FurniSpace

-A world where your dream home is a virtual canvas waiting to be furnished.

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"The true sign of intelligence is not knowledge but imagination."

- Albert Einstein

Abstract

The Furnispace app is a revolutionary mobile application designed to transform the way individuals buy furniture for their homes. By leveraging advanced technologies such as room scanning, dimension measurement, color analysis, and personalized recommendations, Furnispace offers a convenient and streamlined experience for users. With the ability to scan their rooms using their smartphone's camera, users can effortlessly capture room dimensions and visualize furniture placements through augmented reality (AR). The app's color matching algorithms analyze the room's color scheme, providing suggestions for furniture that harmonizes with the existing décor. By incorporating machine learning techniques, Furnispace offers personalized furniture recommendations based on user preferences and browsing history. Users can further customize their furniture selections, choosing from various materials, finishes, and configurations.
This report provides an extensive analysis of the furniture app, covering its features, underlying algorithms, business model, and a comprehensive study to facilitate a deep understanding of the app's functionality and potential impact.

Introduction

AI has opened up a vast realm of possibilities, expanding the horizons of human imagination like never before. It enables us to perform tasks and create things that were previously impossible. By leveraging the power of AI, we can create technologies that make our lives more comfortable, efficient, and convenient. In the home decor industry, AI has revolutionized our ability to imagine and explore new design possibilities. With AI-driven tools and technologies, we can now experiment with different styles, visualize personalized spaces, and transform our living environments into havens that reflect our unique preferences.
The Furnispace app is a prime example of harnessing the potential of AI in the furniture and home decor industry. By bridging the gap between e-commerce and in-store experience, it offers users the ability to virtually place furniture items in their own homes, providing a look and feel of how the products will fit and look within their space. This virtual try-before-you-buy experience allows customers to visualize and assess furniture items in the context of their own homes, considering factors such as size, color, and style. It helps customers make more informed decisions and reduces uncertainty when making online furniture purchases.
Furthermore, the app goes beyond just virtual placement and provides intelligent recommendations based on users' history and preferences. It offers a vast catalog of furniture items, allowing users to browse through a wide range of options. Additionally, Furnispace incorporates visual search technology, enabling users to scan their rooms and find similar furniture items already present in their spaces. This feature enhances convenience and efficiency by simplifying the process of finding matching or complementary furniture pieces.
In a traditionally limited scope industry, Furnispace plays a vital role in broadening possibilities. It empowers customers to break free from the constraints of physical stores and envision their ideal living spaces virtually. The app's intelligent recommendation system

assists users in discovering new furniture pieces that align with their tastes, providing a curated shopping experience. By leveraging the power of AI, Furnispace offers a transformative solution that revolutionizes the way we buy furniture and create personalized spaces, ultimately enhancing our overall quality of life.

Problem statement

In today's fast-paced world, many individuals face challenges when it comes to finding and purchasing furniture that perfectly fits their homes. The process often involves visiting multiple stores, measuring dimensions manually, and struggling to envision how the furniture will look in their space. Additionally, coordinating deliveries and installation services can be time-consuming and cumbersome.
The problem is further compounded by the difficulty of matching furniture to the existing color schemes and styles of a room. Many people struggle to find furniture that compliments their décor and meets their specific requirements.
Therefore, there is a need for a user-friendly mobile application that simplifies the furniture buying process. The app provides an efficient way for users to scan their rooms, automatically measure dimensions, analyze color schemes, contact interior designers, and offer personalized furniture recommendations. It also allows users to customize furniture options and facilitate seamless online transactions. Furnispace employs machine learning techniques to understand users' preferences, previous purchases, and browsing history. By analyzing this data, the app offers personalized furniture recommendations that align with individual styles, preferences, and budgetary considerations. This personalized approach helps users overcome decision paralysis and saves them valuable time in the furniture selection process. By addressing these challenges, the app aims to revolutionize the furniture shopping experience, making it convenient, enjoyable, and stress-free for users.

