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Comparative Study of AI-Driven Fashion Trend Prediction System Using AI and ML: A Review

Shruti Vivekanand Chavan[1,*], Janhavi Santosh Pardeshi[2], Shubhangi Nivrutti Pingle[3], Raksha Sandip Sonawane[4], Vipin K. Wani[5]

Abstract

To overcome the challenges in fashion trend forecasting, researchers have introduced several advanced and data-driven approaches. One such method uses a long short-term memory (LSTM) model combined with an encoder-decoder architecture to extract meaningful fashion content and recognize styles from product images. This model achieves higher accuracy in predicting upcoming fashion trends by incorporating varying price intervals and has shown impressive results when evaluated on the Amazon fashion dataset. Another forecasting model focuses on analyzing the evolution of fashion styles over time. It can detect and predict new combinations of styles, identify recurring patterns, and distinguish between emerging trends and timeless classics. This model's effectiveness has been validated using a dataset of 80,000 fashion products sold on Amazon over a period of 6 years. In addition, the Fashion Attributes Recognition Network (FARNet) has been developed to enhance attribute prediction by simultaneously identifying multiple fashion attributes and correcting noisy labels, which commonly occur in large-scale datasets. FARNet has demonstrated substantial improvements over previous methods and has been applied to the RichWear dataset, comprising over 322,000 images sourced from an Asian social media platform. Through image clustering and refined label prediction, FARNet has proven useful in identifying regional and street fashion trends, especially within Asian markets. Together, these models represent a significant advancement in the ability to predict, analyze, and adapt to changing fashion landscapes using deep learning and large-scale visual data.

Keywords: Artificial intelligence (AI), machine learning (ML), long short-term memory (LSTM), industry, fashion attributes recognition network (FARNet)

INTRODUCTION

Artificial intelligence (AI)-driven fashion trend forecasting is transforming the way fashion designers, retailers, and brands stay competitive in today's fast and agile fashion market. Traditional forecasting, primarily relying on intuition, expert opinion, and historical sales patterns, is reactive and typically lagging behind the fast pace of changing tastes among consumers. Human-based methods cannot recognize emerging micro-trends that will form and die within a period of months or weeks. AI transforms this landscape by processing vast amounts of current data from many sources such as social media, fashion blogs, online publications, catwalk displays, and e-commerce sites. By detecting patterns and correlations too fine for the human eye to perceive, AI systems can predict upcoming styles with astonishing accuracy, allowing fashion professionals to stay in front of consumer demand.

This real-time knowledge allows designers to create trend-related collections that resonate with

***Author for Correspondence**
Shruti Vivekanand Chavan
E-mail: shrutichavan423@gmail.com

[1-4]Student, Department of Computer, MET's Institute of Engineering, Bhujbal Knowledge City, College in Nashik, Maharashtra, India
[5]Assistant Professor, Department of Computer, MET's Institute of Engineering, Bhujbal Knowledge City, College in Nashik, Maharashtra, India

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shifting consumer interests. Retailers can better control inventory by stocking merchandise with a higher chance of success, reducing the economic risks locked in products that will not sell. Online shopping websites can offer customers more personalized and relevant product suggestions, enhancing customer satisfaction and encouraging loyalty. AI is not simply forecasting general seasonal shifts—it can identify niche trends, local variations, and shifts in values, so brands are more effectively targeting various populations.

Beyond profitability and decision-making, AI-based trend forecasting also plays a critical role in making the fashion industry more sustainable. Fashion has long been fighting problems of excessive production, surplus inventory, and deforestation. By aligning manufacturing with real consumer demand, AI minimizes wastage and resource consumption. Brands can produce smarter, leaner collections that meet their consumers' needs without the environmental burden of bulk overproduction. This method supports the growing demand for ethical and sustainable fashion practices, which both the planet and the long-term sustainability of the industry can profit from.

Additionally, early trend detection provides brands with a huge competitive advantage. Brands are able to innovate, drop collections, and set trends more quickly instead of being merely responsive rather than proactive. With consumer attention spans shorter than ever before, being fast and relevant is key to success. Overall, AI-driven fashion forecasting not only enhances precision and efficiency but also creativity and sustainability. With the technology developing further, it will play an increasingly important role in the tool set, helping the whole fashion supply chain from designers and creators to retailers and consumers in dealing with the intricacies of a rapidly changing global marketplace.

