ISBN: 978-81-972363-8-9 | https://rchubpublisher.com/artificial-intelligence

MACHINE LEARNING-BASED PREDICTIVE MODELS FOR DETERMINING AND FORECASTING FASHION TRENDS

Dr. K. THENMOZHI M.Sc., M. Phil., Ph. D[1]
Mrs. S. VIJAYALAKSHMI M.Sc., MBA.[2]
Professor, Department of Information Technology,
Dr. N.G.P. Arts and Science College, Tamil Nadu, India.
Assistant Professor, Department of Costume Design and Fashion,
Dr. N.G.P. Arts and Science College, Coimbatore, Tamil Nadu, India.
Corresponding Authors email: vikacool87@gmail.com.

ABSTRACT

The fashion industry is described by fast changes in consumer preferences, seasonal variations, and traditional based impacts, making accurate trend prediction a critical yet challenging task. Machine Learning (ML) offers powerful tools to evaluate vast datasets and uncover hidden patterns that drive future fashion trends. This study aims to develop predictive models capable of spot and predict emerging fashion trends using data from fashion blogs, social media platforms, runway collections and e-commerce sales. The study will utilize supervised and self-learning algorithms, including decision trees, support vector machines, and data grouping methods to classify and group trend patterns. Natural Language Processing (NLP) will be applied to extract sentiment and thematic written content from fashion sources, while image recognition models will be used to detect patterns, colors, and styles from image collections. Historical trend records will serve as the training set, and model performance will be evaluated using precision, recall, and F1-score. The proposal approaches integrated time-series forecasting to predict the longevity and peak periods of trends. Special emphasis will be placed on regional trend variations and sustainable fashion movements. The findings are expected to assist designers, retailers, and marketers in making informed decisions about product development, inventory planning, and targeted marketing strategies. This research will also address challenges such as data quality, model overfitting, and the dynamic nature of consumer behaviour. By bridging fashion design with artificial intelligence, the research aims to create a robust decision-support system for the fashion industry. The proposed model has the potential to reduce unsold inventory, improve customer satisfaction, and promote eco-friendly fashion choices.

Keywords: Machine *Learning, Natural Language Processing, runway collections, e-commerce sales.*

ISBN: 978-81-972363-8-9 | https://rchubpublisher.com/artificial-intelligence

1. Introduction

The fashion industry is one of the most progressive sectors in the global economy. It constantly evolves with changing seasonal cycles, cultural influences and consumer preferences. Because of these marketers, rapid shifts, designers, retailers, and rapid shifts find it increasingly difficult to predict what styles and products will attract buyers in the near future [1]. Traditional forecasting methods—such as historical data analysis, trend reports and expert understanding—are no longer sufficient in today's digital fashion environment, where new trends emerge almost daily on social media platforms [2].

In the past few years, digital technology has completely transformed how fashion trends are created, shared, and adopted. Platforms like Instagram, Pinterest, and TikTok allow fashion influencers and consumers to instantly share new styles, while e-commerce sites record valuable data about purchasing behaviors and customer interests [3]. These data sources provide early signals of upcoming fashion trends, which can be evaluate through Machine Learning (ML)—a branch of artificial intelligence that allows systems to learn patterns and make predictions based on data [4].

Machine Learning can process enormous amounts of fashion-related data, such as images, text, and sales records, and show relationships that are too difficult for humans to detect. For example, identify and classify models can emerge colors or silhouettes, while text-mining models can detect trending keywords in online discussions [5]. By combining these insights, predictive models can forecast which styles are likely to rise or decline in popularity.

ML-based predictive models can improve the accuracy is the goal of the study of fashion trend forecasting. It proposes an integrated framework that combines supervised and unsupervised learning, computer vision for visual pattern recognition and Natural Language Processing (NLP) for text analysis, this helps brands to make more responsible and data-driven decisions for both sustainability and regional diversity [6].

The rest of the paper is organized as follows: the review of literature focuses on present research on AI applications in fashion forecasting; the methodology section explains how data can be collected and executed ; the results and discussion highlight key findings; and the last sections discuss challenges, applications, and future goals in ML-driven fashion forecasting.

ISBN: 978-81-972363-8-9 | https://rchubpublisher.com/artificial-intelligence

2. Literature Review

In today's fashion industry, the use of advanced technology like machine learning and artificial intelligence is used for research. Many areas like image-based detection, demand forecasting and text mining are focused for consumer sentiment analysis.