Market/customer/business need assessment :

<u>Customer need assessment:</u>

- The main purpose of customer need assessment involves understanding the requirements and expectations of the app's target users.The various features to be considered here are:

- Extensive Furniture Catalog:
  To accommodate a wide variety of consumer preferences, the app should have a broad catalog of furniture goods in a range of sizes, styles, and pricing points. Customers will remain interested and promote repeat use if the furniture alternatives are regularly updated in the catalog.

- User Friendly interface:
  To avoid the hassle of in-store shopping, customers expect an intuitive and easy-to-use interface that allows them to browse and search for furniture products effortlessly as well as allowing them to access other prominent features like virtual placement of furniture and recommendation based on likes and history.

- Personalized recommendations:
  Users appreciate personalized recommendations based on their style preferences, browsing history, and previous interactions with the app.
  The app should suggest furniture items that complement the user's existing decor or offer style inspiration to help them discover new furniture options.

- Accurate and Realistic Visualization:
  The app should accurately render the size, scale, texture, and color of furniture to ensure it blends seamlessly with the user's physical environment.
  Users should be able to adjust the scale and position of furniture items easily to achieve an accurate representation of how they would fit in their room.

Market need assessment:

- The global furniture market has been experiencing steady growth in recent years. According to Statista, the global furniture market was valued at around $582 billion in 2020 and is projected to reach over $800 billion by 2025. This indicates a positive growth trajectory for the overall industry.

- The objective of this market need assessment is to evaluate the demand and potential market opportunities for a furniture app that leverages Artificial Intelligence (AI) to enable customers to virtually place furniture in their rooms along with finding similar furniture items as present at their home and receive personalized recommendations which matches their home style

- The market need/ demand for this app is high because it enables users to virtually but precisely visualize how a piece of furniture will appear in their living area and allows them to style it in accordance with their theme without having to take measurements, visit multiple stores, or have a rough sense of style in mind.

- Competitive Advantage:
  In the existing market, apps which integrate ML and AR to give a personalized experience of virtually placing furniture in your room are very less, hence there is a competitive advantage that FurniSpace holds over other Furniture E-commerce apps. The USP is involves compatibility with various room environments, compatibility with various operating systems and multiple brands accessible at one place

- Since the furniture and home decor industry is a narrow space , there is a huge potential of growth for this app along with a huge possibility of user adoption because of users' interest and willingness to adopt a furniture app that offers AI-powered virtual placement at home that can be found out by conducting market research, surveys, or user interviews

Business need assessment:

- Due to the rise of E-commerce platforms for furniture and home decor, especially after COVID-19, the traditional furniture makers and sellers are losing business. Although some amount of the population still prefers to visit physical stores to examine the furniture's quality, test comfort, it is very difficult to visualize how it fits their space, hence more people are turning towards apps which allow a seamless browsing experience.

- These traditional furniture sellers can increase their business by partnering with the FurniSpace app which will increase their customer database and sales

- Risk analysis:
  Technical difficulties might arise while creating and deploying AI algorithms, picture recognition software, and virtual placement technologies. It might be difficult to ensure precise furniture arrangement, cope with varying space circumstances, and manage diverse furniture types and sizes.
  Ensuring compatibility with various devices and operating systems can also be a challenge.

- Benefits: There is a growing need and interest for furniture apps that incorporate Augmented Reality (AR) and ML technology to enable virtual placement of furniture in customers' rooms along with personalized recommendations since users want an effortless experience.

Target Specification:

- App Purpose:

  - Bridge the gap between in store furniture purchase and online furniture browsing.
  - Provide small business furniture sellers with a platform to reach a wider audience beyond their physical store location and help them save cost of a huge physical showroom
  - Enhance user experience by providing an interactive environment of adjusting the furniture in their home frame virtually and select relevant styles and colors, minimizing the risk of making unsuitable purchases.
  - Increase purchase confidence and reduce returns by minimizing the risk of making unsuitable purchases.

