



(REVIEW ARTICLE)



## Enhancing E-commerce furniture shopping with AR and AI-driven 3D modeling

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### Abstract

This research aims to enhance the customer experience in e-commerce furniture portals through the integration of augmented reality (AR), a dynamic pricing tool, and AI-driven 3D modeling. Utilizing machine learning algorithms, specifically SIFT and FLAAN, we develop highly accurate 3D models of furniture. The portal features various filters, including price range and categories, to streamline the shopping experience. The AI-enabled pricing tool, implemented through web scraping techniques on platforms like Amazon using BeautifulSoup, ensures sellers can set competitive and accurate prices, enhancing customer value. The platform allows sellers to request the addition of 3D models for their products. Admins then select the most similar 3D .obj models from the Shapenet dataset and embed AR links into the portal, enabling buyers to visualize furniture in their own space through augmented reality. This capability significantly improves the shopping experience by allowing customers to see how furniture fits in their home environment before purchase. The portal is built using Django for the backend and PostgreSQL for database management, ensuring a fast, secure, and reliable user experience. By combining AR, advanced 3D modeling, AI-driven pricing, and robust backend technologies, this research contributes to the development of a seamless and engaging e-commerce platform for furniture retail.

**Keywords:** 3D modeling; SIFT; FLAAN; Augmented reality; Shape Net

### 1. Introduction

The growing demand for immersive and interactive online shopping experiences has spurred research into the use of augmented reality (AR) in furniture portals. Traditional online furniture shopping is limited by the inability of customers to visualize how pieces will look and fit in their own environments, often leading to dissatisfaction and high return rates. Augmented reality in furniture portals aims to address these limitations by allowing users to superimpose 3D representations of furniture into their actual rooms using smartphones or tablets. These portals generate detailed 3D models that can be viewed from multiple angles, providing customers with a realistic sense of how the furniture will appear and fit in their space.

This innovation has the potential to revolutionize online furniture shopping by making it more interactive, realistic, and personalized. By enabling customers to visualize furniture in their own homes, AR can help them make more informed and confident purchasing decisions.

Research into AR-enabled furniture portals is still in its early stages, with current efforts focused on enhancing the accuracy and realism of 3D models and exploring applications beyond the furniture retail industry. Overall, this technology represents a significant advancement in the realm of e-commerce, promising to enhance the shopping experience and customer satisfaction.

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This research aims to create an interactive AR-based furniture portal leveraging machine learning for model detection and mapping. The portal enables customers to visualize furniture pieces in their own spaces, reducing the likelihood of buyer's remorse and enhancing the decision-making process. The growing popularity of AR in e-commerce underscores the potential of this technology to revolutionize the online furniture shopping experience.

Local companies yet to adopt AR technology, creating a gap between consumers and companies. This lack of adoption prevents users from visualizing furniture pieces in their personal spaces, limiting the purchasing experience and potentially resulting in incorrect choices. Therefore, it is essential for local companies to embrace AR technology to enhance consumer experience and create new business opportunities.

The objectives of this research include:

- Enabling customers to visualize furniture through AR technology.
- Providing a cost-free platform for sellers to start their online business.
- Enhancing company sales performance with online tools like AR and pricing tools.
- Offering customers the same service level as in a physical store.
- Assisting customers in quickly locating the right item using smart search and filters.

