LUISS

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ARTIFICIAL INTELLIGENCE IN THE LUXURY FASHION INDUSTRY:
Revolutionizing and Enhancing Design, Creativity, Consumer Experience and Sustainability

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CHAPTER 1– AI SYSTEMS & DATA ANALYSIS

INTRODUCTION

Before starting the discussion, it is essential to define what is a luxury brand. Luxury brands aim to reach two central values: the first one is exclusivity and the second one is identity.

The *exclusivity* gives *status* to the brand: the idea is that not all people can economically afford the articles because their price is higher than the price of supplementary products in the market. In that way, the clients who buy a luxury object feel that they have a higher social status than those who do not; in other words, they feel that the brand adds value to themselves. The *exclusivity* value is also reflected in the few productions of the same item. Generally, luxury brands do not produce massively, they rather create strategies to launch few copies: the result is an effect of high demand and low offer. In this way, their competitive advantage is based on the feeling of uniqueness of their product.

On the other side of the coin, luxury brands don't compete with similar brands in the market; they have a reflective and introspective job in which they continuously improve themselves to reach an high brand loyalty and keep their Luxury brand label. The *identity* of these brands is so strong that just because of their logo, brands are able to charge even 100 times more for the same item[1].

The strategy that they implement is, in this sense, a focus strategy.

The fashion luxury industry, which has been valued at approximately $300 billion globally in 2023, represents one of the most dynamic and fast-evolving sectors in the global economy. Major markets, including Europe, North America, and China, account for over 70% of global luxury sales, with China alone contributing nearly 35%. Driven by increasing consumer demand for exclusivity, quality, and innovation, the industry is expected to grow at a CAGR (Compound Annual Growth Rate) of 3.25% through 2024-2028, fueled by the rise of e-commerce, social media influence, and a younger, more digitally-savvy luxury costumers-base. Sustainability and ethical production have also become critical, as 64% of luxury shoppers now prioritize brands with sustainable practices. [2]

[1]Giri, C., Jain, S., Zeng, X., & Bruniaux, P. (2019). A detailed review of artificial intelligence applied in the fashion and apparel industry. *IEEE Access, 7,* 95376–95396. https://doi.org/10.1109/access.2019.2928979

[2] Statista. (n.d.). *Luxury Fashion - Worldwide | Statista market forecast*. https://www.statista.com/outlook/cmo/luxury-goods/luxury-fashion/worldwide#global-comparison

Hence, it is essential for the industry to become customer-centric, as well as for successfully regulating environment-friendly manufacturing practices. Consequently, it is important that the industry adopt sustainable production practices to alleviate and reduce waste production.

Evidently, the fashion luxury industry is one of the most dynamic industries with new data being generated every time a new garment or product is designed, produced and sold. However, the industry still lacks the extensive adoption of AI methods, as it still using computational tools based on classical algorithms and modern AI techniques are confined to academic research[3]. In this perspective, it is a requisite for the industry to adopt new AI techniques to obtain competitive advantage and improve business profitability.

AI applications have the potential to redefine fashion luxury enterprises, leading to substantial growth and revenue, as they can significantly impact and influence every stage of the value chain, from design and production to shipping, marketing, and sales.

In 2020, the adoption of AI in the fashion industry became so widespread that fashion businesses refusing to embrace it risked financial insolvency. Consequently, the global AI in fashion market size surged from $0.65 billion in 2022 to $0.91 billion in 2023. [4]

For instance, AI-powered design tools assist fashion designers in generating innovative concepts and predicting consumer preferences. In production, AI-driven automation enhances efficiency and sustainability by analyzing vast amounts of data to optimize marketing strategies and personalize the shopping experience for consumers.

1.1 AI TECHNOLOGIES

We should start our analysis by understanding the concept of Artificial Intelligence: Artificial intelligence (AI) refers to computers and machines that are capable of mimicking the problem-solving and decision-making capabilities of humans. AI is designed to perform tasks that typically require human intelligence, such as recognizing patterns, making decisions, and understanding natural language.[5]

[3]Takyar, A., & Takyar, A. (2023, April 19). *AI in fashion: Use cases, benefits and future trends in the fashion landscape*. LeewayHertz - AI Development Company. https://www.leewayhertz.com/ai-use-cases-in-fashion/

[4] *Ibid*

[5] Academy, F. R. (2023, March 1). How artificial intelligence is used in the fashion industry. *Fashion Retail Academy*. https://www.fashionretailacademy.ac.uk/news/how-artificial-intelligence-is-used-in-the-fashion-industry

There are four main types of Artificial Intelligence, including:

- Reactive AI**:** Reactive AI is a type of AI that can react to new situations and learn from them, without having been explicitly programmed to do so. Examples of reactive AI within the fashion industry include visual search and personalised product recommendations. They will be discussed in the following chapter.
- Limited Memory AI**:** Limited memory AI systems are those that can learn from experience and use this knowledge to improve their performance in the future. Examples of limited memory AI within the fashion industry include customer service chat bots, trend forecasting and inventory management.
- Theory of Mind AI: Theory of mind AI, which is the most advanced type of AI, has the ability to understand human emotions and motivations and respond in a human-like manner. This type of AI is not widely used in the fashion industry, but there are some emerging applications, such as virtual styling assistants and interactive shopping experiences.
- Self-Aware AI**:** Self-aware AI, also known as reflective AI, is a more advanced form of artificial intelligence that is capable of not only understanding and interpreting data, but also reflecting on its own internal processes and improving its performance over time. This type of AI does not currently exist.[6]

1.2 TYPES OF DATAS

One common characteristic of the different types of AI technologies is the fact that they all rely on the interpretation of big datasets. When analyzing the global fashion luxury industry, various types of data are critical for understanding market dynamics, consumer behavior, and operational efficiency.

In fact, nowadays the rich relevant datasets go beyond the physical store shopping Activities, as they now include textual information, images, videos, locations, and more importantly all the interactions and all kinds of heterogeneous network information. For instance, several studies have used the fashion data to discuss the fashion

[6] Marr, B. (2021, July 15). *What are the Four Types of AI?* Bernard Marr. https://bernardmarr.com/what-are-the-four-types-of-ai/

recommendation, branding prediction and even the next season trends. [7]

These data types help companies stay competitive, identify trends, and respond to changing market conditions. Here is a list of the most relevant types of data to analyze in the global fashion industry:

1. Consumer Data: this type of data is useful to better understand what strategies to implement for the marketing and sales sector of a firm.

- Demographics: Age, gender, income, education level, and geographic location of consumers in different regions.
- Behavioral Data: Shopping habits, product preferences, frequency of purchases, and brand loyalty.
- Psychographic Data: Lifestyles, values, attitudes, and personal interests that influence purchasing decisions.
- Cultural Data: Local fashion preferences, cultural norms, and regional differences in style and fashion consumption.

Useful key tools to provide the analysis of these data are the segmentation analysis and the application of the Abell matrix. The former is a marketing technique that, based on common characteristics, allows you to split your customers or products into different groups. This, in return gives the ability to create tailor-made and relevant advertisement campaigns, products or to optimize overall brand positioning.