- Increase sales conversion and differentiate from competitors by incorporating AR and AI technologies for virtual room placement and personal recommendations
- Allow collaborations between small business furniture sellers and other industry stakeholders such as interior designers or home decor influencers through us.
- The goal is to establish FurniSpace as a go-to platform for furniture shopping and interior design exploration.
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- Target audience:

    - Interior designers who seek furniture options for their projects
    - Home owners/ home dwellers in urban areas who require space efficient furniture options
    - Office and business owners
    - Tech Savvy users
    - Students and dorm room owners

External Search:

1. https://housing.com/news/6-ai-powered-interior-designing-tools-to-decorate-your-home/#:~:text=Smart%20furniture%20placement,-Arranging%20furniture%20in&text=AI%2Dpowered%20tools%20provide%20intelligent,harmonious%20and%20aesthetically%20pleasing%20arrangement.
    - AI is transforming the field of interior design in several ways. Key highlights include:
    - AR and VR: AI enables designers to create immersive 3D renderings using augmented reality (AR) and virtual reality (VR) technologies, helping clients visualize design options in real-time.
    - Virtual assistants: AI-powered virtual assistants provide designers with information on prices, products, and styles, saving time and enhancing productivity.
    - Personalized recommendations: AI analyzes data and generates customized design recommendations based on client preferences, ensuring tailored and satisfying design experiences.
    - Predictive analysis: AI helps interior designers stay ahead of trends by analyzing large datasets and identifying emerging design trends before they become mainstream.
    - Brain-Computer Interfaces (BCI): BCI technology, integrated with AI, allows designers to streamline the design process, generate 3D models, predict customer preferences, and automate manual tasks, boosting creativity and productivity.

2. https://www.matellio.com/blog/augmented-reality-app-like-ikea/
   It explains how AI, ML and AR can be used in Interior Designing Apps. Machine learning algorithms learn User's taste, preferences, requirements and spending capacity and use that information to make personalised recommendations.

   Augmented reality allows users to virtually place objects in a camera scanned room by using AR frameworks like ARKit (iOS) or ARCore (Android) that provide tools and libraries for real-time rendering and display of virtual objects in the camera view. Apply techniques like pose estimation to align the virtual furniture with the physical environment accurately

   Computer Vision can help analyze images and video, detect objects in those and also get suggestions based on those photos. It is used for object detection, image segmentation, feature extraction and camera calibration.

3. https://blog.insightdatascience.com/end-to-end-object-detection-for-furniture-using-deep-learning-45a235f47a9a
   It describes how to build an object detection algorithm using a convolutional neural network-based algorithm called "You Only Look Once" to identify, classify, and localize different types of furniture in images and videos.
   You Only Look Once "YOLO", is a cutting-edge detection algorithm that can identify distinct objects within the space of an image. It looks at the image once, divides it into grid cells, which are responsible for predicting bounding boxes, and outputs a score known as the Intersection Over Union (IOU). For each bounding box, the grid cells also predict a class alongside the probability distribution over all possible classes. The class-specific confidence score is a multiplication of the individual box confidence predictions and the conditional class probabilities.

