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AR-ENABLED ECOMMERCE: AN ALL-IN-ONE VIRTUAL SHOPPING SYSTEM USING AUGMENTED REALITY

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Abstract: The evolution of e-commerce has significantly reshaped modern consumer behavior, offering unparalleled convenience and access to global marketplaces. However, a major drawback of traditional online shopping is the inability to perceive products in a real-world context, leading to uncertainty, misjudgment of size, placement issues, and frequent product returns. Augmented Reality (AR) offers a transformative solution by enabling customers to visualize products in their own environment through mobile devices. This study presents the development of an AR-based e-commerce system that integrates optimized 3D product models, Firebase-based secure authentication, and Google Scene Viewer for AR visualization. The methodology emphasizes true-to-scale model creation, mobile-optimized rendering, gesture-based interaction, and cloud-linked product retrieval. The proposed system significantly enhances user clarity, improves product understanding, and increases purchase confidence. Test results demonstrate that AR visualization can reduce product-related ambiguity and strengthen the overall shopping experience. In addition to furniture and home products, the system is extended to support virtual clothing try-on and accessories visualization, enabling users to preview apparel, glasses, watches, and jewellery on their own body using AR-based overlay techniques.

Index Terms **-** Augmented Reality, E-commerce, Google Scene Viewer, 3D Models, Firebase Authentication, Mobile AR

I. INTRODUCTION

E-commerce has transformed into an integral part of daily life, thanks to the ubiquitous use of smartphones. However, even today, online shopping relies much on 2D images and product descriptions—each lacking attributes that would help in rendering the right judgments about size, scale, style, and placement, among others. The products purchased, when not meeting the expectations, make customers unhappy and lead to returns.

AR bridges this gap by merging virtual 3-D models with a user's physical environment. By applying markerless tracking, surface detection, and real-time rendering, AR lets shoppers preview products at actual size, rotate them from any angle, and understand how they fit within their space. As companies such as IKEA and Amazon are proving, AR is fast becoming an essential tool in ecommerce.

However, building a reliable AR shopping system comes with challenges:
• Optimized 3D models of high quality that perform smoothly on mobile devices.
• The accuracy of AR changes according to different light conditions.

• Surface detection may behave differently across devices.
• The backend systems should store and load the 3D assets efficiently.
• User authentication must remain secure.

The proposed system will be an accessible AR shopping application with integrated model optimization, Firebase services, and Google Scene Viewer to respond to these challenges.

II. LITERATURE SURVEY

Thompson et al. [1] presented an AR-based mobile shopping prototype to help users visualize furniture in their homes. They used Google ARCore for plane detection, spatial tracking, and object anchoring. The authors converted product models into optimized .gltf formats and allowed natural gesture-based interactions. However, the system performed poorly on mid-range smartphones because of high-polygon assets. Additionally, inconsistent lighting conditions made virtual shadows and surface detection less accurate.

Patel and Kumar [2] proposed a cloud-client AR setup for home décor ecommerce. Their system streamed 3D assets from remote servers and included mesh decimation, texture compression, and lighting correction to ensure smooth rendering. While users could virtually place decorative items like artwork and lamps, the system relied heavily on stable network connectivity. This dependence led to loading delays in low-bandwidth situations.

Williams and Chen [3] studied how AR affects user purchase intent through a large-scale comparison of traditional image-based shopping interfaces and ARenabled shopping. Their findings showed that AR boosted user confidence, satisfaction, and engagement, thanks to features like 360° viewing and detailed product inspection. However, limited texture resolution and poor rendering of complex materials, such as metal and glass, reduced the realism of product models.

Liang et al [4] focused on optimizing 3D models for mobile AR systems. They introduced a multi-stage rendering pipeline that included mesh simplification, texture atlas generation, normal-map baking, and physical material processing. Their optimized assets showed a 40-55% performance improvement on mobile devices. Despite these improvements, aggressive optimization sometimes caused a loss of fine surface details, lowering model realism.

Hernandez and Garcia [5] created a cloud-synchronized AR framework to support large-scale ecommerce product catalogs. By using Firebase and Amazon S3, their system allowed real-time loading of AR assets without needing local storage. This approach enhanced scalability and device efficiency.