If the selected analysis instrument is the Abell Matrix Model instead, the focus would be on the Customer Groups, which refers to who the business is targeting. For a business to be successful it is important to know who their audience is, as without this they would not be able to segment, target, or construct the right messages.

2. Market and Trend Data: these types of data are useful to work on market research as they contribute to the strategic management process.

- Global Fashion Trends: Emerging styles, popular designs, and seasonal fashion trends that shape consumer demand.

[7] (Shaap, F. (2021). Fashion and data mining. *Iris Publishers*. https://doi.org/10.33552/JTSFT.2020.03.000572)

- Regional Trends: Variations in fashion trends by region (e.g., North America, Europe, Asia), influenced by local culture, weather, and fashion influencers.
- Economic Indicators: Data on global economic conditions, consumer confidence, disposable income, and spending power.
- Industry Growth: Market growth rates, size of the fashion industry in different regions, and key drivers of growth.

Useful key tools to provide the analysis of these datas are the PESTEL analysis, which examines the Political, Economics, Social, Technological, Environmental, and Legal factors in the environment, Porter's 5 forces**,** which evaluates the competitive forces within the fashion luxury industry, and the SWOT analysis, that assesses Strengths, Weaknesses, Opportunities, and Threats based on market and trend data.

3. Product Data: these types of data are useful for product development and for some value chain activities optimization, especially regarding Operations and supply chain management,

- Product Performance: Sales data by product category, top-performing items, and products with declining demand.
- Product Development: Data on innovation, materials, and new product lines being developed globally.
- Inventory Data: Stock levels, inventory turnover rates, and product availability across regions.

Useful key tools to provide the analysis of these data can be the Product Life Cycle analysis, which allows firms to manage the stages of product introduction, that are the introduction, growth, maturity and decline stages, and the KPI Dashboards, that displays Key Performance Indicators, which are quantifiable measures of performance for specific strategic objectives over time, in interactive graphs and charts, allowing for an organized and quick review and analysis.

4. E-commerce and Digital Data: these types of data are useful for digital marketing management and for customer experience management.

- Online Sales Data: E-commerce sales by product category, online conversion rates, and customer retention rates.

- Web Traffic Analytics: Data on website visits, engagement metrics, bounce rates, and click-through rates across online platforms.
- Mobile App Data: Usage data for shopping apps, including session duration, in-app purchases, and user activity.

5. Social Media and Influencer Data: these types of data are useful for brand management, digital marketing and public relation management.

- Social Engagement: Data on customer interactions with brands on social media platforms, including likes, shares, comments, and user-generated content.
- Influencer Impact: Metrics on the effectiveness of influencer partnerships, including reach, engagement, and conversions driven by influencers.
- Sentiment Analysis: Analysis of customer sentiment through social media conversations, reviews, and mentions of brands.

Many of the useful key tools to analyze these types of data are part of AI technologies, that play the role of Social Listening Tools; these tools monitor social media mentions, engagement, and sentiment. Another key tool to analyze Social Media and Influencer Data is a special type of ROI (Return On Investment) which is called the Influencer ROI: this indicator measures the impact of influencer campaigns on brand awareness and sales.

6. Sustainability and Ethical Data: these types of data are useful for the development and engagement with Corporate Social Responsibilities (CSR) and for supply chain management.

- Sustainability Practices: Data on sustainable sourcing, production processes, and environmental impact of fashion companies.
- Regulatory Compliance: Compliance with environmental and labor regulations, certifications for sustainable practices, and ethical sourcing.
- Consumer Preferences: Demand for sustainable and ethical fashion products and consumer attitudes towards environmental issues.

Useful key tools to provide the analysis of these data are the implementation of sustainability reporting**,** that measures environmental impact and compliance with sustainability initiatives (e.g., Global Reporting Initiative standards) or the Life Cycle Assessment (LCA)**,** that assesses environmental impacts from sourcing to disposal of products.

7. Competitive Data: these types of data are useful for the process of strategic planning, analyzing the competitive environment and all the key performance metrics of competitors within the same industry.

- Competitor Analysis: Data on competitor product lines, pricing strategies, and market positioning.
- Market Share: Insights into the global market share of different fashion brands and retailers.
- Global Brand Presence: Data on the geographic distribution of competitors, including store locations and online presence in different markets.

Useful key tools to provide the analysis of these data are the Competitor Analysis Frameworks, that tracks competitor strategies in terms of pricing, product, and market positioning, together with the implementation of the BCG Matrix, which evaluates a portfolio of brands/products in relation to market share and market growth, to understand how to prioritize the firm's different businesses.

8. Financial Data: these types of data are useful for financial management, to manage investors' relationships and investment decisions.

- Revenue Data: Sales revenue by region, product line, and channel (e.g., online vs. in-store sales).
- Profit Margins: Data on profit margins across product lines and regions, along with cost structures.
- Investment Data: Data on capital investment in new markets, technologies, and product innovations.

Useful key tools to provide the analysis of these data are financial ratios such as gross margin and ROI, to analyze profitability, liquidity, and efficiency.

9. Supply Chain and Operational Data: these types of data are useful for supply chain management and value chain activities' management, with a particular focus on activities like procurement and operations.

- Supply Chain Efficiency: Data on production times, lead times, and bottlenecks in the supply chain.

- Logistics Data: Information on global shipping times, costs, and logistics network performance.
- Sourcing Data: Details on sourcing strategies for materials, supplier locations, and production hubs globally.

10. Cultural and Regional Data: these types of data are useful for international business strategies and global management.

- Local Regulations and Tariffs: Data on trade regulations, import/export restrictions, and tariffs that affect global operations.
- Cultural Preferences: Understanding regional cultural norms, religious influences, and historical fashion styles that impact consumer preferences.
- Local Events and Holidays: Analysis of the impact of local events, holidays, and fashion weeks on consumer behavior and purchasing patterns.

Useful key tools to provide the analysis of these data are the CAGE distance framework, which analyses the cultural, administrative, geographic, and economic distance between markets, the adoption of Cultural Adaptation Strategies, that allow firms to tailor products and marketing to local cultural and regional preferences, and lastly the PESTEL analysis.

11. Technological Data: these types of data are useful for innovation management, implementation of IT strategies and for R&D purposes.

- Adoption of New Technologies: Data on the use of AI, augmented reality (AR), virtual reality (VR), and other digital technologies in fashion design, retail, and marketing.
- Innovation Data: Insights into technological innovations such as 3D printing, fabric innovations, and the adoption of digital fashion.

Implementation and use of AI technologies have made it possible to analyze these huge datasets in a much faster and simpler way. In the next chapter we are going to discuss how this evolution for the technological data analysis has taken place.

12. Customer Interaction Data: these types of data are useful for customer service and customer experience management.

- Customer Support Data: Interaction data from customer service channels, including queries, complaints, and feedback.
- Feedback and Reviews: Analysis of customer reviews and feedback across online platforms to identify satisfaction levels and areas for improvement.

Useful key tools to provide the analysis of these data are **the** Net Promoter Score (NPS)**,** that measures customer loyalty and satisfaction by looking at their likelihood of recommending a certain business, and Customer Satisfaction Index (CSI**)**, that is an analytical tool which measures the level of satisfaction of customers for a given product or service, helping companies to determine the reason why customers may or may not be satisfied with the product

13. Macro-Level Data: these types of data are useful for the implementation of global strategies, as well as for risk management. They help the company with the compliance process with national and non-national policies.