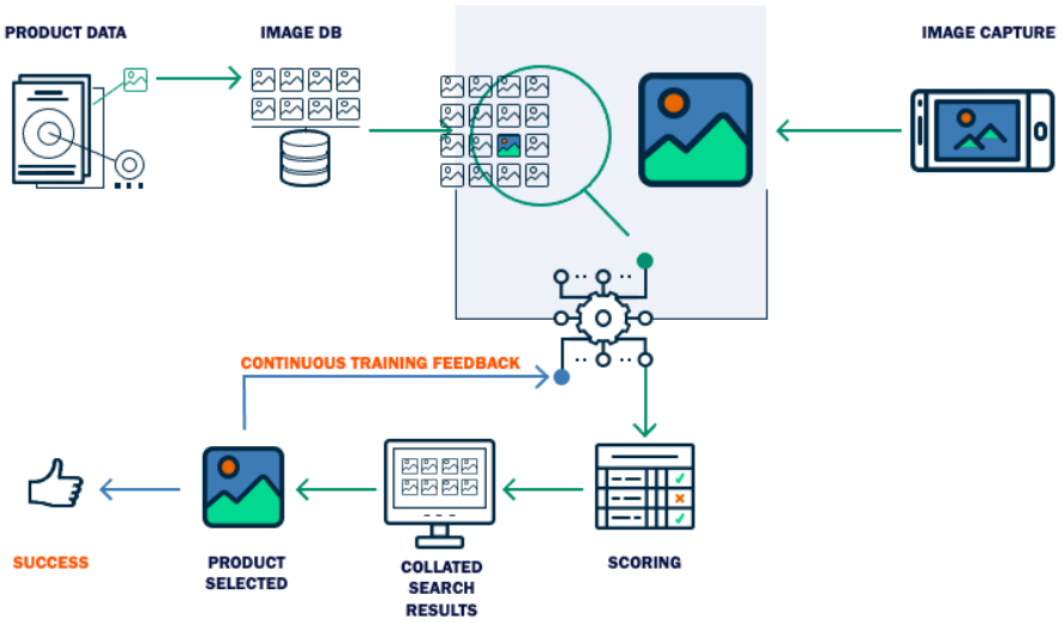
4. https://formafurniture.com/how-ai-is-changing-the-furniture-industry/

   AI is revolutionizing the furniture industry in various ways. Machine learning algorithms analyze consumer data to predict design trends, enabling designers to create furniture that aligns with consumer preferences.
   - Bridging the gap: AI interior design tools assist in finding practical solutions that align with customer requirements by utilizing impressive visualization tools and structural calculations.
   - Customer surveys and recommendations: AI tools can conduct surveys to understand customer preferences and recommend designers who have previously worked on similar designs, ensuring a better match between customers and designers.
   - Precise dimensions and multiple solutions: AI provides designers with exact room dimensions and structures, allowing them to create and explore multiple design solutions before finalizing a particular design.

5. https://www.ideo.com/datascope/building-a-visual-search-algorithm
   It explains the step by step algorithm to build Visual Search using VGG-16 :
   The core concept behind this method of visual search relies on using the intermediate results of a pre-trained CNN as a vector—a list of numbers representing characteristic features of the input image—and finding products that reduce to similar vectors. The logic behind this is that a CNN trained at visual classification typically has two sections: a series of convolutional layers trained at extracting meaningful visual information from the input image and a series of dense layers trained at performing the classification task. Using the output of the convolutional layers to represent images allows us to perform comparisons in a vector space that corresponds to visual attributes as opposed to semantic attributes

6. https://www.earley.com/insights/how-does-visual-search-work#:~:text=Visual%20search%20allows%20users%20to,shown%20in%20the%20figure%20below.

   Mentions the exact flowchart of how the Visual Search technique works



Benchmarking:

Existing Furniture E-commerce apps involving AI and AR are as follows:

1. IKEA Place:
   Features: Virtual Placement of furniture, Save the scanned places, visual search, accurate AR rendering.
   Areas of improvement:Slow loading of the home page, Slow room scanning, brand exclusive, no premium features.
2. Houzz: Trending designs, discussions , Stories, latest designs, get connected with designers

3. Homestyler: Daily challenges with a given theme to decorate a room with virtual furniture.

These existing furniture apps, such as IKEA Place, Houzz, and Wayfair, can serve as valuable references for developing FurniSpace.
We can observe the user/ customer feedback, app reviews and social communities of these apps to gain more insights about the areas of improvement for these apps and bridge those gaps in FurniSpace.

They provide a wealth of insights into user-friendly interfaces, extensive furniture catalogs, augmented reality (AR) technology, and visual search capabilities. By studying these apps, we can gain inspiration for creating a clean and intuitive interface, curating a diverse selection of furniture items, implementing accurate AR placement, and leveraging image recognition algorithms for visual search.