Singh et al. [6] looked into AR adoption in retail and its impact on consumer behavior. Their study found that AR increased user trust, engagement, and perceived usefulness by enabling spatial simulation of products. The researchers concluded that AR interactions help reduce hesitation in purchasing by providing a clearer sense of space.

Expanding on Identified Gaps in Literature

1. Limitations of Category-Specific AR Systems: Many current AR systems focus only on specific categories, such as furniture or home decor. This limits user experiences and applications. There is a strong chance to create a more flexible AR platform that supports a wider range of categories. This would help users easily visualize different types of products in their surroundings.
2. Cost and Hardware Dependency: The high cost of AR implementation often stops businesses from using these technologies. Performance can also vary greatly depending on the hardware. An affordable and effective AR system that works well on various devices could improve access for both consumers and businesses.
3. Variability in Mobile AR Experiences: The quality of mobile AR experiences can differ widely based on device specifications, such as camera quality, processing power, and sensors. Creating a system that optimizes AR experiences for different device abilities would help more users engage with AR technology effectively.

4. Issues with Lighting Inconsistencies: Lighting plays a key role in AR applications. Differences between digital and real-world environments can lead to unrealistic shadows and reflections. Developing better algorithms to handle different lighting conditions could significantly boost the realism of AR experiences, making them more convincing and enjoyable.

Proposed Solution

To address these gaps, this work suggests creating a scalable, multi-category AR system. By using lightweight 3D models, the system aims to reduce dependency on high-end hardware while maintaining performance quality. This approach will lower economic barriers and boost the usability of AR applications across different user environments and device types. With a focus on realistic lighting and shadow effects, along with features for multi-object interactions, the proposed system seeks to raise the standards of AR technology, improving its use in various industries and everyday life.

III. METHODOLOGY

A. 3D Model Collection: Gather a range of 3D product models for the ecommerce system. Make sure the dataset includes
different categories like furniture, electronics, home décor, appliances, and accessories.

B. Model Optimization and standardization: After collecting the data, we improved the models for better performance on
mobile devices. This process involved reducing the polygon count, compressing textures, and correcting orientation and
scale. These changes were necessary to prevent lag during AR placement and to ensure the models loaded quickly on
different devices.

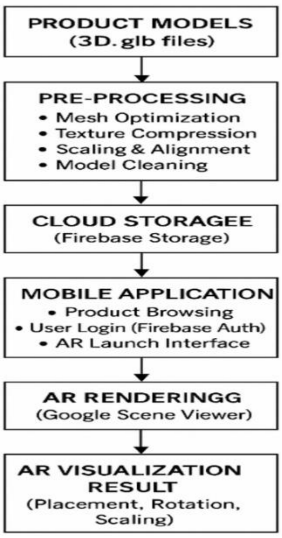

Figure 1: Architecture diagram of the proposed system

C. System Architecture Development: The proposed system featured a mobile app, a cloud database, and an AR rendering
engine. We built the app using Android Studio, while Firebase Authentication managed secure login and user access. We
stored product information and 3D model URLs in Firebase Realtime Database and Firebase Storage. Google Scene Viewer
handled AR rendering, surface detection, and placement. This modular setup allowed efficient communication among the
components.

D. AR Integration and User Interaction: We incorporated Google Scene Viewer into the application for real-time visualization of 3D products. The AR module utilized ARCore to detect surfaces and adjust lighting immediately. Users could rotate, scale, and move the virtual objects with simple touch gestures. This helped them see how a product fits in their space.

E. Application Development: This phase focused on checking the AR application's performance and making necessary improvements. We tested the app on various Android devices to see how well it functioned in different real-world situations.

F. System Testing and Evaluation: The final phase focused on testing the application on different Android devices. We did this under various lighting and environmental conditions. We looked at performance metrics like model loading time, AR stability, gesture responsiveness, and rendering accuracy.