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## 2. Literature Reviews

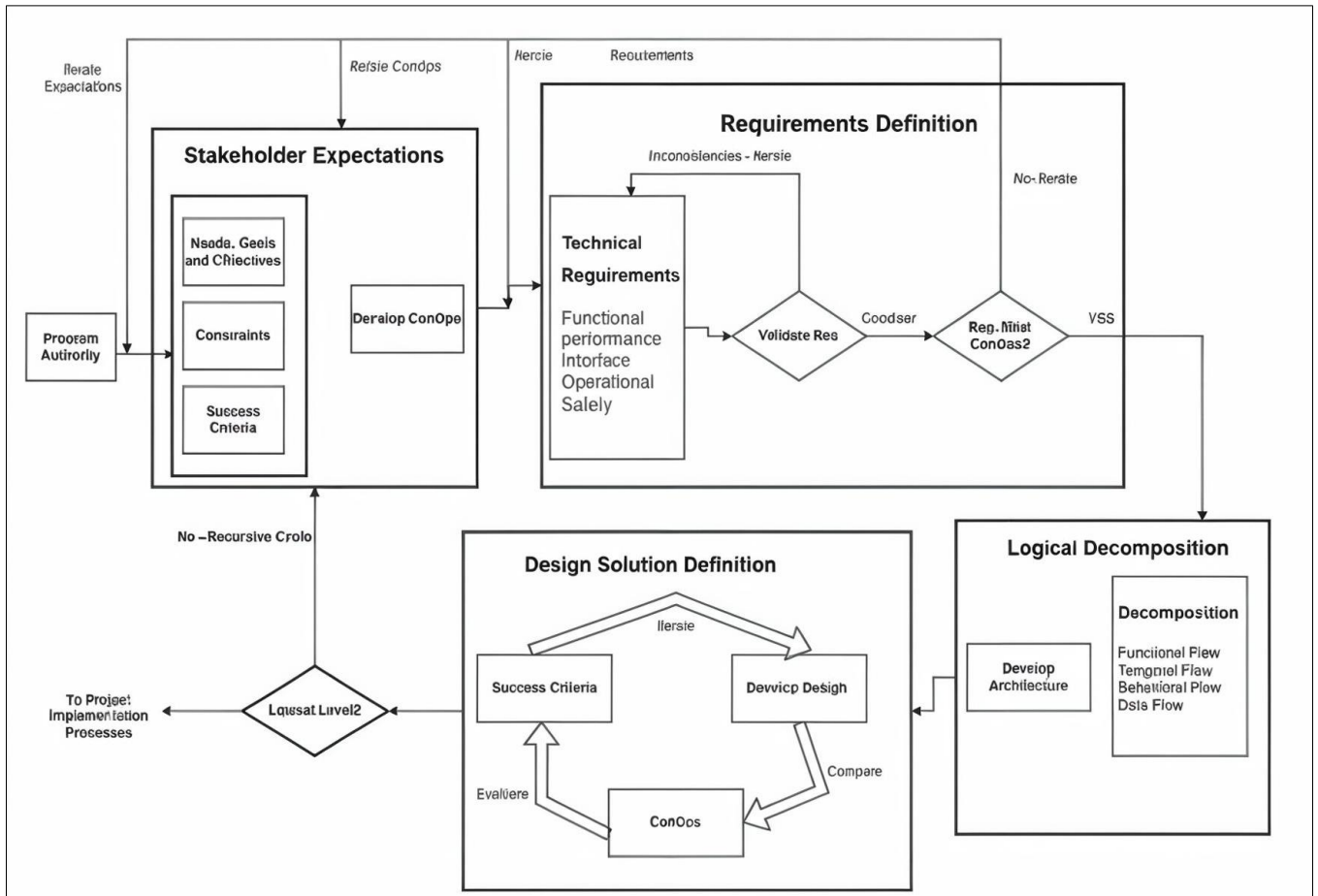
Developing countries can significantly increase financial resources by integrating e-commerce into their business strategies. According to Ohidujja Man et al. [2], "E-commerce is a revolution turning point in online business practices and can make a huge contribution to the economy." AR is poised to play a crucial role in enhancing the online purchasing experience by enabling real-time fusion of PC-created material with live visual display [7]. AR marketing integrates computerized data into the subject's perception of the actual world, enhancing the online shopping experience [1]. The market value of AR has seen a substantial increase, with expectations to generate significant revenue by 2020 [8]. Chatbots designed for e-commerce, incorporating Deep Learning techniques, offer customer care by providing information about product catalogs and the purchase process [6]. Previous studies have explored using AR and machine learning to optimize manufacturing processes and products [3]. According to Alpana Chand, "General operations including artificial intelligence will continue in the manufacturing sector to help produce the data required for improving production processes" [4]. This research leverages the SIFT and FLANN algorithms for 3D model generation, enabling the identification of targeted items from input images through feature extraction and matching.