Applicable patents:

A thorough study of applicable patents is required to avoid infringement, assess patentability, identify licensing opportunities, gather business intelligence, and make informed decisions in technology or product development. It helps in understanding existing patents, avoiding legal risks, and leveraging opportunities for innovation and protection.
Applicable patents for FurniSpace can be:

- Augmented Reality (AR) Technology: Patents related to AR technology that enables virtual placement of furniture in a real-world environment. This may include patents related to markerless tracking, 3D object recognition, and visualization techniques.
- Image Recognition and Visual Search: Patents related to image recognition algorithms, computer vision technology, and visual search techniques that enable users to search for furniture items based on images or visual features.
- User Interface Design: Patents related to user interface (UI) design that provides a seamless and intuitive experience for virtual furniture placement and browsing the wide catalog. This may include patents related to gesture-based interactions, user experience design, and intuitive navigation.
- Recommendation Systems: Patents related to personalized recommendation algorithms that suggest furniture items based on user preferences, browsing history, or similar user profiles. This may include patents related to collaborative filtering, machine learning, and data analysis.
- Mobile App Development: Patents related to mobile app development techniques, frameworks, or technologies that enhance the performance, security, or user experience of the furniture app. This may include patents related to app architecture, mobile data synchronization, or secure payment processing.

Applicable regulations:

FurniSpace will adhere by all the required regulations, government, environmental , advertising and marketing,International Trade and Customs Regulations: as well as Financial and Payment Regulations such as:

- Data Protection and Privacy: It will ensure compliance with data protection regulations such as the Personal Data Protection Bill, protect user data, obtain appropriate consent, and implement robust security measures to safeguard personal information.
- Consumer Protection: It will Comply with consumer protection laws and regulations, including accurate product descriptions, transparent pricing, clear refund and return policies, and fair advertising practices.
- Intellectual Property: It will respect intellectual property rights, including copyrights and trademarks, and will avoid using copyrighted images or designs without proper authorization.
- Digital Sustainability: It will consider the environmental impact of data storage, transmission, and consumption associated with the app. Encourage digital sustainability practices, such as reducing unnecessary data transfers, optimizing data compression, and promoting responsible digital behavior among users.
- Financial and Payment Regulations:
  It will follow payment gateway regulations and financial transaction compliance and Goods and Services Tax (GST) compliance for sales and taxation.
- International Trade and Customs Regulations:
  Import and export regulations for cross-border transactions and shipments.
- Advertising Standards Council of India (ASCI) Guidelines:
  Advertisements within the app will adhere to ASCI guidelines to ensure fair and responsible advertising practices.

Applicable constraints:

Some of the constraints on FurniSpace app are:

- Space: Incorporating AR rendering and ML algorithms in a furniture app can pose space constraints. Users may require sufficient device storage and high processing power for downloaded AR assets, while older devices may experience performance issues. Physical space limitations must be considered for accurate AR furniture placement.
- Vendor Onboarding and Management: Onboarding multiple vendors onto the app, verifying their credibility, and managing their inventory, pricing, and order fulfillment processes can be challenging.
- Data Standardization: Integrating furniture data from multiple vendors may involve dealing with varying data formats, structures, and quality. Ensuring consistent and standardized data across vendors can be a complex task

- Implementing accurate visual searches which resemble almost accurately the user designs.
- Budget: Implement all resources within a given budget.

Business Model:

- Value proposition: The furniture e-commerce app offers a convenient shopping experience by allowing users to virtually place furniture in their rooms and find desired items through visual search. It provides a wide selection of furniture from multiple trusted vendors, contacts of interior designers and professionals and assured quality. It also includes premium features like trending designs and exclusive collections for users to stay stylish and access unique pieces.
- Free model: The freemium model allows users to experience the core functionalities of the app for free, while offering additional value through premium features that cater to users seeking enhanced customization, exclusive designs, and personalized recommendations. The goal is to attract a larger user base with the free features and convert a portion of them into paying customers who desire the added benefits and customization options provided by the premium features.
- Revenue Streams:
    - Premium subscription model: Provide features like advanced customization options(including a variety of materials, upholstery options, configuration and modular options), exclusive collections, or access to trending interior design and curated collections. with an ability to save them, as premium features. Offer these features through a monthly subscription model or one-time purchases.
    - Vender onboarding and partnership: Charging a one time onboarding fee from the vendor to join the app and taking a small commission on each transaction.
    - Advertising and Promotions: Offer advertising opportunities for vendors to promote their products within the app, charging fees for sponsored listings or featured placements.
    - Affiliate Partnerships: Collaborate with complementary businesses (e.g., interior designers, home decor brands) and earn affiliate commissions for referred sales.
    - Data Analytics: Utilize data collected from virtual placement and visual search interactions to provide insights to vendors for a fee, helping them understand customer preferences and optimize their offerings
- Customer Retention and Engagement: Implement a loyalty program that rewards customers for repeat purchases or referrals, encouraging customer retention and engagement.

Concept generation:

- Identifying the Need: The initial idea for FurniSpace originated from personal experience, the desire to purchase a piece of furniture as a gift to my parents but being unable to visit physical stores due to time constraints/ geographical limitations. Recognizing this need sparked the idea to create a solution that would allow users to virtually visualize furniture in people 's homes before making a purchase.
- Conducting Market Research: To validate the idea and understand the market potential, an intense research phase followed. This involved studying the existing furniture e-commerce apps, landscape, analyzing customer preferences, customer feedback, and identifying gaps or challenges faced by consumers when shopping for furniture online. It also included researching emerging technologies like AR and visual search to explore their application in the furniture industry.
- Understanding User Requirements: The research phase involved gathering insights from potential users through surveys, interviews, and focus groups. This helped identify key requirements and pain points of users, such as the need for a realistic visualization of furniture in their spaces, access to a wide range of furniture options, and customization capabilities..
- Defining Key Features: Based on the research findings, a list of essential features was compiled. This included virtual furniture placement , visual search tech, a diverse catalog of furniture items from multiple vendors, trending designs of the day, advanced customization options, curated collections to cater to various design preferences and creating a social community for users to share their feedback and complaints..

Final Product Prototype:

- User Interface :
    - FurniSpace will have an interactive and vibrant user interface with many animations and a minimalistic theme with pastel color scheme.
    - Navigation menu will be displayed as a hamburger icon for easy access to different sections of the app (Premium features, Contact Interior designers, Profile, Visual search)

- Home Screen:
    - Wide range of furniture items categorized by type, style, and vendor. Filter and sort options will be available to refine search results based on price, material, and other criteria.
    - Navigation menu for easy access to different sections of the app.
    - Product listings with images, descriptions, pricing, and customer reviews.

- Virtual Placement:
    - Activate the AR feature, i.e ‘Virtual Try On’ to place virtual furniture in the user's room using their device's camera.
    - Real-time rendering of furniture items with accurate sizing, positioning, and lighting.
    - Interactive controls to resize, rotate, and move furniture within the room.
- Visual Search:
    - Capture or upload an image to search for similar furniture items within the app's catalog.
    - Search results with visually similar furniture items and options to view details and make a purchase, will be displayed.