- Political and Economic Stability: Data on geopolitical events, trade agreements, and economic stability that affect global trade in the fashion industry.
- Global Health Data: Insights into how global health crises (like the COVID-19 pandemic) impact the fashion industry, consumer behavior, and supply chains.

Useful key tools to provide the analysis of these data are scenario planning, which is a useful technique for firms competing in industries characterized by unpredictability and change, that prepares for potential future macro-level events (e.g., economic crises, political instability), and the PESTEL analysis, to understand the broader macroeconomic and political environment affecting global trade.

By analyzing these types of data, fashion companies can make informed decisions about product development, market expansion, consumer targeting, and operational improvements. Data-driven insights are essential to staying competitive and responsive to the ever-changing dynamics of the global fashion industry.

1.3 DATA ANALYSIS TECHNIQUES WITH AI TECHNOLOGIES

According to a 2021 study by Juniper Research, 96% of surveyed retail executives plan to invest in AI in the near future. What's even more interesting is that an Oxford Economics survey found that 40% of executives think that AI is crucial to business success and that a failure to implement the technology will end up costing them their customers and employees, as well as hurt their bottom line (a company's income after all expenses have been deducted from revenues). [8]
Here's a detailed explanation of the AI technologies and techniques commonly used in the fashion industry to analyze all types of data that we mentioned in the first paragraph:

Machine Learning

Machine learning (ML) is a branch of artificial intelligence (AI) and computer science that focuses on using data and algorithms[9] that involves training a machine learning algorithm on a large dataset of examples so that it can learn to make predictions or decisions based on new input data. As the algorithm learns from the errors it makes on the training data, it adjusts its internal parameters to improve its predictions: but we will discuss it more accurately in a while.
The learning system of a machine learning algorithm can be divided into three main parts.

1. A Decision Process: In general, machine learning algorithms are used to make a prediction or classification. Based on some input data, which can be labeled or unlabeled, your algorithm will produce an estimate about a pattern in the data. Labeled data are carefully annotated with meaningful tags, or labels, that classify the data's elements or outcomes, while unlabeled data consists of raw inputs with no designated outcome
2. An Error Function: it evaluates the prediction of the model. If there are known examples, an error function can make a comparison to assess the accuracy of the model.
3. A Model Optimization Process: If the model can fit better to the data points in the training set, then weights are adjusted to reduce the discrepancy between the known example and the model estimate. The algorithm will repeat this iterative "evaluate and

[8] Takyar, A., & Takyar, A. (2023, April 19). *AI in fashion: Use cases, benefits page 2.*
[9] *What is machine learning (ML)? | IBM.* (n.d.). https://www.ibm.com/topics/machine-learning

optimize" process, updating weights autonomously until a threshold of accuracy has been met. [10]

Natural Language Processing (NLP)

NLP plays a critical role in human-machine communication. Billions of gigabytes of data are being created in unstructured formats, that do not adhere to a pre-defined data model and is not straightforward to analyze, making it unusable to use regular programming techniques. [11]NLP can interpret this unstructured data helping fashion companies to understand customer feedback, reviews, and social media sentiment.

Natural language processing has been studied by computer scientists since 1950s. The computer scientist Alan Turing thought for the first time that the ability to integrate human language to machines would have been an important determinant of intelligence in machine. Following this reasoning, he later created the Turing test to measure the machine intelligence: a machine passes the Turing test if it can fool people into believing it is a human. At that time and throughout the 1960s, the first chatterbots were created, exemplifying the power of natural language-based interfaces. [12]

Data Analytics & Data Mining

Data analytics allows fashion luxury brands to collect and analyze customer data from various touchpoints—online interactions, purchase history, social media engagement, and more. [13]

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[10] Aptean. (2023, April 3). Machine Learning in Fashion: How it's shaping the industry. *Aptean.com.* https://www.aptean.com/en-US/insights/blog/machine-learning-in-fashion-industry

[11] *Artificial intelligence for fashion.* (n.d.). Google Books. https://books.google.it/books?id=ZRF- (*Artificial Intelligence for Fashion*, n.d., pp. 22–26)

[12] Adebowale, T. (2024, February 19). *The role of natural language processing in fashion e-commerce*. Woven Insights Blog. https://woveninsights.ai/site-blog/the-role-of-natural-language-processing-in-fashion-e-commerce/#:~:text=Natural%20Language%20Processing%20In%20Fashion%20E%2DCommerce,-Natural%20Language%20Processing&text=NLP%20powers%20many%20applications%20in,understand%20their%20customers%20and%20products

[13] Jayan, J. (2024, April 5). *Unlocking New Opportunities in the Fashion Industry with Data*

Through data mining, the fashion luxury industry could benefit to derive the brand and production association. For example, when a user comments on a brand/product (online interaction), it is very likely that this user also compares this brand/product with alternative ones, which could be similar products from the same brand or similar products from the competing brands. Understanding the brand and product associations is essential in the fashion industry because it could help firm strategically allocate their resources to maintain their competitive advantages. [14]

Deep Learning

Deep learning is another type of machine learning process that uses interconnected nodes or neurons in a layered structure that resembles the human brain. Every neural network, which is a ML model, consists of layers of nodes, or artificial neurons—an input layer, one or more hidden layers, and an output layer. Each node connects to others and has its own associated weight and threshold. If the output of any individual node is above the specified threshold value, that node is activated, sending data to the next layer of the network. Otherwise, no data is passed along to the next layer of the network.

Through neural networks, deep learning models process and comprehend complex data such as social media posts and influencer activities, identifying patterns and fashion trends in clothing styles, colors, and design elements that will likely gain popularity soon. This analysis enables fashion luxury businesses to make data-driven decisions, adapt to evolving consumer preferences, and maintain competitiveness in the ever-dynamic fashion landscape.[15]

1.4 APPLICATION AREAS

The fashion luxury industry faces numerous challenges that demand innovative solutions to stay competitive. Let us understand what are the application areas of the just discussed AI

Analysis. PromptCloud. https://www.promptcloud.com/blog/unlocking-new-opportunities-in-the-fashion-industry-with-data-analysis/#:~:text=Data%20analytics%20allows%20fashion%20brands,shopping%20habits%2C%20and%20style%20inclinations.

[14] Shaap, F. (2021b). Fashion … page 4

[15] *What is a Neural Network? | IBM*. (n.d.). https://www.ibm.com/topics/neural-networks

technologies in the fashion luxury industry and how they can help firms to overcome these challenges.

APPLICATION AREAS OF MACHINE LEARNING:

ML algorithms can identify patterns and objects within images, making it ideal for tasks like recognizing apparel styles, colors, and even detecting counterfeit products.

1. Computer vision: ML in the fashion luxury industry mainly relies on the computer vision (CV) system, which is a computer science field focused on enabling AI-based software to retrieve meaningful information from visual materials. Some of the typical CV tasks include:

- Image classification or detecting an object and linking it to a single specific classifier or several classifiers in the case of multiple-category classification.
- Semantic segmentation classifies pixels trating all objects belonging to the same category as one entity.
- Instance segmentation or labeling multiple objects within the same class separately. It allows for a more precise object identification and differentiation.