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## 3. Implementation

### 3.1. System Design Processes

The system design involves understanding stakeholder expectations, defining needs and objectives, and developing a concept of operations. The design process includes identifying inputs, process activities, and outputs to ensure the portal meets the requirements of all stakeholders.



**Figure 1** System Design Process

### 3.2. Technical Requirements

The technical requirements for the portal include developing a user-friendly interface, integrating a pricing tool, and ensuring accurate 3D model generation. The portal is designed to be responsive, reliable, and scalable, providing a seamless experience for users.

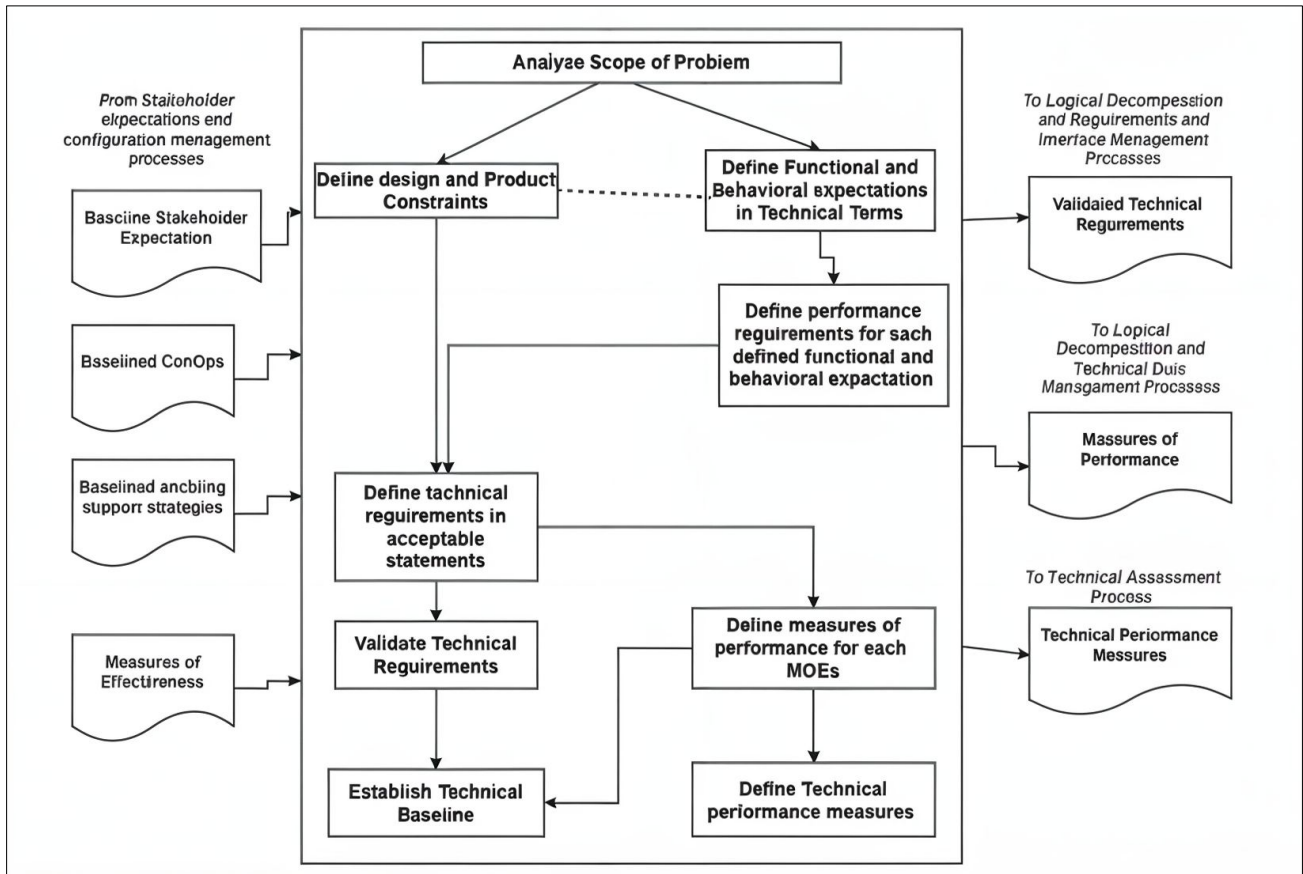


Figure 2 Technical Requirements

### 3.3. Data Collection and Analysis

The dataset used for this project is obtained from ShapeNet, containing over 55,000 3D models of various furniture items. The models are annotated with fine-grained semantic details, enabling accurate feature extraction and matching. The size of the dataset is 25 GB, ensuring comprehensive training for the machine learning algorithms.

### 3.4. Machine Learning Model

The machine learning model is trained using SIFT and FLANN algorithms. SIFT is used for feature extraction, while FLANN matches local features between the query and reference images. The model undergoes extensive training with 1000 epochs to ensure high accuracy in 3D model generation.

### 3.5. Augmented Reality Integration

The AR technology allows users to visualize furniture in their personal spaces by overlaying 3D models onto the real-world environment. This integration enhances the customer experience by providing a realistic preview of the furniture.