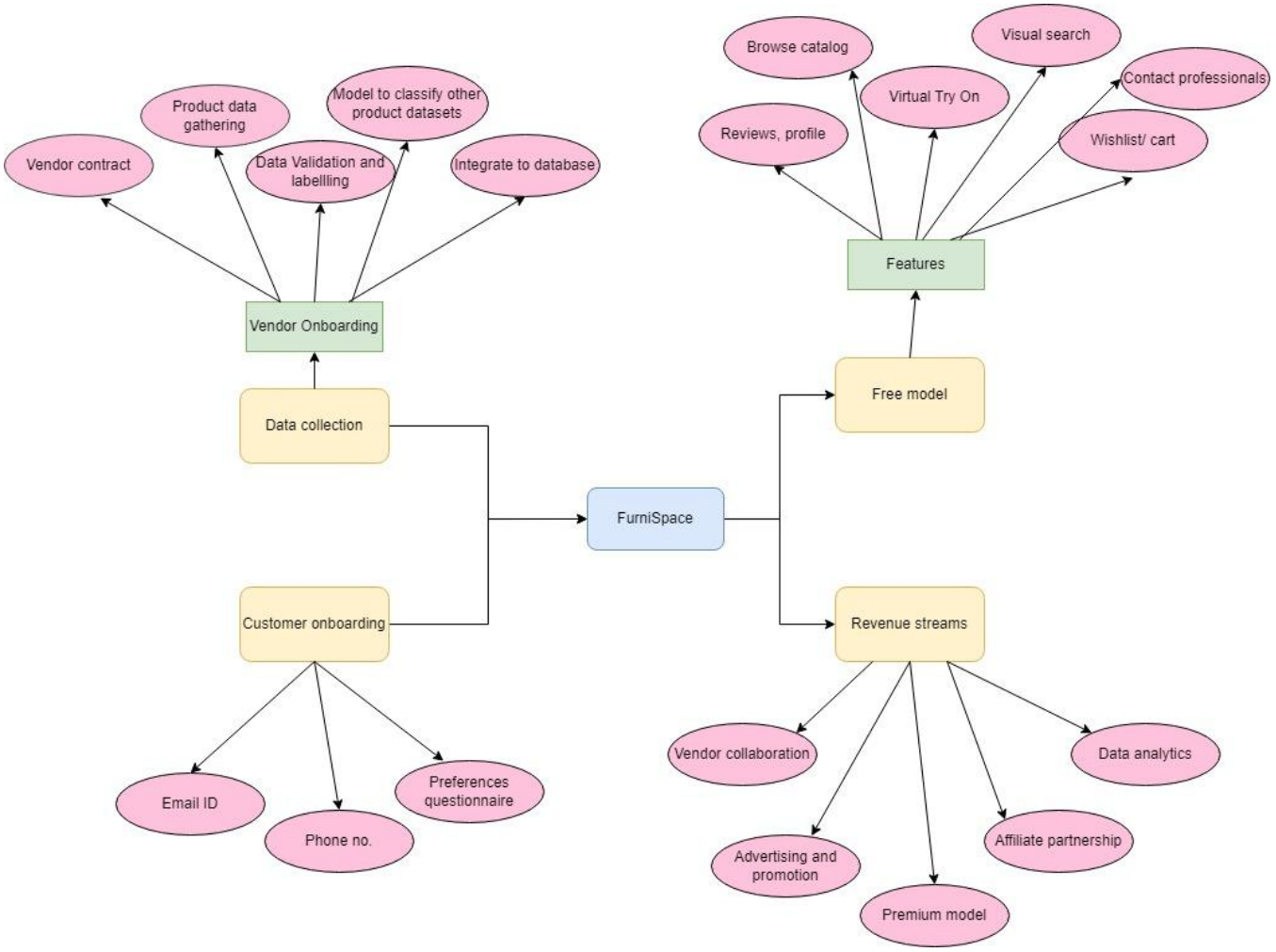
- Local Professionals:
    - A directory of local professionals will be provided, such as interior designers or contractors, who can assist users with furniture selection, customization, or room design.
    - Contact information, portfolios, and customer reviews to help users make informed decisions will be included.

- Customer Reviews:
    - Users can leave reviews and ratings for purchased furniture items.
    - Display average ratings and customer feedback on product listings to guide other users' purchasing decisions.

- Premium Features:
    - Showcase customization options for furniture items, such as choosing materials, colors, finishes, or dimensions.
    - Access to trending designs and curated collections not available to regular app users.

- Profile:
    - Access to saved collections, wishlist and personal carts.
    - View user reward points collected under the loyalty program.
    - Personalized recommendations based on past history and items in the wishlist.
    - View Saved images of Virtual Try On section.
    - Secure payment gateway for In- App purchases.