It is possible to distinguish two major ways of image recognition implementation in the fashion industry. These include visual search and smart recommendations.

1. Visual search: Visual search is the AI-driven technology that incorporates the techniques of visual recognition for images, video, and 3D. It allows computers to scan an image uploaded, identify objects detected, and categorize them. Then, a program matches the found items with ones in a database according to the following key factors listed in order of decreasing importance.

- Type.
- Purpose of use (in case it is not naturally defined by the type).
- Size (adjusted to “real” dimensions, rather than ones reflected in a picture).
- Style.
- Color.

For example, if you upload a screenshot of a bag, a system will define it as a bag first. Then, algorithms will figure out if it is a handbag, a shopping bag, or man bag. The next step of the

algorithm would be recognizing its size next, then its style, whether it is a luxury or a simple bag, and finally, its color. Every pixel of this bag will be matched with all the pictures of bags in the system to find exactly the same or similar ones.[16]

As we have already said, the first step that allow this visual search process is the recognition of the initial image. Common image recognition techniques include pattern recognition, neural network recognition and dimension reduction.

- Pattern recognition is generally used for the recognition and classification of ordinary fabrics and clothing.
- Neural network recognition is a neural network algorithm is generally used for body shape recognition.
- Dimension reduction recognition is referred to a method of reducing variables in a training dataset used to develop machine learning models. The process keeps a check on the dimensionality of data (the number of columns of data) by projecting high dimensional data to a lower dimensional space that encapsulates the 'core essence' of the data**.** Dimension reduction recognition process is divided into linear dimension reduction recognition and nonlinear dimension reduction recognition. The former assumes that data is linearly related and project data using linear combinations of features, while the latter accounts for more complex, curved structures in the data, preserving nonlinear relationships. Dimension reduction recognition is generally used for the screening and expression of clothing features. This technology can help us quickly locate the defects of products. It can also help us plan the corresponding plan in time. [17]

It is important to notice that image recognition does not only allow for visual search, but it also speeds up the production and sales of textiles and clothing.
Better outcomes from visual recognition have increased the demand for visual search exponentially.

As we have already mentioned, linked to image/product recognition there is the concept of counterfeited products. Luxury brands have been battling counterfeits and illegal markets for

[16] (Fu, S. (2020). The application of computer image recognition technology in textile and clothing. *Journal of Physics Conference Series*, *1574*(1), 012004. https://doi.org/10.1088/1742-6596/1574/1/012004
[17] *Ibid*

decades through different preventative methods such as lawyers, anti-imitation technology, and supply-chain validation. Counterfeited products are hurting fashion luxury companies' bottom line, as they cost the industry billions of dollars annually and undermine brand integrity.

The 2023 Operation Fake Star report notes that Legitimate industries lose EUR 23.3 billion in direct sales and EUR 37 billion in total sales due to the counterfeit industry. [18]

In this scenario, AI technologies can be a potent tool to fight against counterfeiting by detecting discrepancies in logos, materials, helping fashion brands and authorities to take action, protecting both consumers and legitimate businesses from the negative effects of counterfeit products. An example is that brands are using smart packaging such as embedding invisible signatures that can be scanned by consumers and easily tracked through the supply chain.

Invisible or cryptographic signatures are part of the printing process of product packaging. Customers have the option of using a mobile application to scan the product and immediately know whether it is authentic or not. This also leads to consumer engagement. A brand can reach out to customers and say, 'We know you came across a fake product, let's address this for you.'

Invisible signatures are also significantly less expensive than traditional technologies such as labels, which require a lot of capital expenditure and equipment and can disrupt the supply chain if faked."[19]

2. Virtual try-ons**:** Computer vision also powers augmented reality (AR) and virtual reality (VR) applications, which are technologies that superimpose a computer-generated image on a user's view of the real world. .[20] There are few differences among VR and AR technologies: AR uses a real-world setting, where the user can control its presence in the real world: moreover, it can be accessed with a smartphone and enhances bot virtual and real world. VR is completely virtual and requires a headset device, it enhances only fictional reality.

These technologies application in the fashion luxury industry is absolutely innovative, as they enable customers to virtually experience clothing and accessories before completing a purchase, as well as analyzing body shape and size to provide realistic simulations

[18] *State of the fake report - 2023 - entrupy*. (n.d.). https://www.entrupy.com/report/state-of-the-fake-report-2023/
[19] Jenns, C. (2023, July 10). The role of smart packaging in the fight against counterfeiting. *Packaging Gateway*. https://www.packaging-gateway.com/features/role-smart-packaging-against-counterfeiting/?cf-view

[20] Zakeke. (2024, June 12). *Why Virtual Try-On Fashion is The Future of Shopping*. Zakeke. https://www.zakeke.com/blog/why-virtual-try-on-fashion-is-the-future-of-shopping/

In this way, virtual try-ons increase traffic and sales for fashion retailers, because customers who try cloths virtually are going to be more likely to buy items that they wouldn't have otherwise. A direct consequence is the reduction of the returns, because customers are more informed and build more accurate expectations about the product they will receive. Virtual try-on can significantly reduce the need for physical samples and prevent unsold stock, by using 3D twins for cloths or shoes, businesses can become more sustainable and cut costs associated with producing physical samples and avoiding overproduction.

In addition, virtual try-on can help retailers reach new customers who might not have visited their store otherwise (for example due to distance impediments).

Combining virtual try-on fashion with real time customization creates the perfect mix for today's demanding customers, as these immersive experiences are the key to staying competitive and achieving success in the modern market.

APPLICATION AREA OF NATURAL LANGUAGE PROCESSING

NLP powers many applications in e-commerce.

NLP can elevate customer service experience through the implementation of chatbots and virtual assistants by providing real-time support, answering product inquiries, and assisting with purchases. They can also guide customers through the selection process based on their preferences and needs. Throughout the 1960s, the first chatterbots were created, and the most famous example during this time was ELIZA. ELIZA was one of the first programs to pass a restricted version of the Turing test: the chatbot processed user's inputs, saving them in memory and recalling them during a conversation.

Voice recognition is another emerging aspect of virtual assistants, that allows consumers to search products or purchase them using voice commands via smart speakers. Fashion luxury brands are progressively integrating chatbots to elevate their marketing position and strategies, that we are going to analyze more deeply in the following chapter.

NLP in fashion e-commerce allows online retailers to better understand their customers and products by analyzing customer reviews, product descriptions, and other text.

Some e-commerce companies are also testing NLP for automated product tagging. By understanding the text and images on a product page, AI models can suggest tags that

match the item, making products more discoverable on the site and across the web. Natural language processing (NLP) techniques allow you to gain insights from all this unstructured data to better understand your customers' needs, interests, and shopping habits.

APPLICATION AREAS OF DATA MINING AND DATA ANALYTICS

The first application area of Data Mining is for the smart recommendation system improvement and automation. Data Mining processes large volumes of information previously obtained from visual search and then generates smart proposals of unique sets of personalized suitable fashion choices for a customer. [21] The smart recommendation system is based on data mining process and is designed to combine AI and ML, allowing end-users to make personalized service/product recommendations, acting as a buying guide for prospective buyers to make appropriate buying suggestions.