## 4. Research Methodology

### 4.1. Research Design

The research design for this study is a combination of qualitative and quantitative methods, focusing on the development, implementation, and evaluation of an AI-enabled AR-based furniture portal. The study follows a systematic approach, including literature review, system design, data collection, model training, and performance evaluation.

### 4.2. Data Collection

The data for this research was collected from the following sources:

- **ShapeNet Dataset:** This dataset contains over 55,000 3D models of various furniture items, annotated with detailed semantic information. The dataset was used to train the machine learning algorithms for accurate feature extraction and matching.
- **User Feedback:** Surveys and interviews were conducted with potential users, including customers and sellers, to gather insights into their needs, preferences, and expectations regarding the furniture portal.

#### 4.3. System Design and Development

The system design process involved the following steps:

- **Stakeholder Analysis:** Identifying and understanding the needs and expectations of stakeholders, including customers, sellers, and investors.
- **Requirements Definition:** Defining functional and performance requirements based on stakeholder inputs. This includes user interface design, AR integration, and 3D model generation.
- **Concept of Operations:** Developing a detailed operational plan that outlines the system's capabilities, design, and maintenance strategies.
- **Technical Specifications:** Specifying the technical requirements for the system, including hardware, software, and network configurations.

#### 4.4. Machine Learning Model Training

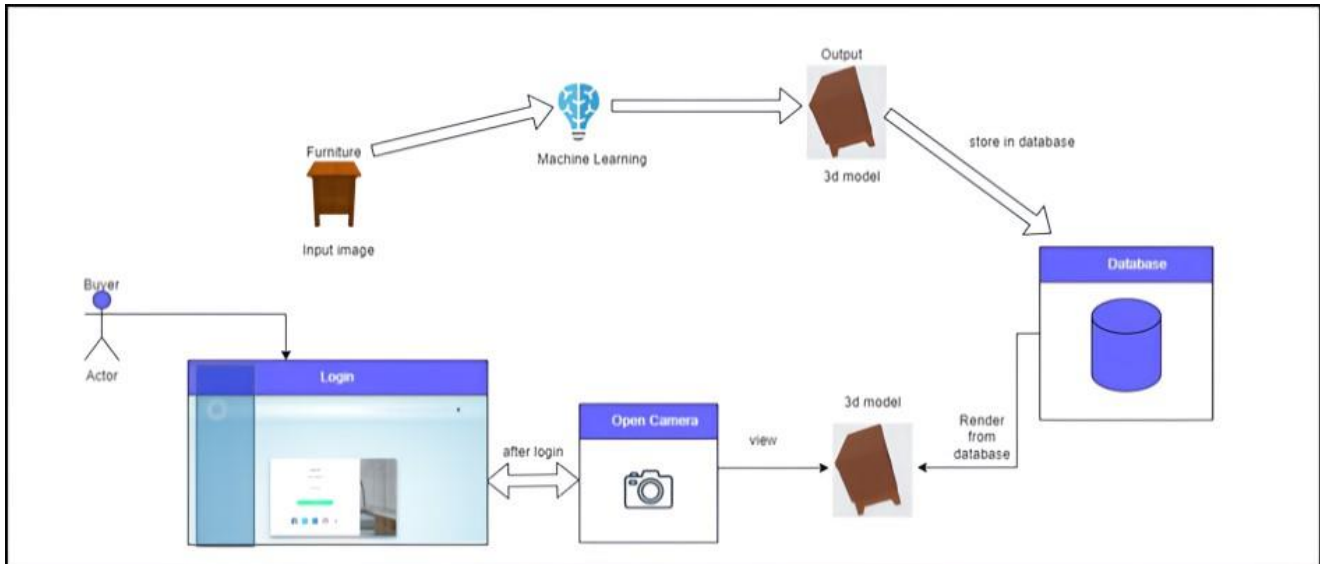
The machine learning model was developed and trained using the following steps:

- **Data Preprocessing:** Cleaning and preparing the data from the ShapeNet dataset for training. This involved normalizing the data, augmenting it with additional features, and splitting it into training and testing sets.
- **Feature Extraction:** Using the Scale-Invariant Feature Transform (SIFT) algorithm to extract key features from the 2D images.
- **Feature Matching:** Implementing the Fast Library for Approximate Nearest Neighbors (FLANN) algorithm to match the extracted features with those in the database.
- **Model Training:** Training the model with the preprocessed data for 1000 epochs to ensure high accuracy in 3D model generation.
- **Model Evaluation:** Evaluating the model's performance using metrics such as accuracy, precision, recall, and F1-score. The model achieved an accuracy rate of 99%.

#### 4.5. Formation of 3D Model

The formation of 3D models was a critical component of the project, involving the following steps:

- **Image Acquisition:** Collecting multiple 2D images of furniture items from various angles to create a comprehensive dataset for training.
- **Feature Detection and Description:** Applying the SIFT algorithm to detect and describe features in the 2D images.
- **Feature Matching:** Using the FLANN algorithm to find correspondences between features in different images.
- **3D Model Construction:** Reconstructing the 3D models from the matched features using point cloud and surface reconstruction techniques. This process involves generating a mesh from the point cloud and applying textures to create realistic models.



**Figure 3** 3D Model Construction

#### 4.6. Augmented Reality Integration

The AR integration process involved the following steps:

- **AR Software Development:** Developing the AR functionality using AR software and tools that allow for real-time overlay of 3D models onto real-world environments.
- **User Interface Design:** Creating a user-friendly interface that allows customers to easily interact with the AR features, including viewing, rotating, and resizing 3D models.
- **System Testing:** Conducting rigorous testing to ensure the AR functionality works seamlessly across different devices and environments.

#### 5. Performance Evaluation

The performance of the furniture portal was evaluated based on the following criteria:

- **User Engagement:** Measuring the level of user interaction and satisfaction with the portal through surveys and usage analytics.
- **System Responsiveness:** Assessing the speed and reliability of the system in delivering AR experiences and processing user requests.
- **Model Accuracy:** Evaluating the accuracy of the machine learning model in generating 3D models from 2D images.
- **Cost-Benefit Analysis:** Analyzing the economic impact of the portal, including cost savings from reduced return rates and increased sales.

#### 6. Testing

The final phase involved implementing the system and conducting comprehensive testing to ensure its functionality and performance. This included:

- **Frontend and Backend Integration:** Ensuring seamless communication between the user interface, AR functionality, and the backend database.
- **User Acceptance Testing (UAT):** Engaging real users to test the system and provide feedback for further improvements.
- **Load Testing:** Assessing the system's performance under heavy user load to ensure scalability and reliability.

## 7. Conclusion

Integrating AR technology into an e-commerce furniture portal offers numerous benefits, including enhanced user experience, increased sales, and streamlined business operations. The research successfully developed a platform that meets stakeholder expectations and provides a unique, interactive shopping experience for customers and sellers.

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## Compliance with ethical standards

### *Disclosure of conflict of interest*

No conflict of interest to be disclosed.

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