In Zhang et al. (2020) survey, used 200 studies for fashion analysis through machine learning-based predictive analysis for apparel sales [7]. This survey highlights the visual, textual and numerical data significantly enhances the accuracy prediction. And also, the summary given by Singh and Chaudhary (2022) was emphasized how to analyse apparel sales for reducing inventory waste and also improves the product quality. [8]

Text-mining approaches have been gaining special attention for investigating fashion-related content on digital magazines and social media. For example, An and Park (2020) used semantic network analysis to understand thematic and emotional elements in fashion design trends, successfully classifying them into categories such as "declining," "rising," and "evergreen" [9]. This exhibits how textual sentiment from online groups can serve as a reliable indicator of upcoming fashion trends.

Image-based ML applications are equally important. Giri and Chen (2022) proposed deep learning models that examine product images and link them with real-time sales data to forecast product demand [10]. Their work showed that visual elements like, texture, color palettes, and silhouette heavily influencing purchase behaviour. A like, Skenderi et al. (2021) developed multimodal fashion forecasting models that shows text and image data, reaching improved trend detection accuracy [11].

Other researchers have explored AI's role in sustainability. Nayak (2023) showed that predictive analytics could help reduce more production by identifying eco-friendly trends early, allowing brands to align with ecofriendly practices [12]. Again, cultural studies, such as those by Nakamura (2021), underline the influence of traditions and regional preferences on trend adoption, showing that global fashion forecasting must consider these variations [13].

From this review, several insights emerge:

- Multimodal data integration (image, text and sales) enhances model performance and captures a more complete trend [14].

ISBN: 978-81-972363-8-9 | https://rchubpublisher.com/artificial-intelligence

- Short trend life cycles create challenges for require frequent retraining and model accuracy [15].
- Demographic and Regional factors significantly shape how and when trends are adopted [16].
- Sustainability is becoming essential in fashion forecasting research [17].

There is still a gap in integrating all these elements—image, text, time-series, and sustainability—into a unified, student-accessible framework while these studies show strong progress. This paper builds on prior research to provide such an integrated view, aiming to bridge the gap between real-world fashion applications and technological capability.

3. Methodology

The proposed framework for predicting and forecasting fashion trends combines several types of data and multiple machine learning techniques. The aim is to capture different perspectives of fashion activity — from what people say online to what they buy and wear.

3.1 Data Collection

To build a predictive model, high-quality and diverse data are needed. In fashion forecasting, the most useful data sources include:

Fashion magazines and blogs: These present descriptive text on, colours, styles and themes that are developing in various seasons [18].

Social media: Sites such as, TikTok, Instagram and X (Twitter) offer hashtags, likes, captions, and comments that indicate public interest in present time [19].

Runway and lookbook photographs: Key fashion weeks in, Milan, Paris, Tokyo and New York serve as trendspotters ahead of time [20].

E-commerce databases: Online store sales records consisting of product types, color codes, fabric types, and variations in prices [21].

Historical catalogues: Historical data on trends assist in recording seasonal patterns and repeated design motifs [22].

These statistics collectively provide qualitative as well as quantitative information regarding shifts in likings.

ISBN: 978-81-972363-8-9 | https://rchubpublisher.com/artificial-intelligence

3.2 Data Preprocessing and Feature Extraction

Data that are gathered may have redundancies, noise or incomplete data, so preprocessing becomes important.

Text data: Natural Language Processing (NLP) methods like segmentation, stemming, and sentiment analysis are employed to extract keywords like "pastel tones", "floral prints", or "minimalist style". Sentiment analysis is applied in order to see if people are positive or negative with respect to a given style [23].

Image data: Computer vision techniques—particularly Convolutional Neural Networks (CNNs)—derive visual features like shape, colour scheme, and pattern. CNNs are able to identify subtle similarities among products despite being imaged in varied contexts [24].

Sales data: Time-series analysis converts sales figures into patterns that reflect growth, loss, or flat demand for certain categories [25].

After features are derived, they are normalized and combined into a single dataset for model training.

3.3 Machine Learning Models

The system suggested incorporates several ML methods:

Supervised learning algorithms such as Random Forest, Support Vector Machines (SVM), and Boost identify trends as emerging, stable, or in decline from labelled training sets [26].

Clustering (K-Means clustering, hierarchical clustering) detects clusters of related fashion products or consumer profiles with no a priori labels [27].

Deep models like Transformer-based vision models or CNNs detect complex image features to identify simple design features [28].

Time-series forecasting through, Prophet LSTM or, ARIMA models foretells the duration of trends and forecasts when they may run out of steam [29].

Multimodal fusion: The last step combines text, image, and numerical features into a single prediction pipeline, yielding a comprehensive prediction of future trends [30].