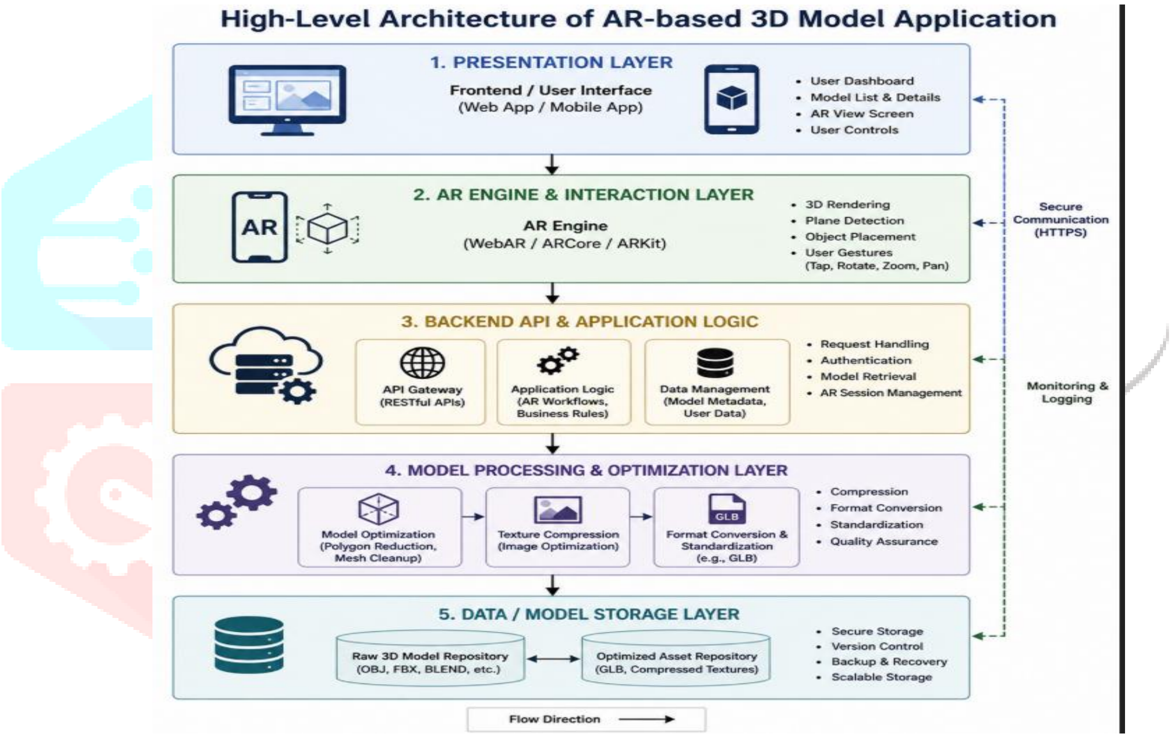

Figure 2: High level architechtural design

IV. RESULTS AND DISCUSSIONS

The results of the proposed AR-based ecommerce system are presented in this section. This system combines several modules for processing 3D models and for AR visualization.

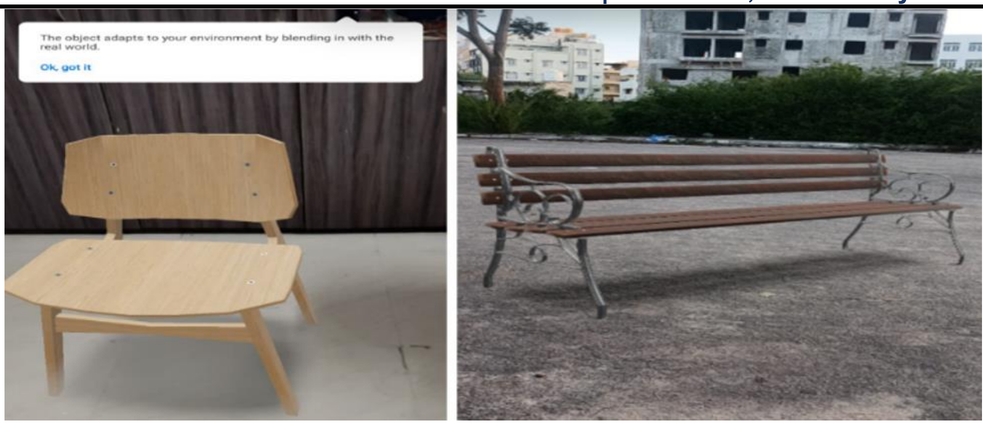

Figure 3: Example of a 3D product model rendered in AR Environment

Figure 3 shows the AR placement of a wooden chair and a bench in real-world environments. The system detects surfaces and anchors both models at true scale. The wooden chair matches well with indoor lighting. The bench displays steadily in an outdoor setting. These results show that the AR visualization module works well in different environments.

