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Artificial Intelligence In E-Commerce: A Review Of Personalization, Dynamic Pricing, Visual Search, Fraud Detection And Agentic Commerce

Shelot Raj Satish Prof. S. R. Borhade Prof. M. C. Kolse Prof. S. K. Said
Department of Artificial Intelligence and Data Science
Jaihind College of Engineering
Pune, Maharashtra, India

Abstract—Artificial intelligence is transforming e-commerce by changing how businesses attract, engage and retain customers. This paper reviews AI applications across the e-commerce value chain. It examines personalized recommendation, from item-to-item collaborative filtering to deep click-through-rate models that capture changing user interests; dynamic and algorithmic pricing and its effects on marketplaces; demand forecasting and price optimization for inventory planning; visual and voice search; conversational chatbots and assistants for customer support; and fraud detection on payments and accounts. Using machine learning, natural language processing and computer vision, these technologies analyse customer behaviour and transactions in real time, increasing conversion, order value and satisfaction while reducing operational cost and losses. The paper also discusses emerging trends such as generative AI for product content, conversational commerce, hyper-personalization and autonomous shopping agents. A five-layer e-commerce AI architecture comprising data, customer intelligence, decision, engagement and trust layers is proposed, along with research gaps, objectives, a comparison of applications and challenges including privacy, algorithmic bias, transparency, implementation cost and skills. The review concludes that long-term success depends on responsible and transparent AI that protects consumer trust.

Index Terms—E-commerce, artificial intelligence, recommendation systems, dynamic pricing, visual search, fraud detection, chatbots, personalization

I. INTRODUCTION

Every click, search and purchase on an online store generates data. Large platforms use this data to decide which products to show, at what price and when to send an offer. Smith and Linden [1] reported how recommendations became central to Amazon's business over two decades, and smaller retailers now access similar capabilities through cloud AI services.

AI in e-commerce extends beyond recommendations. It sets prices, forecasts demand, answers customer queries, finds products from photos and blocks fraudulent orders. These capabilities raise efficiency but also raise concerns about privacy, manipulation and fairness.

This paper reviews AI applications across the e-commerce value chain and proposes an architecture that includes a trust layer.

II. BACKGROUND AND FUNDAMENTAL CONCEPTS

1. E-Commerce Value Chain

Fig. 1 maps AI applications onto the customer journey: discovery, decision, purchase and post-purchase, with back-end operations supporting each stage.

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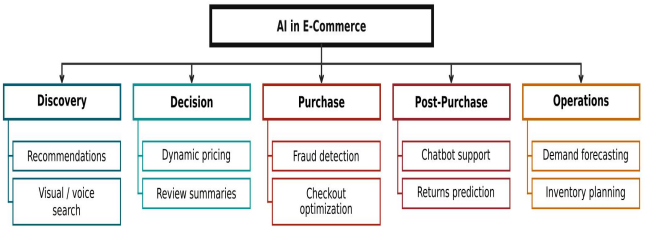


Fig. 1. AI applications across the e-commerce customer journey.

2. Key Metrics

Conversion rate, average order value, customer lifetime value, return rate and fraud loss are common measures of AI impact.

III. LITERATURE SURVEY

Recommendation. Linden *et al.* [2] described item-to-item collaborative filtering that scales to millions of products. Cheng *et al.* [3] combined memorization and generalization in Wide & Deep models, and Zhou *et al.* [4] proposed the Deep Interest Network, which uses attention over a user's behaviour history to predict click-through rates for each candidate ad or product.

Pricing and forecasting. Chen *et al.* [5] empirically analysed algorithmic pricing on a large marketplace and found that sellers using algorithms changed prices frequently and won the buy box more often. Ferreira *et al.* [6] combined machine learning demand forecasting with price optimization for an online retailer and reported increased revenue. DeepAR [7] forecasts demand probabilistically across many products.

Visual search. Yang *et al.* [8] described a visual search system at eBay that lets shoppers find items by uploading photos.

Fraud detection. Dal Pozzolo *et al.* [9] addressed class imbalance in card fraud detection, and Carcillo *et al.* [10] combined unsupervised and supervised learning to improve fraud detection. Table I summarizes these works.

Sr. No.	Ref.	Year	Methodology	Findings	Research Gap
1	[2]	2003	Item-to-item CF	Scalable recommendations	Popularity bias
2	[9]	2015	Imbalanced fraud learning	Calibrated undersampling	Card data only
3	[6]	2016	Forecasting + price optimization	Revenue increase	Single retailer
4	[5]	2016	Algorithmic pricing study	Frequent repricing effects	One marketplace
5	[3]	2016	Wide & Deep	Memorization + generalization	Feature engineering
6	[8]	2017	Visual search	Search by photo at scale	Image quality varies
7	[4]	2018	Deep Interest Network	Attention over behaviour	Short-term focus
8	[10]	2021	Hybrid fraud detection	Improved detection	Feature design

TABLE I Summary of Literature Survey

IV. RESEARCH GAP

- **G1:** Personalization can create filter bubbles and reduce product diversity.
- **G2:** Dynamic pricing may be perceived as unfair or discriminatory.
- **G3:** Small sellers lack data and expertise to use advanced AI.
- **G4:** Chatbots still fail on complex queries and in regional languages.
- **G5:** Generative product content may contain inaccurate claims.