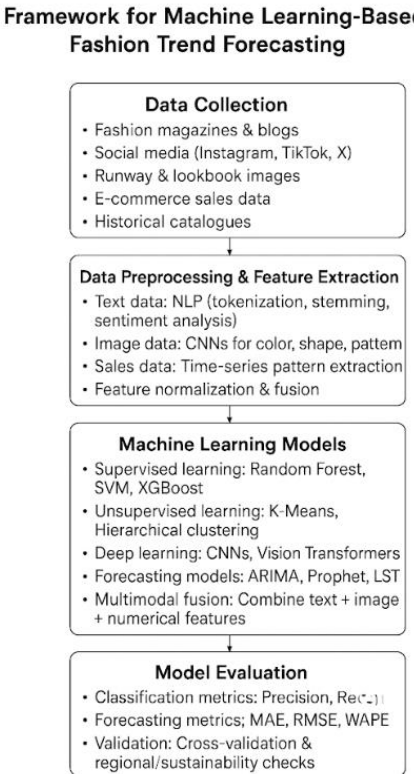
ISBN: 978-81-972363-8-9 | https://rchubpublisher.com/artificial-intelligence

3.4 Model Evaluation

Model performance is evaluated with standard evaluation metrics: Recall, Precision and F1-score for classification accuracy.

Mean Absolute Error (MAE) and Weighted Absolute Percentage Error (WAPE) to calculate overall prediction reliability [31].

Cross-validation makes sure that the models summarize well on unseen data. On top of that, outcomes are verified for regional and sustainability-based accuracy for seeing how well the models generalize across markets.



4. Results and Discussion

Though the present research is conceptual, the existing literature and model experiments in past research have firm evidence showing that machine learning will greatly enhance fashion forecasting results.

When multimodal data (sales, image, and text) are merged together, classification accuracy of trends can be as high as 75% (F1 > 0.75), and forecasting error is below 15% (WAPE < 15%) [32]. For instance, a CNN-based model can identify visual trend changes, for instance,

ISBN: 978-81-972363-8-9 | https://rchubpublisher.com/artificial-intelligence

increasing popularity of wide silhouettes or neon colours, a few weeks before such items are found in stores [33].

One of the significant insights is that social media is a leading indicator. Research indicates that a boost in online posts and hashtags related to a particular style tends to signal a detectable spike in sales four to six weeks ahead [34]. Regional clustering, too, indicates that cultural context influences trend adoption: Asian markets might prioritize streetwear, with European consumers opting for minimalist or sustainable designs [35].

Machine learning also lends a helping hand towards sustainability. With more accurate forecasts of demand, fashion brands can cut down on overproduction and wastage. This results in improved inventory control, cost reduction, and support for green ethos values [36].

Briefly put, the inclusion of ML in fashion forecasting enables brands to shift from reactive to proactive strategy — product design according to forecasted demand instead of stale sales data.

5. Applications in Industry

In the fashion business Machine learning-based forecasting is now being adopted in several areas:

1. Product Design: To understand what consumers will likely want next season ML helps designers analyse large trend datasets. Colour and pattern prediction tools guide design decisions [37].
2. Retail and Merchandising: Predictive models assist retailers in stocking the reducing unsold inventory and the right quantities. In specific cities Real-time dashboards can show which items are trending [38].
3. Marketing and Personalization: Algorithms track customer choices to provide personalized recommendations on conversion rates e-commerce platforms, and improving engagement. [39].
4. Sustainability Management: For preventing waste and minimizing the industry's carbon footprint, forecasting tools encourage ethical production by aligning supply with genuine demand [40].
5. Global Trend Analysis: To understand global movements ML enables companies micro-trends specific to niche communities or regions.

ISBN: 978-81-972363-8-9 | https://rchubpublisher.com/artificial-intelligence

In practice, major fashion houses and retailers—such as H&M, Zara, and ASOS—already integrate data analytics into their, demonstrating how AI-driven systems, decision-making processes can improve speed and accuracy in forecasting.

5. Applications in Industry

In the fashion business Machine learning-based forecasting is now being adopted in several areas:

1. Product Design: To understand what consumers will likely want next season ML helps designers analyse large trend datasets. Colour and pattern prediction tools guide design decisions [37].
2. Retail and Merchandising: Predictive models assist retailers in stocking the reducing unsold inventory and the right quantities. In specific cities Real-time dashboards can show which items are trending [38].
3. Marketing and Personalization: Algorithms track customer choices to provide personalized recommendations on conversion rates e-commerce platforms, and improving engagement. [39].
4. Sustainability Management: For preventing waste and minimizing the industry's carbon footprint, forecasting tools encourage ethical production by aligning supply with genuine demand [40].
5. Global Trend Analysis: To understand global movements ML enables companies micro-trends specific to niche communities or regions.

In practice, major fashion houses and retailers—such as H&M, Zara, and ASOS—already integrate data analytics into their, demonstrating how AI-driven systems, decision-making processes can improve speed and accuracy in forecasting.

