ShopMart: AI-Powered E-Commerce Recommendation System

Problem Statement

Overview

ShopMart is a mobile-compatible e-commerce platform connecting buyers and sellers.
Features an AI-powered recommendation system for personalized shopping experiences.

Key Features

- AI-Driven Personalization: Collaborative Filtering, Content-Based Filtering, and Context-Aware Recommendations.
- User Engagement: Loyalty programs, personalized discounts, and multi-role dashboards.
- Smart Shopping: Real-time analytics, visual search, and AI chatbot support.

Impact

Bridging the gap between buyers and sellers with AI-driven intelligence.

Idea

Concept

An AI-powered, data-driven marketplace for seamless e-commerce interactions.
Enhances customer experience through smart product recommendations and engagement strategies.

How It Solves the Problem

- AI-based recommendations reduce product overload.
- Loyalty programs and discounts drive repeat purchases.
- Chatbot and visual search simplify product discovery.

Innovation & Distinctiveness

- Hybrid Recommendation System: TF-IDF, Apriori, and Collaborative Filtering.
- AI Chatbot (DeepSeekAI): Smart customer support and product queries.
- Reinforcement Learning: Optimizing loyalty program rewards.

Prototype & Future Scope

- Built with React.js and Express.js, ensuring a clean UI.
- Future enhancements: Multi-language support, NLP-based product searches, and advanced analytics.

Key Highlights

- AI-powered personalized shopping experience.
- Efficient and scalable system architecture.
- Seamless user experience across all devices.

Technical Approach

Dataset Creation

- Web Scraping: Extracted data from Amazon and Flipkart (product descriptions, images, prices, reviews).
- Data Cleaning and Structuring: Removing duplicates, handling missing values, standardizing categories.

Recommendation System

User-Focused Recommendations (Personalized Shopping Experience)

A Hybrid Recommendation Model was implemented, combining:

- Collaborative Filtering – Suggests products based on user behavior, past interactions, and similar user preferences.
- Content-Based Filtering – Recommends products similar to those previously viewed or purchased by the user.

How it Works:

- Tracks purchase history, click patterns, and browsing behavior to personalize recommendations.
- Uses TF-IDF (Term Frequency-Inverse Document Frequency) to extract important product features.
- Implements real-time filtering and adaptive learning for more relevant suggestions.

Seller-Focused Recommendations (Sales Insights & Strategies)

For Companies and Sellers, the recommendation system provides market-driven insights:

- Product Performance Analysis – Identifies which products are selling well vs. underperforming.
- Sales Optimization Strategies – Suggests promotional techniques and targeted discounts to boost sales.
- Demand Forecasting – Predicts future demand based on historical sales and trends.

How it Works:

- Analyzes sales trends, seasonal demand, and competitor pricing to recommend actions.
- Uses the Apriori Algorithm to identify frequently bought-together product combinations.
- Recommends marketing strategies such as bundling, flash sales, or targeted ads.

Admin-Focused Recommendations (Profit & Business Insights)

For Admins, the system focuses on maximizing profitability and operational efficiency:

- Company Performance Analysis – Identifies which sellers contribute the most to platform revenue.
- Strategic Decision-Making – Recommends partnerships, advertising investments, and platform improvements.
- Fraud Detection and Risk Management – Flags unusual seller behavior or potential violations.

How it Works:

- Aggregates seller performance metrics to highlight top-performing brands.
- Uses predictive analytics to forecast platform-wide sales growth.
- Suggests investment areas for increasing platform engagement and profitability.

Implementing Visual Search for Users

Training a Deep Learning Model (Feature Extraction using ResNet-50)

- Used ResNet-50, a deep convolutional neural network, to train on product images from the dataset.
- The model extracts high-level features from images (such as shapes, colors, textures, and patterns).
- The extracted features are stored in a feature vector database for efficient retrieval.

Query Image Processing

- When a user uploads an image, the system preprocesses it (resizing, normalization, etc.).
- The image is passed through the pre-trained ResNet-50 model, which extracts its feature vector.
- The system then compares this feature vector with the stored feature vectors in the database.

Finding the Best Matches

- A Nearest Neighbor Search Algorithm (cosine similarity) is used to find the most similar images in the database.
- The system retrieves the top N visually similar products and displays them to the user.
- Each result includes product details like price, rating, reviews, and availability.