Similar and personal recommendations are two types of suggestions that smart recommendations system can generate, and they differ under many aspects:

Similar recommendations are suggestions based on the similarity of items to the one the user is currently viewing or has interacted with. The system looks at the features of the product (e.g., style, color, brand, category) and recommends other items that share similar attributes. For example, if a user is viewing a black leather handbag, similar recommendations would suggest other black or leather handbags that share common features.

Personal recommendations are suggestions tailored to an individual user's preferences, past behavior, and interactions with the system. Personal recommendations consider the user's overall shopping history, likes, purchases, and preferences to offer items that are specifically relevant to them. For example, if a user frequently buys minimalist clothing in neutral tones, the personal recommendation would suggest items that match this overall pattern, even if they are not directly related to the current item being viewed.

Another technique employed in recommendation systems and virtual stylists is called reinforcement learning, which is another way through which AI technologies learn from user

[21] *AI Clothing Detection: Use cases for fashion and e-commerce – PostIndustria*. (n.d.). https://postindustria.com/ai-clothing-detection-use-cases-for-fashion-and-e-commerce/

interactions to provide more relevant product suggestions and style advice over time. With the adoption of the reinforcement learning technique, we are able to detect 2 more types of recommendation systems, based on the products filtering process:

1. Collaborative filtering: These systems use customer behavior and preferences to recommend fashion items based on what similar customers have liked or purchased. Collaborative filtering can enhance personalization in fashion e-commerce.
2. Content-based filtering: This technique recommends products based on the features and attributes of the items themselves, considering factors like color, style, and material.

Another application area of data mining is for inventory management, since data mining can significantly help companies optimize stock levels, reduce costs, and meet customer demand more effectively. Retailers often struggle with stockouts or excess inventory, which all together lead to missed sales opportunities and financial losses. By analyzing historical sales data, seasonal trends, and external factors (like promotions or economic conditions) Data Mining can forecast future demand for products helping businesses to predict how much of each product will be needed, reducing the risk of overstocking or understocking.

In order to build a reliable future demand, data mining can classify products based on their sales velocity. Fast-moving items can be restocked promptly, while slow-moving items may be ordered less frequently or put on promotion to clear out excess stock.

To monitor how quickly different products sell, data mining techniques studies and analyzes a company's inventory turnover rate: by comparing sales data across various periods, it can identify bottlenecks or excesses, keeping high-demand items in stock and avoid wastage or obsolescence in low-demand products.

Lastly, but of relevant importance, data mining is crucial for sustainability issues. The fashion industry is under growing scrutiny for its environmental impact. Nowadays the industry's mainly concerns are all about reducing wastes, implementing sustainable materials and ethical manufacturing practices. AI-driven solutions can track and trace the supply chain activities, providing transparency to consumers concerned about the country of origin of the product they purchase. By utilizing data from suppliers, data mining techniques can verify the authenticity of sustainable and ethical claims, also monitoring factors such as fair labor practices, responsible sourcing of materials, and compliance with environmental regulations.

APPLICATION AREAS OF DEEP LEARNING

For fashion and luxury companies, deep learning has a wide range of applications that can transform various aspects of their operations, from design to marketing and customer experience. Deep learning systems, similarly to the previous analyzed techniques, have the capability to process and analyze extensive volumes of market research data from diverse sources, and "can be used to improve the retail experience by understanding customers better than ever before – perhaps better than they even know themselves."[22]

For example, deep learning algorithms can analyze customer preferences to create highly personalized recommendations, as traditional approaches to customization are time-consuming and expensive and limit their scalability. AI systems and deep learning techniques can analyze extensive amounts of customer data, including purchase history, browsing behavior, and demographic information. Using this data, AI can create highly personalized marketing campaigns, tailoring content, product recommendations, and promotions to match individual customer preferences. For example, AI can send personalized email recommendations, display targeted ads, and suggest products on a fashion brand's website based on a customer's unique style, past purchases, and interests. Such a degree of personalization enhances customer engagement and nurtures brand loyalty.

Deep learning models are applied also in trend analysis, because it analyzes social media, online content, and historical fashion data to detect emerging trends and predict future styles. This enables fashion companies to stay ahead of the curve and adjust their collections accordingly. [23]

By analyzing social media posts, reviews, and other online content, deep learning is also able to gauge consumer sentiment toward the brand, products, or campaigns. These models can detect patterns in language and tone to provide real-time insights into how customers perceive the brand.

CHAPTER 2 - MARKETING & DESIGN

[22] Williams, D., & Williams, D. (2018, August 9). *The role of artificial intelligence in luxury fashion*. TOPPAN DIGITAL LANGUAGE. https://toppandigital.com/translation-blog/role-artificial-intelligence-luxury-fashion/

[23] Du, J., Luo, C., Shegog, R., Bian, J., Cunningham, R. M., Boom, J. A., Poland, G. A., Chen, Y., & Tao, C. (2020). Use of deep learning to analyze social media discussions about the human papillomavirus vaccine. *JAMA Network Open*, *3*(11), e2022025. https://doi.org/10.1001/jamanetworkopen.2020.22025

2.1 GENERATIVE AI

A branch of AI known as Generative AI focuses on teaching robots to optimize patterns in order to maximize materials efficiency, creating original and innovative ones. Generative AI (GenAI) tools generate design suggestions and even create virtual prototypes of clothing items. Designers can experiment with different fabrics, styles and colors to visualize the final product, streamlining the creative process and potentially reducing design iterations.

Unlike traditional AI, which functions according to preset rules, generative AI may learn from data and develop content automatically.

More technically speaking**,** Generative AI is a class of Machine Learning algorithms: the new and original content that it generates is based on a set of input data read by neural networks. Neural networks are used to identify patterns and structures within existing data**.**
GenAI takes advantage of different learning approaches, which may be unsupervised or semi-supervised: it trains on the basis of these learning apporaches, making it easy and fast to leverage large amounts of data to create more basic models.

The difference between a set of unsupervised and semi-supervised data is the fact that, in the former the dataset contains input data but no corresponding output labels and the model's task is to discover underlying patterns or structures without being told what the correct outcome is, while the latter is a combination of label and unlabeled data to improve learning efficiency and accuracy.

The process of Generative AI starts with feeding an *LLM model* with huge amounts of data (web pages, books, internal company documents, etc.). A Large Language Model (LLM) is a deep learning algorithm that can perform a variety of natural language processing (NLP) tasks and are trained using massive datasets, enabling them to recognize, translate, predict, or generate text or other content. [24]

[24] *What are Large Language Models? | A Comprehensive LLMs Guide*. (n.d.). Elastic. https://www.elastic.co/what-is/large-language-models

Another techniques used for GenAi are th**e** Generative Adversarial Networks (GANs), that plays a significant role in the fashion industry. The GAN model is an unsupervised deep learning method that generates or edits new fake images. A GAN is composed of two neural networks, namely, a generator and a discriminator, which compete against each other. Thanks to the use of GANs, the learning process will be automatic, but experts will need to monitor and adjust the data to ensure their accurancy. The two neural networks will progressively improve the generation quality and collaborate to create innovative and distinctive fashion designs, styles, and even complete outfits.

