fixed and equal to the distinct food items in the menu.
- Each cook will prepare only one designated food item at a time.
- The initial values like historical time for each food item, number of food items and the number of cooks for each food item will be taken as input from the admin panel.

Fig. 8. Items added to cart

Fig 9. Order placed successfully

There will be a queue for each of the food items. Orders will be placed in these queues in FCFS manner. Now, for the first item in the queue, we will take the average of the past orders, however for the next items we will sum the times for previous items in the queue and return the effective time.

Formula:
ETA for current order = $\sum_i$ *(ETA of all previous orders)* + $\sum_i$ *(ETA of all items in current order)*

The customer can view the ETA of the order both before and after placing the order. As we can see in Fig.8 ETA is displayed before the user places the order as well in Fig. 9 ETA is displayed after the order is placed successfully.

E. I'M FEELING LUCKY

The I'm feeling lucky is basically a recommendation system, which suggests food items to the users based on certain criteria or factors. Fig. 10 shows the different factors or scores for a food item 'Donut'.

Following factors are considered:
1. Weekday
2. Time of the day
3. Popularity (number of orders for that food item)

Each food item is given a certain score in all of the above categories. For each order placed in the future, we make updates in the Factor table (Table with above factors keeping count of the past orders satisfying that factor). Now, when a new user comes up, the current factors will be considered and based on the Factor table, Lucky Scores of each item are calculated. The food items are ordered in descending order of their scores and the top 3 items are returned, so that the user can make an informed choice. The user interface for this is shown in Fig. 11.

Formula to calculate Lucky Scores:
LuckyScore(item) = PopularityScore(item) + MealTypeScore(item) + DayOfWeekScore(item)

Now, whenever a new order is placed, the scores of the items are updated in the database as follows:
*PopularityScore(item) = PopularityScore(item) + (1 * itemQuantity)*
*MealTypeScore(item) = MealTypeScore(item) + (0.8 * itemQuantity)*
*DayOfWeekScore(item) = DayOfWeekScore(item) + (0.5 * itemQuantity)*

A lot of trial and error was involved while considering the increments to update these parameters, whenever a new order is placed. After a few iterations, the formula was finalised as above.


```
_id: ObjectId("60194138121b70eb7ee70cbd")
itemName: "Donut"
breakfastScore: 2
lunchScore: 2
snackScore: 9
dinnerScore: 3.5
mondayScore: 0.8
tuesdayScore: 0.8999999999999999
wednesdayScore: 1.1
thursdayScore: 1.2
fridayScore: 0.6
saturdayScore: 1.7000000000000002
sundayScore: 1
popularityScore: 29
```


Fig 10. MongoDB database entry for an item "Donut"

Fig 11. I'm feeling Lucky screen

E. FAVOURITES

The user can click on the favourites tab to view his most frequently ordered items. All past items of the user are stored in the database. These orders are filtered on the server side, and top 3 most frequently ordered items are sent back to the user. Fig 12. Shows the favourites screen shown to a particular user.

F. NUTRITIONAL CONTENT

The user can view the nutritional content of the food item by clicking on the "i" icon as seen in Fig. 6. It displays details about Carbohydrates, Fats, Protein along with the Energy content of each of the food items. To extract the above information we make use of the Edamam API.

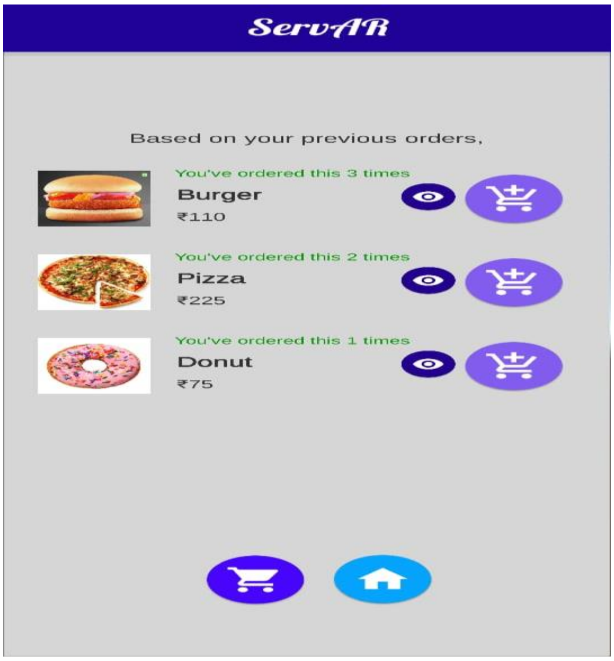

Fig 12. Favourites screen

VI. CONCLUSION

With the rise of technology and new developments day-by-day, it is necessary to evolve and find various uses of the technologies in different sectors. We implemented the proposed system using Unity for the mobile application and Blender for creating 3D models. The AR system is managed by Vuforia engine. The application related data is stored in MongoDB. The REST API backend, as well as the admin panel is created using Flask. Different modules such as Rating and review system, Menu, Favourites, ETA, I'm feeling lucky, were added to the system. Thus we implemented an application which uses the device camera to scan the restaurant menu, to show 3D models of the different food items and place orders in a seamless fashion.

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