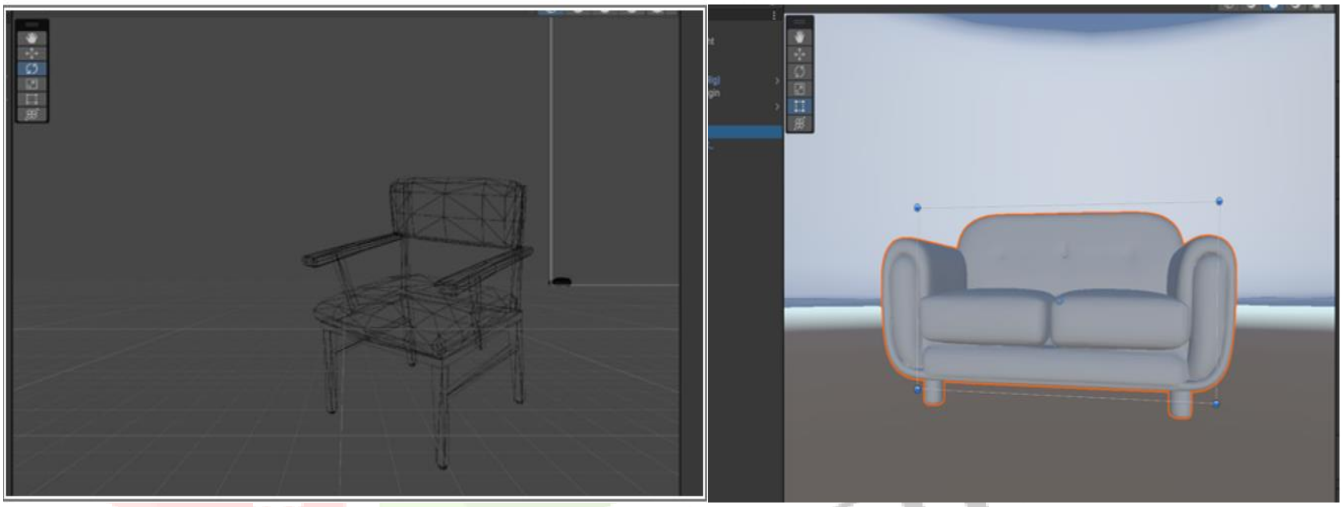

Figure 4: Visualization in simulated environment

The Figure 4 shows the simulated AR environment used during the preprocessing and visualization testing phase. The 3D sofa model is displayed in a controlled virtual environment to assess scale accuracy, lighting behavior, and surface placement features before deployment. This simulation environment enabled quick changes to model orientation, scale, textures, and materials. It offered a preview of how the model would look in real-world AR situations, ensuring accuracy and reducing the need for repeated device tests.

Figure 5: Main page

Figure 5 shows the user authentication workflow that uses Firebase Authentication. The first screen displays the welcome interface of the AR Virtual Shopping application. Users can choose to log in or sign up. The second screen explains the account creation process. Users enter their email, password, and confirmation details to register securely. The final screen shows the login interface. This allows existing users to access their accounts with their registered credentials.

Performance Discussion

The results clearly show that the AR ecommerce system works well in different visualization scenarios. The product listing interface allows for easy browsing and presents products clearly. The AR viewer successfully detects surfaces, loads models quickly, and keeps visuals stable during rotation, scaling, and movement. Techniques for optimizing models help achieve fast loading times and smooth performance. Real-world AR visualizations accurately represent scale and blend well with the environment. This confirms the success of preprocessing and the integration of Google Scene Viewer. Overall, the system improves the shopping experience by letting users see products in their environment before buying.