In the fashion retail industry, where both aesthetics and consumer pleasure are important factors and speed and novelty are crucial, generative adversarial network offers an efficient way to generate new product designs at a low cost. [25]

In fact, utilizing generative algorithms, AI can create unique and interesting images that merge computer-generated styling with human-driven creativity. Generative AI in this way offers an entirely new approach to creating visual art, thanks to the artworks that it can create combining generative elements and infinite variations of the same image.

Generative AI improves customer satisfaction by diversifying and personalizing fashion designs and increasing the representation of all body types with generated models.

The creation of automated digital experience in online shopping is another important role of GenAI, as it upgrades the shopping experience by tailoring it to individual preferences.
It offers personalized clothing options and styling tips, enhancing communication between the luxury brand and the customers. A robust promotional strategy yields higher lead generation and fortifies the brand image: in fact, such bespoken communication can potentially boost revenue by 5-15% and elevate ROI by 10-30%. [26]
Remaining on the communication sector, AI enhances client support services, with intelligent agents like chatbots and virtual assistants providing advanced, multilingual guidance. They handle complex inquiries and deliver custom recommendations. The approach

[25] In, C. D. (2024, January 3). *Generative AI Fashion Industry: Use Cases & Examples in 2024*. AIMultiple: High Tech Use Cases &Amp; Tools to Grow Your Business. https://research.aimultiple.com/generative-ai-fashion/

[26] Tsymbal, T. (2024b, August 23). *Generative AI in fashion [2024 Insights]*. Master of Code Global. https://masterofcode.com/blog/generative-ai-in-fashion

makes the buying journey more intuitive and responsive to personal needs. Targeted marketing elevates user satisfaction, drives significant business growth, and strengthens customer-brand relationships. [27]

Ensuring relevance and engagement, they simultaneously enhance the efficiency of advertising by identifying consumers behaviors, informing targeted outreach campaigns, and customizing loyalty programs and offers.

2.2 AI & DESIGN: CREATIVE DESIGNING

With its great ability to generate new images and content, generative AI can assist fashion designers in the creative design process by developing new ideas or helping to refine and optimize existing designs with the latest trends.

Creative directors and their teams could input sketches and desired details—such as fabrics, color palettes, and patterns—into a platform powered by generative AI that automatically creates an array of designs, thus allowing designers to play with an enormous variety of styles and looks.

This process of creative designing can be done through a variety of techniques, including the standard use of GenAI, theough which entirely new fashion designs are created following specified constraints and parameters - the desired aesthetic, materials, and target market - or with the Style Transfer technique. In this technique, Generative AI can be used to apply the style of one design to another, allowing designers to create variations on existing designs or combine elements from different sources.[28]

Generative designing enhances the design stage of product development by providing designers with a powerful tool to explore, optimize, and innovate in the early stages of the design process.

The starting point of the application of GenAI in designing is the exploration of the Design Space, as its algorithms can rapidly explore a vast design space, still considering a wide range

[27] Tsymbal, T. (2024, August 14). *Generative AI in fashion … page 22*
[28] *Ibis*

of parameters and constraints. Designers will come up with innovative solutions and uncover design possibilities that they would not immediately consider if relying on traditional methods.

Another important stage of the design process is the optimization of design, because Generative design aims to optimize designs based on specific criteria, such as weight reduction, structural integrity, or material usage, reducing the need for physical samples.

Not only materials will be saved, but GenAI, by relying on automated design exploration process, also saves time and reduces the need for manual iterations. This efficiency is particularly relevant to reach competitive advantage in industries with tight deadlines and costs.

Regarding the more concrete part of the product design, GenAI covers many application areas: first of all it is able to turn sketches into fully colored images.
Designers and artists can experience their vision in real-time with minimal effort, being also able to experiment without difficulty.
Fashion brands automatically can become more creative as the algorithms leverage the ability to analyze numerous sketch-to-color combination and generate multiple variations.
As a direct result, human errors in color-matching and patterns will be substantially reduced.

The representative fashion models are a central part for the fashion luxury brands campaign and using generative AI to create them can help fashion companies to better serve a wide range of customers and showcase their products in a more realistic and accurate way, allowing designers to understand how the clothes would look on different body types.

For being representative for all human body types, it can be used to create a diversity of fashion models in a virtual world in several ways, for example with virtual try-ons, that we have already discussed in the first chapter, and with 3D rendering. The 3D fashion models created by Generative AI can be rotated and viewed from different angles, but they can also be customized to represent a wide range of body types, colors, and sizes.

Technical designers and specialists are progressively integrating AI technologies in the manufacturing arm of the fashion luxury industry to handle repetitive tasks, including describing sewing details and points of measurement, and understanding how certain fabrics interact and stretch when worn.

Regarding fabrics design, many studies have been conducted on garment design. The beginning of the research on the AI-based garment design was conducted to combine design attributes of fashion products that have already been released and to suggest new styles.

For example, several IT companies have developed and possess AI-based garment design technologies. Since fashion brands need to create numerous designs to launch new garment products for at least two seasons per year, the adoption of AI-based garment design generation technology can be one way to increase work efficiency, by reducing the workload of fashion designers and product planners.[29]

In addition, Disco GAN technology has been developed and advanced such that AI identifies the characteristics between different object groups and learns the relationship between the two to modify the design. A practical example of the application of Disco GAN technology on the image of a bag designated as input value and an image of a shoe designated as output value, gives as a result a new shoe design generated by identifying the image characteristics of the handbag and applying them to the shoe. Disco GAN can be an example of style transfer GenAI. We should point out that Artificial Intelligence is not intended to replace designers but to enhance their creative and artistic abilities, allowing them to launch high-value, distinctive collections each season that combine human creativity with technological rigor and precision. With generative AI, the artist's creativity is no longer limited by limitations such as cost or resources. Rather, it allows various professionals like graphic and fashion designers to craft truly innovative or fusion works of art at the click of a button.

Besides, you don't need to be an exclusive fashion designer for creating new designs. [30]

[29] Choi, W., Jang, S., Kim, H. Y., Lee, Y., Lee, S., Lee, H., & Park, S. (2023). Developing an AI-based automated fashion design system: reflecting the work process of fashion designers. *Fashion and Textiles*, *10*(1). https://doi.org/10.1186/s40691-023-00360-w

[30] In, C. D. (2024b, January 3). *Generative AI Fashion Industry… page 22*

2.3 AI & MARKETING

As we have already discussed in the first chapter, machine learning uses computer vision system to provide for important customers services like virtual try-ons, but it is not the only way through which AI technologies can empower fashion luxury businesses.

According to an estimate from McKinsey, which is one of the most competitive management consulting firm in American industry, GenAI could bring in as much as an additional 275 billion $ into the apparel, fashion and luxury sector by 2026, and one way this is happening is through marketing and branding.

Marketing executives and agencies can use generative AI to brainstorm campaign strategies, product campaign content, and even virtual avatars for every marketing channels.