Schematic Diagram:



Product Details:

Customer Onboarding: Furnispace starts with customer registration through Phone number or email, post which they can take an optional questionnaire about their choice of furniture, room setting, colors etc, which would help the machine learning algorithms provide better recommendations.
The data of each user is stored in a User Database at the back-end with a unique reference ID as the primary key.

Product data collection:

- Onboard the vendors to the app by signing agreements and verifying vendor credentials
- Gather data from vendors such as item descriptions, specifications, images, pricing, availability, SKU numbers, and other relevant details. Apply web scraping techniques for the same using Python libraries like BeautifulSoup, Scrapy etc.

- Validate the data and clean it by performing EDA using python, then label the data by assigning relevant attributes and tags to each product, such as style, material, dimensions, color, and brand.
- Use this labeled dataset to create a model to classify other furniture datasets from different vendors. This classification can be done by ML algorithms such as decision Trees or random forests .
- Once the ML model is trained and validated, we use it to classify and tag the remaining uncategorized products in your dataset. The model will predict the relevant tags or categories (style, material, color, etc.) based on the extracted features.
- Enhance the product data by adding additional relevant information such as customer reviews, ratings, recommendations, and related items
- Integrate the standardized product data into the app's backend database.

Algorithms and frameworks used:

Algorithms:

- Image normalization and enhancement
- Object detection: YOLO(by using CNN architecture)
- Pose estimation: RANSAC or Perspective-n-Point (PnP), to estimate the 3D pose of the furniture objects.
- Image segmentation
- FeatureExtraction: VGG-16 CNN model to extract features, obtain a feature vector of each product and store it in the database. When a new image query occurs for visual search, obtain the feature vector of the image and calculate the similarity, retrieve the top-K most similar products based on the calculated similarities.
- Simultaneous Localization and Mapping (SLAM): (For virtual furniture rendering in a room)
- Feature-Based Registration with SIFT (For virtual furniture rendering in a room)
- Hybrid filtering for recommendations
- Decision trees/ neural network (For the trending designs section)

Frameworks and libraries:

- Open pose
- Scikit-learn
- MATLAB
- ARKit (iOS)
- ARCore (Android)
- Open CV
- YOLO v3
- TensorFlow, PyTorch
- Keras
- OpenSLAM
- NLTK
- NumPy, Pandas, Matplotlib

Development frameworks:

- Flask or Django
- Database management systems: MySQL

Conclusion:

In conclusion, the furniture e-commerce app incorporating AI, ML, and AR is a revolutionary solution that harnesses the power of technology to benefit individuals and society as a whole. It exemplifies the vast potential of AI in addressing real-world needs and enhancing various industries. The app revolutionizes the way people shop for furniture, providing a convenient experience.

The extensive market and customer need assessment demonstrate the immense growth potential of this app within the booming furniture industry. As the demand for online furniture shopping continues to rise, the app addresses the evolving needs of customers by providing a seamless virtual placement experience, visual search capabilities, contacts of local professionals such as interior designers, and personalized recommendations.

However, it is crucial to acknowledge and address the constraints and challenges that arise during the development process. These include the need for data standardization from multiple vendors and the potential space limitations of AR rendering and ML algorithms. By focusing on efficient data management, robust algorithms, and optimizing space utilization, the app can overcome these constraints and deliver a superior user experience.

By leveraging the capabilities of AI, ML, and AR, this app transforms the traditional furniture shopping experience into an immersive and efficient process. It not only empowers individuals to make informed decisions but also supports the growth of small business furniture sellers by expanding their reach and customer base.

Moreover, this app aligns with the sustainability goals of our society. By reducing the need for physical showroom visits, it minimizes travel and associated carbon emissions. Additionally, it promotes responsible consumption by enabling users to make confident choices, reducing the likelihood of returns and unnecessary waste.

In a world where AI has the potential to achieve remarkable advancements, this furniture app stands as a prime example of technology-driven innovation. By understanding and meeting customer needs, addressing market opportunities, and mitigating constraints, the app can unlock substantial growth and contribute to a more sustainable and technologically advanced society.