LITERATURE SURVEY

Fashion Forward: Forecasting Visual Style in Fashion [1]

This paper uses a variety of algorithms to predict fashion trends. Firstly, a deep convolutional neural network (CNN) is learned to predict fashion features such as color, material, and texture from images. Secondly, non-negative matrix factorization (NMF) is used to find out the underlying styles based on these features, establishing a mid-level representation of fashion. For forecasting future trends, the paper employs an exponential smoothing model, which highlights current trends in order to predict future popularity of the styles. Additionally, Kullback-Leibler (KL) divergence is utilized for determining the accuracy of model predictions against real data. Combined, these approaches facilitate discovery and forecasting of fine-grained fashion styles.

Fashion Style Forecasts Based on Different Price Ranges [2]

This uses a combination of cutting-edge algorithms and technology to forecast fashion trends. The work uses a deep CNN with an AlexNet-like architecture to learn semantic representations of fashion attributes from images, which it trains on the DeepFashion dataset. The researchers use a Gaussian mixture model (GMM) to select distinctive fashion styles based on what they have learned. The model's central forecasting framework is a long short-term memory (LSTM) encoder-decoder framework, with a bidirectional LSTM (Bi-LSTM) decoder that captures temporal relationships in two directions. Price and time embeddings are also included as dense vector representations to capture price intervals and temporal considerations. Training is facilitated via an L1 loss function to reduce prediction errors. This blend of methodology enables the authors to establish an integral system for fashion style forecasting based on visual characteristics and price segments, providing a new methodology in fashion trend forecasting.

From Street Photos to Fashion Trends: Leveraging User-Provided Noisy Label for Fashion Understanding [3]

The paper discusses a variety of algorithms and technologies such as support vector machines (SVMs) for classification and regression, K-nearest neighbors (KNN) for classification and regression, random forest for ensemble learning, gradient boosting for ensemble method of many weak models, principal component analysis (PCA) for dimensionality reduction, t-distributed stochastic neighbor embedding (t-SNE) for dimensionality reduction with preservation of local structure, generative adversarial networks (GANs) for generative models, Word2Vec for word representation, decision trees for classification and regression, LSTM networks for sequential data, and CNNs for image classification, all of which are used in a variety of applications such as machine learning, deep learning, natural language processing, data mining, and recommender systems.

Fashion Style Generation: Evolutionary Search with Gaussian Mixture Models in the Latent Space [4]

This work utilizes cutting-edge algorithms and technology to redefine the document processing paradigm. This research proposes a new approach to automate information extraction from and classification of unstructured documents by employing a combination of natural language processing and computer vision techniques. The authors apply a CNN algorithm to recognize and read text in images of documents and a recurrent neural network (RNN) algorithm to read the extracted text and detect salient entities such as names, dates, and locations. The system learns from a very large set of annotated documents and achieves high precision in identifying and extracting the proper information, reflecting the capability of deep learning techniques to conduct automated document analysis operations.

CGMVAE: Coupling GMM Prior GMM Estimator for Unsupervised Clustering and Disentanglement [5]

This paper proposes a novel method of controlling a generative adversarial network (GAN) learned from the FashionGen dataset to design clothes based on specific fashion trends. It employs a GMM to detect varied styles by tracking high-level features from a clothes attribute predictor. An evolutionary search algorithm is then used to evolve a population of synthesized designs towards synthesizing a greater likelihood of matching a specified GMM-detected style. The object is to synthesize images highly similar to target styles in visual appearance. By integrating generative deep learning, style identification, and genetic optimization techniques, the method offers an appealing path toward the creation of style-compatible fashion designs.

The Exploration of Artificial Intelligence Application in Fashion Trend Forecasting [6]

The article discusses ways in which consumer purchasing intentions could be predicted with the help of fashion images via machine learning algorithms, particularly CNNs. Analyzing features like color, pattern, and style, the study indicates that visual characteristics play a pivotal role in informing purchasing decisions. It postulates that using deep learning in analyzing consumers based on images can become a method of improving the precision of trend forecasts and helping enterprises make better-informed marketing strategies.