Developing the Loyalty Program

User Engagement and Challenges

Users earn loyalty points by performing actions like:

- Making a purchase
- Writing a product review
- Referring a friend
- Completing engagement challenges (e.g., daily check-ins, exploring new categories)

Q-Learning for Reward Optimization

The system dynamically learns which engagement actions should be rewarded more to maximize long-term user retention.
It does this using Q-Learning, a Reinforcement Learning technique where a Q-value (state-action value) is updated every time a user interacts with the system.

Q-Learning Formula:
$Q(s, a) = Q(s, a) + \alpha \times [R + \gamma \times \max Q(s', a') - Q(s, a)]$

Where:

- $Q(s, a)$ = Q-value for a given state (user engagement level) and action (interaction type).
- α (Learning Rate) = Determines how much new experiences override past knowledge.
- R (Reward) = The points given based on user interaction.
- γ (Discount Factor) = Determines the importance of future rewards.
- $\max Q(s', a')$ = The highest expected future reward from the next state.

Reward Adjustments and Learning from User Behavior

- Every time a user completes an action, the system updates the Q-value based on the reward received.
- If an action leads to higher engagement (e.g., repeat purchases), the reward for that action is increased over time.
- If an action fails to drive engagement, the system reduces its reward value, optimizing the loyalty program dynamically.

User Redeems Rewards

Earned points can be redeemed for:

- Discounts on purchases
- Exclusive deals
- Entry into premium membership tiers

Step 5: Building the AI Chatbot for Customer Support & Product Inquiries

1. Choosing DeepSeek-R1 as the AI Model

We used the DeepSeek-R1 model, a locally deployed Large Language Model (LLM), to efficiently handle user queries. DeepSeek-R1 was fine-tuned specifically for ShopMart to ensure it retrieves accurate product information and provides relevant recommendations.

2. Fine-Tuning with Custom Instructions

The chatbot was fine-tuned using prompt engineering to:

- Understand user queries related to products, orders, and recommendations.
- Retrieve real-time product details from the dataset before answering.
- Provide clear, concise, and engaging responses.
- Offer context-aware assistance rather than generic responses.

We trained it using a question-answer dataset containing frequently asked queries about:

- Product availability, pricing, and specifications.
- Order tracking and return policies.
- Recommendations based on user preferences.

3. Handling User Queries & Dataset Integration

When a user asks a product-related question, the chatbot:

- First checks the dataset (product database).
- Retrieves relevant product details such as price, stock availability, and reviews.

- Generates a response based on the dataset, ensuring accuracy.

Example query flow:
User: "Tell me about the iPhone 15?"

Chatbot Workflow:

- Extracts "iPhone 15" from the query.
- Searches the product dataset for matching details.
- Returns: "The iPhone 15 is available for $999 with a 4.8-star rating. It comes in Black, Blue, and White. Would you like to see similar options?"

4. Improving Response Quality with Context-Awareness

The chatbot maintains session memory to understand follow-up questions.

Example of context-awareness:
User: "How much does the iPhone 15 cost?"
Chatbot: "The iPhone 15 is available for $999."
User: "Does it have a good camera?"
Chatbot: "Yes, the iPhone 15 features a 48MP main camera with improved low-light performance."

This prevents the chatbot from treating every question as an isolated query, making interactions more natural and engaging.

Implementing Elastic Search for User Response Tracking

- Used Elastic Search to efficiently store and retrieve user interactions and responses.
- Enabled real-time tracking of user preferences and activity to enhance personalization.

Integration with Frontend and Deployment

- Combined all components into a seamless frontend experience using React.js.
- Connected the backend (Express.js) with the machine learning models, database, and Elastic Search.
- Conducted testing and optimization to ensure performance, scalability, and user-friendliness.

Feasibility and Viability

Scalability

- Supports large product databases and real-time user interactions.
- Uses efficient ML algorithms that scale with data growth.

Cost-Effectiveness

- Uses open-source tools and frameworks (React.js, Express.js, PostgreSQL, Elastic Search).
- Optimized for performance with minimal infrastructure costs.

Security and Compliance

- Ethical web scraping practices followed with public APIs where possible.
- PostgreSQL ensures secure and structured data storage.

User Accessibility

- Mobile-optimized UI for seamless cross-device experience.
- Multi-language support to enable a global user base.