V. OBJECTIVES

- **O1:** To review AI applications across the e-commerce value chain.
- **O2:** To examine recommendation, pricing, search, support and fraud systems.
- **O3:** To discuss emerging trends such as generative and agentic commerce.
- **O4:** To propose a five-layer e-commerce AI architecture with a trust layer.
- **O5:** To identify challenges and responsible-use practices.

VI. PROPOSED SYSTEM ARCHITECTURE

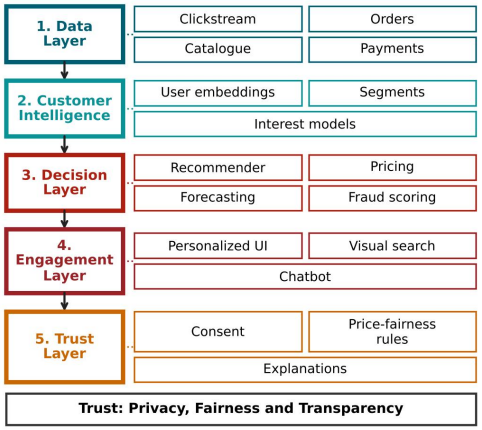


Fig. 2 shows the proposed architecture.

Fig. 2. Proposed five-layer e-commerce AI architecture.

- **1. Data Layer**
- Clickstreams, orders, catalogue data, reviews, images and payment events are collected with consent.
- **2. Customer Intelligence Layer**
- Embeddings and segments represent customers and products; behaviour models capture changing interests.
- **3. Decision Layer**
- Recommendation, pricing, demand forecasting and fraud scoring models make real-time decisions.
- **4. Engagement Layer**
- Personalized home pages, visual and voice search, chatbots and generated product descriptions serve customers.
- **5. Trust Layer**
- Privacy controls, price-fairness rules, explanations ("recommended because you viewed…") and human review of generated content protect consumers.

VII. METHODOLOGY AND WORKING

Fig. 3 describes a personalized session. The click-through probability of product i for user u is predicted as

$$p(click \mid u, i) = \sigma(f_\theta(e_u, e_i, context)) \quad (1)$$

and products are ranked by expected value, for example p · margin, subject to diversity and fairness constraints. Recommendation quality is evaluated offline with metrics such as NDCG and online with A/B tests.

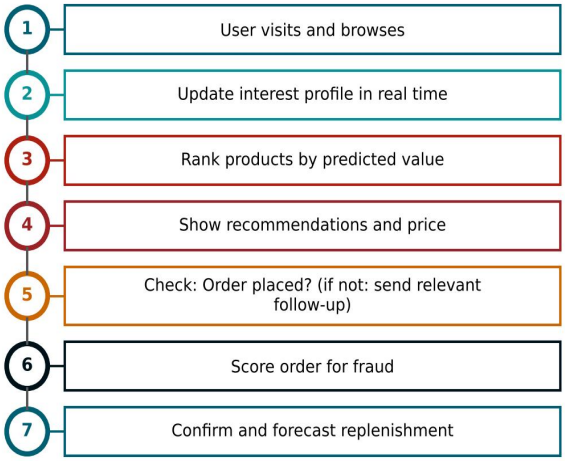


Fig. 3. Personalized shopping session workflow.

VIII. COMPARATIVE ANALYSIS

Table II compares e-commerce AI applications by main technique, business benefit and key risk.

Application	Technique	Benefit	Key Risk
Recommendation	CF / deep CTR	Higher conversion	Filter bubbles
Dynamic pricing	Demand models / RL	Revenue	Perceived unfairness

Application	Technique	Benefit	Key Risk
Visual search	CNN embeddings	Easier discovery	Privacy of photos
Chatbots	NLP / LLMs	24×7 support	Wrong answers
Fraud detection	GBM / anomaly	Lower losses	False declines

TABLE II Comparison of E-Commerce AI Applications

IX. CHALLENGES AND FUTURE SCOPE

Table III summarizes challenges. Future directions include shopping agents that compare and purchase on behalf of users, multilingual voice commerce for Indian markets, AR try-on and sustainable logistics optimization.

Challenge	Mitigation
Data privacy	Consent; data minimization (DPDP Act)
Algorithmic bias	Fairness checks; diverse exposure
Transparency	Explain recommendations and prices
Cost for small sellers	Platform-provided AI tools
Generated content errors	Human review; fact checks

TABLE III Challenges and Mitigation

X. CONCLUSION

AI has become a core driver of competitive advantage in e-commerce, improving discovery, pricing, support and security. The reviewed literature shows mature recommendation, forecasting and fraud detection methods and fast progress in visual and conversational interfaces. Long-term success depends on responsible and transparent deployment that protects consumer trust.

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