V. CONCLUSION

The results clearly indicate that AR can change online shopping by making product evaluation more intuitive, interactive, and user-focused. The development of an AR-based ecommerce system shows how augmented reality can improve product visualization and help users make decisions while shopping online. By combining 3D model processing, Firebase-based backend services, and real-time AR rendering, the system offers users an interactive and realistic preview of products.

Some key conclusions from the project include:

- Better product understanding through true-to-scale visualization.
- Less confusion and hesitation from users who typically rely on 2D product images.
- Effective 3D model optimization that results in faster loading times and smoother AR performance.
- Increased user engagement and better decision-making due to realistic surface detection and stable placement.
- A demonstration of how AR technologies can work with mobile ecommerce to create a more immersive and interactive shopping experience.

This project highlights the growing potential of AR in retail and stresses the importance of blending computer graphics, mobile development, and cloud technologies to provide a seamless user experience.

Limitations and Future Work

- The application performs well, but AR surface detection may be less accurate in low-light or featureless environments.
- The current dataset of 3D models is limited. Adding more diverse, high-quality assets will make it more usable.
- A lightweight version of the app can be made for low-end devices to increase accessibility.
- Adding extra AR features, such as object snapping, shadow simulation, and multi-product placement, can enhance realism.
- Future work could include integrating AI-driven recommendations and improving the UI/UX for a better shopping experience.

REFERENCES

[1] Azuma, R. T. 1997. A Survey of Augmented Reality. Presence: Teleoperators and Virtual Environments, 6(4): 355–385.

[2] Javornik, A. 2016. The Mainstreaming of Augmented Reality: A Systematic Review in Marketing. Journal of Business Research, 69(9): 381–395.

[3] Marques, B., Costello, S. and McDonnell, R. 2018. An Evaluation of ARCore and ARKit for Mobile AR Applications. Proc. IEEE ISMAR Adjunct, pp. 1–6.

[4] Kim, K., Billinghurst, M., Bruder, G., Duh, H. B. L. and Welch, G. 2018. Revisiting Trends in Augmented Reality Research: A Review of ISMAR 2008–2017. IEEE Trans. Vis. Comput. Graph., 24(11): 2947–2962.

[5] Rese, A., Baier, D., Geyer-Schulz, A. and Schreiber, S. 2017. How Augmented Reality Apps Are Accepted by Consumers. J. Retail. Consum. Serv., 38: 153–163.

[6] Poushneh, A. and Vasquez-Parraga, A. Z. 2017. Impact of AR on Customer Experience and Willingness to Buy. J. Retail. Consum. Serv., 34: 229–234.

[7] Speicher, M., Hell, J. and Krüger, A. 2014. A Survey on Augmented Reality Tools and Frameworks for Mobile Devices. Proc. IEEE ICAT, pp. 27–36.

[8] Sunan, R. S. 2023. Feasible Technology for Augmented Reality in Fashion: A Systematic Review. Procedia Computer Science, 226: 150–160.

[9] Zhang, H., Liu, Y. and Wang, J. 2022. Virtual Clothing Try-On Using Deep Learning and Augmented Reality. Computers & Graphics, 104: 104–115.

[10] Gupta, S. and Mehra, A. 2023. AR-Based Eyewear and Accessories Visualization Using Face Tracking. Multimedia Tools and Applications, 82: 14123–14145.

[11] Nguyen-Ngoc, K. et al. 2023. DM-VTON: Distilled Mobile Real-Time Virtual Try-On. arXiv preprint arXiv:2308.13798.

[12] An, S. et al. 2021. ARShoe: Real-Time Augmented Reality Shoe Try-On System on Smartphones. arXiv preprint arXiv:2108.10515.

[13] Chinthamu, N. 2025. Augmented Reality in Retail: Transforming the Shopping Experience. ITM Web of Conferences, 72.

[14] Sarkis, N. 2025. The Impact of Augmented Reality in the Fashion Industry. Journal of Fashion Marketing and Management, 29(1): 1–17.

[15] Xue, L. 2024. In-Store Augmented Reality Design for Fashion Retail. Int. J. Retail Distribution Manage., 52(2): 210–225.