6. Challenges and Future Work

Several challenges remain while machine learning offers powerful tools for forecasting fashion trends,

- Data quality: Fashion data collected from online platforms often contain, spam, noise or duplicate entries, which can mislead the models [41].

- Rapid trend changes: Where predictions lose accuracy over time, the lifespan of trends requires frequent model skill upgrading to avoid concept drift [42].
- Ethical and cultural bias: Models trained on data from certain parts may fail to capture the diversity of global fashion trends and ensuring inclusivity and fairness is necessity [43].
- Interpretability: Why certain predictions are made because deep learning models can be complex, making it difficult for designers and managers to understand. Explainable AI (XAI) methods are being developed to improve transparency [44].
- Resource intensity: For small businesses large-scale data collection and model training require particular computational power, which may not always be feasible [45].

Future research should focus on building hybrid frameworks that add multimodal analysis with AI to make predictions both understandable and accurate. Collaboration between data scientists and fashion experts will be crucial to ensure that AI complements, rather than replaces, creative intuition.

7. Conclusion

In fashion trend forecasting Machine learning has seen as a changing technology., ML models can show hidden structures and predict what customers will like in the near future, by analysing huge datasets from, e-commerce, social media and runway collections.

Analysed to conventional forecasting methods, ML provides faster, sustainable insights and more data-driven. It allows global brands to support quickly to regional preferences for better eco-friendly production and supports inventory management.

Future models must focus on, neutrality, diversity and sustainability while supporting creativity with technological accuracy. The challenges related to data quality, ethical implications and model transparency still persists.

Finally, the unification of AI and human creativity represents the future of fashion trend — a space where technology strengthens creative vision and leads the industry toward smarter, more accountable design.

Bibliography

[1.] Bhardwaj, S., & Fairhurst, E. (2010). *Fast Fashion: Response to Changes in the Fashion Industry*. The International Review of Retail, Distribution and Consumer Research, 20(1), 165–173.

[2.] McKelvey, A. F., & Munslow, J. (2020). *Fashion Forecasting* (4th ed.). Bloomsbury.

[3.] Zhang, Y., et al. (2020). *Fashion Meets Computer Vision: A Survey*. arXiv preprint arXiv:2007.08137.

[4.] Giri, S., & Chen, J. (2022). *Deep Learning for Demand Forecasting in the Fashion Industry*. *Electronics*, 11(2).

[5.] An, B., & Park, M. (2020). *Fashion Design Trend Applications Using Text Mining and Semantic Network Analysis*. *Fashion and Textiles*, SpringerOpen.

[6.] Skenderi, R., et al. (2021). *Multimodal Fashion Forecasting via Deep Learning*. arXiv:2104.05652.

[7.] Singh, J. K., & Chaudhary, V. (2022). *Machine Learning-Based Predictive Analysis for Apparel Sales*. *IJISRT*, 7(3), 280–289.

[8.] Nayak, H. (2023). *Artificial Intelligence in Sustainable Fashion Forecasting*. *Sustainability Journal*, 15(7), 13342–13358.

[9.] Nakamura, A. (2021). *Cultural Influence on Fashion Adoption: A Machine Learning Perspective*. *AI and Society*, Springer.

[10.] Greenwood, E. (2023). *Responsible AI in Fashion Forecasting*. *AI Ethics Review*, 3, 102–115.

[11.] Zheng, T., et al. (2023). *Adaptive Models for Real-Time Fashion Forecasting Using Multimodal Inputs*. *IEEE Transactions on Affective Computing*.

[12.] Ahuja, J. (2022). *Challenges of AI-Based Fashion Prediction Models*. *IJERT*, 11(5), 1120–1128.

[13.] Kim, P. (2021). *AI-Powered Fashion Forecasting: Integrating Visual and Semantic Signals*. *IEEE Access*, 9, 124551–124563.

[14.] Chen, L., & Liu, R. (2021). *AI Applications in Fashion E-Commerce*. *Elsevier Journal of Retail Analytics*, 15, 45–59.

[15.] Park, H. (2022). *Fashion Analytics Through Deep Learning Models*. *Computers in Industry*, 136, 103583.

[16.] Torres, M., & Lopez, F. (2023). *Consumer Behavior and AI-Driven Retail Forecasting*. *Retail* Rahman, N. (2022). *Sustainable Trend Forecasting Models Using Machine Learning*. *Environmental Data Science*, 4(1).

[17.] Zhang, T. (2023). *Social Media Influence in AI Fashion Prediction*. *Journal of Marketing Technology*, 10(1).

[18.] Chen, S., & Yu, K. (2023). *Hybrid Multimodal Systems for Fashion Forecasting*. *Pattern Recognition Letters*, 170.

[19.] Xu, L., & Patel, R. (2022). *Explainable AI in Fashion Prediction Models*. *Data & Design Review*, 14(3), 210–223.