In fact, the first example of the application of AI technology to improve marketing strategy are the AI-Generated Campaigns. AI-Generated campaigns are becoming very popular as big fashion luxury brands like Burberry, Gucci, and Valentino are leading the way in adopting AI for creating their fashion campaigns. These companies have already started using AI to generate high-quality images, optimize their marketing strategies, and offer personalized experiences to their customers.

For a good marketing positioning, also Machine Learning technologies serve a central role, as they allow to reach the right target audience using customer data. These data will then be collected and analyze to personalize for each customer his/her promotional campaign through audience, by designing emails, website pages, captions and ads.

Generative-AI agents can serve luxury brands also when it comes to “clienteling,” a retail strategy whereby sales associates develop long-term relationships with a brand’s highest-spending customers to encourage purchases and improve brand loyalty (high-end brands can hit a sales conversion rate of 60 to 70 percent in luxury boutiques, through appointment-only shopping, for example). GenAI powered tools can keep communication with these highest-spending customers even after they leave the store, analyzing each of these consumers profiles and online real-time interaction.

In 2023, various fashion brands like Valentino and Moncler used AI-generated images to deliver eye-catching marketing campaigns, while other brands like Ganni and Collina Strada hosted runway events featuring AI-inspired designs. [31]

As a result, companies stay ahead of trends while meeting the customers' future needs more effectively.

Also non-luxury brands have embraced the AI-Generated campaigns: for example in March 2023, the brand Stradivarius presented its first collection and campaign designed with AI. This campaign was one of the first created with AI and caused a significant stir within the fashion industry. The campaign was approached in a very interesting way, as the garments that were ultimately produced were simply inspired by those created with AI.

Another illustration of the application of Generative AI in marketing is the gamification experience developed by a renowned American designer. Such an innovative approach significantly enhances trademark uniqueness in the competitive landscape.

FashionVerse, created by Tommy Hilfiger, blends Gen AI with mobile gaming for fashion enthusiasts. The target are the millennials and Gen Z, and the experience they are offered is a lifelike 3D styling experiences. Players style avatars in realistic outfits, competing in creative clothing challenges. The app leverages advanced Generative AI for enhanced fabric textures and avatar realism. Hilfiger envisions video games as a future retail platform, emphasizing the value of virtual purchases. FashionVerse's AI acts as an online tailor, elevating graphics substantially. Such an approach merges playing and fashion, appealing to tech-savvy, style-conscious users. This application sets a new standard in the industry, creating a unique and engaging buying experience.[32]

[31] Harreis, H., Koullias, T., Roberts, R., & Te, K. (2023, March 8). *Generative AI: Unlocking the future of fashion.* McKinsey & Company. https://www.mckinsey.com/industries/retail/our-insights/generative-ai-unlocking-the-future-of-fashion

[32] Tsymbal, T. (2024c, August 23). *Generative AI in fashion … page 22*

2.4 FASHION LUXURY BRANDS: CASE STUDIES

The entire discussion brings us to understand that the luxury shopping experience is undergoing a digital renaissance. Now we can analyze, more in depth, how Luxury Brands are leading with AI and how they have decided to implement AI technologies in their value chain activities, leveraging their core competences and gaining their competitive advantage while embracing the renaissance.

Burberry, a pioneer in digital innovation, uses AI to enhance customer interaction, both online and in-store. Its chatbots and interactive apps provide a tailored shopping experience, blurring the lines between digital convenience and personal touch.

Regarding the sphere of consumer experience, Burberry has established augmented reality (AR) in its app which allows consumers to see how the garments they purchase would look in a person's daily environment, enabling them to buy cloths immediately through the app without lines or delays.

Additionally, at the launch of the Olympia bag, the brand decided to bring to life the Greek goddess who gave the piece its name. By scanning a QR code, consumers could observe the statue in 3D and capture images of it, creating a luxurious experience that is not common, at least at the moment, in other stores. [33]

Gucci instead has been using AI technologies and pattern recognition to redefine creativity and efficiency. Kering, the international luxury group which manages the development of a series of renowned Houses in Fashion, announced in 2019 that Gucci would be the first luxury brand to utilize AI to reduce waste by using it to inform systems about where and where not to sell products. The technology will also be used on the sales floor, providing sales assistants with mobile applications to help increase sales by providing real-time information on available colors and sizes.

Gucci uses AI to analyze a wealth of data from social media, sales, and fashion shows, gaining insights into consumer preferences and emerging trends. This data-driven approach allows

[33] Admin. (2023, February 20). *Luxury brands are diving deeper into technology*. Equinox AI Lab. https://equinoxailab.ai/luxury-brands-are-diving-deeper-into-technology/

Gucci's designers to create patterns and styles that almost completely satisfy the specific needs of their audience.
One of the key enablers of Gucci designers' success has been the luxury brand's investments in technology across the board, as seen in their ArtLab, a futuristic factory where artistic experimentation is blended with 21st-century production processes.

Staffed by a workforce of 800 people, the ArtLab is the centre of product development and lab testing with in-house prototyping and sampling activity for leather goods, new materials, metal hardware and packaging. As a result, the brand can transform ideas and concepts into products at a higher speed than many of their competitors, meeting the Gen-Z demand for quick and unique product drops while enabling creatives to implement their ideas much faster than ever before.[34]

Chanel, the luxury French powerhouse, aims at blending its traditional craftsmanship and technology by using AI in textile development.

Chanel in fact collaborates with tech companies and startups to integrate AI into their textile manufacturing process. By using AI algorithms, Chanel can predict the performance of new fabrics and materials, ensuring that they align with the brand's luxurious and exclusive standards. The direct consequence of this integration is the development of innovative textiles that are both high-quality and durable, maintaining Chanel's reputation for excellence.

A practical example is Chanel's investment in a beauty try-on tool, a world-first for the brand. Dubbed Lipscanner, the in-house app, allows users to scan a color from social media, magazines or items of clothing and Chanel will match it with the brand's closest shade from its 400-strong lipstick line. If the user takes a color inspiration from another face, Lipscanner's artificial intelligence (AI) will be able to identify the product's texture from matte to glossy and match with one of the brand's closest products. Consumers can also pair lipsticks with outfits and accessories by using the Color Picking feature. Based on a photo taken within the app or in consumer's camera rolls, an algorithm can also analyze the shade of an outfit that will pair two

[34] AI, Data & Analytics Network. (2024, February 16). *How Gucci is Using AI and Data*. AI, Data & Analytics Network. https://www.aidataanalytics.network/data-monetization/columns/how-gucci-is-using-ai-and-data-part-1

or three Chanel lipsticks that will be best suited. Once a color has been identified, the user can virtually try-on the product within the app and send pictures or share on social media. [35]

When it comes to fabric selection, not only Chanel, but also Louis Vuitton employs AI to evaluate the performance and sustainability of new materials. AI models assess the aesthetic qualities and durability of fabrics, aiding in the creation of materials that meet Louis Vuitton's luxury standards.

Additionally, AI is used to optimize fabric usage, minimizing waste through efficient pattern-cutting algorithms, contributing to the brand's sustainability efforts.
Louis Vuitton has integrated AI not only for material innovation and sustainability, but also for customer service and personalization, offering AI-driven chatbots and the LV App to elevate shopping experiences.