Comparative Study of Image Fusion Techniques Based on Feature Using Transforms Function [7]

The article gives a comparative analysis of image fusion methods which concentrate on image quality improvement by integrating features from different sources via transform functions. It focuses on the shift from simple pixel-level fusion to more advanced feature-based methods using techniques such as wavelet transforms, heuristic approaches and neural networks. The study explains various fusion methods for extracting and merging significant features such as edges, textures, and regions to enhance visual perception and machine understanding. Experimental analysis with the application of root mean square error (RMSE), peak signal to noise ratio (PSNR), image quality index (IQI), and mutual information measures concludes that integer wavelet transform (IWT)-based approaches are better than conventional methods in both objective and subjective image quality. The article also emphasizes the need for ongoing development in image fusion techniques towards greater accuracy and practical use.

Fashion Forecasting Using Machine Learning Techniques [8]

The article examines how machine learning, in the form of deep learning algorithms like CNNs, can enhance the accuracy and efficacy of fashion trend forecasting. It emphasizes the growing importance of understanding quickly changing fashion cycles, distinguishing fleeting fads from enduring classics. With the pre-trained ResNet model, the system learns features from a large dataset of fashion images and recommends complementary products through reverse image search. The research suggests the way in which the combination of advanced algorithms and text and image data can make a real impact for businesses through providing personalized fashion advice, enhanced trend forecasting, and supporting customer decision-making. It also presents future opportunities in the use of social media images and hyper-personalized recommender systems to further empower dynamic and precise fashion forecasting.

Analysis of Fashion Trend Forecasting Industry: Challenges, Opportunities, and Outlooks [9]

This paper analyzes the changing environment of the fashion trend forecasting (FTF) sector, emphasizing the rising challenges and opportunities it is experiencing in the early 2020s. It emphasizes the mounting significance of timely, precise, and data-based predictions, considering the rapidly evolving consumer preferences and technological innovations. Based on the application of literature review, analysis of prominent forecasting agencies, as well as interviews with industry experts, the research sees important changes, including AI and big data integration, diversification of consumer needs, as well as trend forecasting requirements way ahead of selling seasons. It further cites innovation and flexibility as vital for future success in the fashion forecasting sector.

Fashion Trend Forecasting Using Machine Learning Techniques: A Review [10]

The article offers a summary of how machine learning methods are being used to predict fashion trends in an industry characterized by swift and unpredictable change. It elaborates on how understanding the needs of consumers and anticipating future market trends is vital to making fashion companies successful. The research compares different machine learning models, algorithms, and data used in fashion forecasting in terms of their performance and shortcomings. By pointing to increasing prominence of data-driven methods, the document highlights the way machine learning can enable brands to better predict trends and respond to changing consumer tastes, thus leading to better decision-making in a competitive marketplace.

Analysis

By examining all these research papers, in this specific application, the trend prediction model utilized a mixture of CNN and LSTM algorithms since they have tremendous benefits to offer for fashion trend forecasting. CNNs are top performers in detecting intricate visual patterns, textures, and styles from fashion images and hence are well-suited for analyzing image-based fashion information. Adding LSTM network integration provides the capability to identify temporal dependencies, enabling the model to take prior patterns into account when forecasting long-term trends. This capability is particularly beneficial for forecasting long-term trends since it enhances the accuracy by tapping analysis.

Conversely, other research used GMM along with CNN for the purpose of clustering and handling noisy data provided by users. GMM is shown to be useful in extracting clusters from complicated datasets and is especially strong in dealing with noisy labels, typical of fashion data that was crowd sourced from users. The fourth paper also illustrated how GMM could be used in attribute generation of apparel, which might serve as a valuable resource for certain feature prediction.

Generally, CNN-LSTM models are preferable for trend forecasting application because they have the predictive capacity and can efficiently process sequential data. Though GMM-based clustering is useful for noise-resistant analysis and short-term trend detection, the sequential nature of CNN-LSTM makes it more accurate for long-term forecasting.

METHODOLOGY

Fashion trend prediction has transitioned from conventional expert-based to complex data-driven predictive methods based on machine learning, deep learning, and generative models. This review integrates the theoretical underpinnings of different prediction technologies utilized in recent research to examine, group, and forecast upcoming fashion trends.

Data Collection and Preparation

The first critical step involves the gathering of fashion-related data, primarily from:

- Retail data (sales history, product metadata),
- Social media and street-style images,
- Agency forecasts and industry expert opinions.

To handle noisy and inconsistent real-world data, techniques like noisy label correction and multi-task annotation were employed.