Impact and Benefits of Each Technical Approach

Each component of ShopMart's AI-powered system enhances user experience, optimizes business operations, and improves decision-making. Here's how each technical approach impacts users, businesses, and the market:

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1. Web Scraping & Dataset Creation

Impact:

- Enables the creation of a rich product dataset with real-world data.
- Provides an accurate and updated database for recommendations and search.
- Ensures product diversity by sourcing data from multiple platforms like Amazon and Flipkart.

Benefits:

For Users: Access to a wide range of products with updated details.
For Businesses: Insights into competitor pricing and product trends.
For the Market: Standardized and structured data for AI-driven decisions.

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2. AI-Powered Recommendation System (Hybrid Model)

Impact:

- Provides personalized shopping experiences using collaborative and content-based filtering.
- Helps businesses optimize product placements and sales strategies.
- Assists the admin in monitoring marketplace performance and profit analysis.

Benefits:

For Users:

- Personalized shopping suggestions reduce choice overload.
- Recommends best-rated, trending, and relevant products.

For Businesses:

- Increases sales and customer retention through data-driven insights.
- Provides predictive analytics on market trends.

For Admins:

- Identifies high-performing brands and products for platform growth.

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3. Visual Search for Users (ResNet50-based Image Recognition)

Impact:

- Transforms how users shop by allowing image-based product searches.
- Reduces dependency on keyword-based search, improving accessibility.

- Boosts engagement and conversion rates by offering a more intuitive shopping experience.

Benefits:

For Users:

- Instantly find similar products by uploading images.
- Eliminates the effort of typing product names or descriptions.

For Businesses:

- Encourages impulse purchases by making discovery easier.
- Increases customer retention by enhancing the shopping experience.

For the Market:

- Sets new industry standards for AI-driven visual search in e-commerce.

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4. Reinforcement Learning-Based Loyalty Program (Q-Learning)

Impact:

- Adapts dynamically based on user behavior, increasing engagement.
- Encourages repeat purchases by offering personalized rewards.
- Optimizes platform-wide retention strategies through reinforcement learning-driven reward adjustments.

Benefits:

For Users:

- Earns bonus points and rewards based on engagement.
- Encourages long-term interaction with the platform.

For Businesses:

- Retains customers by incentivizing purchases.
- Helps brands tailor promotions for maximum impact.

For Admins:

- Provides data-driven insights into what drives user engagement.

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5. AI Chatbot for Customer Support & Product Inquiries (DeepSeek-R1)

Impact:

- Provides real-time responses to customer queries.
- Enhances user experience by offering context-aware, conversational support.
- Reduces human dependency for routine support queries, saving operational costs.

Benefits:

For Users:

- Get instant answers about products, orders, and recommendations.
- Offers a human-like, interactive shopping assistant.

For Businesses:

- Reduces customer service costs by handling inquiries automatically.
- Improves customer satisfaction with quick, accurate responses.

For Admins:

- Provides valuable insights on customer concerns and preferences.

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6. Elasticsearch for User Interaction Tracking

Impact:

- Enables real-time logging and retrieval of user interactions.
- Helps businesses understand user behavior trends and optimize recommendations.
- Improves platform efficiency by tracking engagement metrics.

Benefits:

For Users:

- Ensures faster and more relevant product suggestions.

- Improves search performance and response time.

For Businesses:

- Provides valuable analytics on how users interact with products.
- Helps optimize marketing strategies based on user behavior.

For Admins:

- Enables real-time decision-making with instant data retrieval.

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7. Full-Stack Integration of AI Models into the Platform

Impact:

- Ensures seamless performance across all AI-powered features.
- Provides a unified experience for users, businesses, and admins.
- Enhances platform scalability and efficiency.

Benefits:

For Users:

- Smooth, uninterrupted shopping experience.
- Access to AI-driven features (recommendations, chatbot, visual search, loyalty program, etc.) in one place.

For Businesses:

- Easier model deployment for sales optimization.
- Unified analytics for better business decisions.

For Admins:

- Centralized monitoring of all AI-powered operations.

Tech Stack

- Frontend: React.js
- Backend: Express.js
- Database: PostgreSQL

- Logging and Retrieval: Elastic Search
- Machine Learning: TF-IDF, Apriori, Reinforcement Learning,Deep Learning(ResNet50)
- AI Assistance: DeepSeek-r1

Future Enhancements

- NLP-based search and voice queries
- Multi-language support
- More detailed analytics and dashboards