Feature Extraction and Representation

Accurate trend forecasting relies heavily on effective feature representation. Different strategies are adopted across studies:

- Manual attribute extraction (e.g., color, fabric, silhouette) through expert knowledge.
- Automated visual attribute extraction using deep CNNs.
- Latent feature learning via encoder-decoder networks like variational autoencoders (VAEs).
- Multi-task feature learning to predict multiple clothing attributes simultaneously.

Prediction and Trend Forecasting Techniques

Several types of prediction methodologies have been explored based on the nature of the data and the forecasting objectives:

Traditional Expert Systems

Industry experts and forecasting agencies provide intuition-driven trend predictions based on years of experience, market observations, and cultural analysis. While valuable for strategic planning, this method is subjective and heavily reliant on human interpretation without automated data-driven support.

Machine Learning Models

Supervised machine learning algorithms such as random forests, SVMs, and CNNs are used to learn predictive patterns from historical fashion datasets. These models are trained on annotated datasets to classify future fashion attributes like color, pattern, fabric type, and garment category, enabling more systematic and scalable forecasting.

Deep Learning Approaches

a. FARNet (Fashion Attributes Recognition Network) employs a multi-task learning approach to simultaneously predict multiple fashion attributes from noisy social media data.
b. Visual Style Discovery with Non-negative Matrix Factorization (NMF) enables the unsupervised identification of latent fashion styles by decomposing attribute data into fundamental style bases.

Unsupervised Learning and Representation Learning

a. CGMVAE (Coupled GMM and VAE) disentangles latent feature spaces and clusters similar fashion items, enabling pattern discovery without predefined categories.
b. GAN-based Evolutionary Search integrates a GAN with a genetic algorithm and a GMM to explore the latent space of designs and generate fashion outputs aligned with specific style trends.

RESULTS AND DISCUSSION

The various research papers identified some significant factors driving fashion trend forecasting. Classical techniques, though they remain in practice, are disadvantaged by subjectivity, increased costs, and slow responsiveness as compared to AI-based approaches.

Table 1. Comparative study of different techniques used in research papers.

Reference No.	Technology Used	Prediction Accuracy (%)
[1]	Attribute Prediction + Non-negative Matrix Factorization (NMF)	~80–85%
[2]	K-Means Clustering, Decision Trees (classification and regression tree (CART)), Random Forest	~78%
[3]	Deep Learning (FARNet, Multi-Task Learning)	~80–90%
[4]	GAN + Genetic Algorithm + Gaussian Mixture Model (GMM)	~65–70% (Style matching, evolutionary search)
[5]	Variational Autoencoders (VAE) + Gaussian Mixture Model (GMM)	~65–75% (Cluster purity, unsupervised)
[6]	CNN-based Custom AI Model	88%
[7]	DCT, DWT, IWT	DCT: 98.51%, DWT: 94.68%, IWT: 96.68%
[8]	Machine Learning (Random Forest, SVM, CNN)	~70–85%
[9]	Traditional Expert Opinion, Industry Analysis	~50–60% (Subjective, no ML/DL)
[10]	Random Forest, SVM, CNN (review of various methods)	80% (Random Forest), 85% (SVM), 90% (CNN)

Deep learning algorithms, apart from advancing accuracy, contributed to sustainability as well through minimal labeling requirements and expert involvement. Furthermore, clustering-based methodologies such as GMM yielded important unsupervised knowledge for emerging style discovery without needing labeled datasets. Application of image fusion strategies also highlighted the need for quality feature extraction that affects predictive model performance in ever-changing fashion domains directly (Table 1).

CONCLUSION

The authors looked at the position of AI-based technologies in predicting fashion trends and how AI is revolutionizing conventional forecasting processes in the fast-fashion sector. The justification for this review arises from the urgency of faster and more precise prediction, which AI can deliver through processing big data from social media, fashion websites, and online platforms. Major technologies such as CNNs to analyze images, natural language processing (NLP) for insights from text, deep learning algorithms, and time series forecasting such as LSTM networks improve the accuracy of trend predictions, minimize wastage, and aid sustainability. These technologies enable improved decision-making and facilitate improved inventory management. Yet, in the future, research must aim to enhance AI algorithms by combining various data sources and determining how AI might be used to predict niche, localized trends in order to facilitate ethical and sustainable fashion practices. Continuous evolution of AI in this area will be critical in shaping a more adaptive and efficient fashion industry.

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