The luxury brand utilizes generative AI to create a virtual personal shopping assistant that analyzes customers' browsing patterns and purchase histories to offer tailored product recommendations. It can also suggest complementary products, notify customers of new arrivals that match their preferences, and even offer personalized styling advice, enhancing the overall shopping experience. [36]

Louis Vuitton CEO, Michael Burke, said: "At Louis Vuitton, we always think client first. Today, our clients like to be connected to the Louis Vuitton universe wherever they are… It became evident that we should create the Louis Vuitton Virtual Advisor powered by mode.ai, a 24h/7 service to be able to fully meet their needs." [37]

Dior has been at the forefront of incorporating AI technology into its branding efforts, revolutionizing the luxury beauty sector. One notable example is the launch of Dior Insider, an

[35] *Chanel invests in AI with first-ever try-on beauty app*. (n.d.). https://cosmeticsbusiness.com/chanel-invests-in-ai-with-first-ever-try-on-beauty-app--174709

[36] *Generative AI in Retail: Lessons from Luxury Brands | Icreon*. (n.d.). Icreon. https://www.icreon.com/en/insights/lessons-from-luxury-brands-using-generative-ai#:~:text=For%20example%2C%20Louis%20Vuitton%20utilizes,to%20offer%20tailored%20product%20recommendations.

[37] Arthur, R. (2017, December 9). Louis Vuitton becomes latest luxury brand to launch a chatbot. *Forbes*. https://www.forbes.com/sites/rachelarthur/2017/12/08/louis-vuitton-becomes-latest-luxury-brand-to-launch-a-chatbot/

interactive chatbot software accessible via Facebook Messenger. This AI-powered chatbot allows consumers to engage with Dior, learn about the latest news, and receive personalized product recommendations and tips.[38]

AI-powered AR tools allow customers to try on products virtually, providing a safe and convenient shopping experience.[39]

Dior has experimented with augmented reality (AR) virtual try-ons for accessories, allowing customers to see how a product looks on them without physically trying it on. A curious detail is that Nordtrom, which is a leading American fashion retailer offering compelling clothing, shoes and accessories for men, women and kids, is pioneering in digital mirrors, which enables customers to try on an assortment of clothes and accessories via a AR mirror and tapping into AI to showcase selection of products and recommend accessories to the outfit. [40] Who knows if one day, also Dior and the other fashion luxury brands are going to implement this kind of AR in their prestigious showrooms.

As a result, this luxury brand creates its own virtual audiences for live-streamed fashion shows and enables interaction between viewers and models, making the fashion experience more engaging and interactive.

Also Versace is utilizing AI and VR technology to propose and introduce virtual fitting rooms, expanding their reach and offering a more individualized shopping experience. But the scope of application of AI technologies goes even beyond, because Versace Jeans Couture has also ventured into an AI-generated, digital-impressionist utopia for its Fall-Winter 2023 denim campaign.
Created in collaboration with BRAVÒ STUDIO and under the creative direction of Ivan Olita, the innovative campaign employs a selection of custom AI models and techniques to create the locations and talents digitally, highlighting pieces from the new seasonal collection called "Digital Dreams". Dior's approach brings an optimistic viewpoint to the conversation

[38] *Dior's innovation in fashion through AI*. (2023, November 28). - the Scented Journey -. https://luxuryfragrances8.wordpress.com/2023/11/26/the-ai-couturiers-diors-innovation-in-transforming-fashion-through-artificial-intelligence/

[39] https://www.dior.com/

[40] Chao, C. M., & Parker, K. K. (2019). Artificial intelligence and fashion marketing: A framework for research and applications. Journal of Fashion Marketing and Management

surrounding AI generated imagery, painting a future of endless variation and hyper citational creativity. [41]

[41] Bravò. (2023, December 11). Versace Jeans Couture Collaborates with BRAVÒ on AI Generated Denim Campaign. *LBBOnline*. https://lbbonline.com/news/versace-jeans-couture-collaborates-with-bravo-on-ai-generated-denim-campaign

CHAPTER 3 - SUPPLY CHAIN MANAGEMENT

AI tools can significantly contribute to supply chain optimization by providing advanced analytics, predictive capabilities, and automation to improve efficiency, reduce costs, and enhance overall responsiveness to market dynamics. Successful implementation of AI technologies in the supply chain often involves integrating AI with existing systems and processes, as well as fostering a culture of data- driven decision-making within the organization (always remember that managers need to be ambidextrous).

For the fashion industry, which is fragmented, sprawling and with little-to-zero supply chain visibility, fashion luxury companies face a daunting task not only in their need to meet new supply chain regulations, but also in their efforts to streamline supply chains to support better business outcomes and customer experiences. Striving toward sustainability at the product level requires new fashion luxury businesses to make data driven decision. [42]

These data driven decision will be based on the detailed analysis made by AI technologies of diverse datasets, including historical sales, inventory levels, and external variables like weather and market trends.

AI's ability to synthesize such varied information enables enhanced inventory management and more precise demand forecasting, streamlining overall logistics processes.
These advancements in supply chain processes not only increase operational efficiency and minimize waste, but also play a significant role in increasing profitability for fashion luxury businesses.

[42] Raghavan, M. V. (2022, April 14). Why fashion Supply chain traceability is a tech challenge that begins with AI. *Forbes*. https://www.forbes.com/councils/forbestechcouncil/2022/03/18/why-fashion-supply-chain-traceability-is-a-tech-challenge-that-begins-with-ai/

3.1 SUPPLIER MANAGEMENT

Supplier management refers to the process of managing relationships, performance, and interactions with suppliers to ensure that goods and services are delivered in a timely, cost-effective, and efficient manner. It involves activities such as selecting suppliers, negotiating contracts, monitoring performance, and fostering collaboration to optimize the value of the supply chain.

AI technologies are able to manage various aspects of the supplier relationship, from sourcing and negotiation to performance monitoring and risk management. Here are some ways to manage suppliers using AI: first of all, AI-powered platforms, by analyzing vast datasets, including supplier databases, industry reports, and market trends, help fashion luxury businesses in the process of suppliers' sourcing. Natural language processing (NLP) is the key to analyze supplier contracts and documents for relevant information, enabling their quick and accurate evaluation.

Not only sourcing suppliers, but also evaluating their performance is fundamental for fashion luxury brands to maintain their reputation level: AI advanced tools, by analyzing suppliers' performance data, can assess their reliability, analyzing delivery times, and identifying potential risks in the supply chain. Generative AI is also crucial for performance analysis in the supply chain activities, especially in our fashion industry, in cases where demand fluctuations may impact supplier relationships in the following five years, as noted by 73% of chief procurement officers.

Implementing AI-powered supply chain visibility tools is another method to track and monitor supplier performance, plus a new way of thinking about sustainability.

The ability to precisely trace products and materials through a supply chain can help address many challenges: first of all it allows for greater supply chain visibility and support proof of product provenance—knowing exactly where a product and its materials came from. Moreover, traceability can result in social accountability.

As we have already mentioned, also contract management represents a relevant part to analyze in the supplier management. Artificial Intelligence (AI) can automate the entire contract review process to achieve perfect optimization and remove the repetitive work of thousands of

employees.

Contract regulations are constantly evolving, making it difficult to manage everything manually. You can train your AI-powered contract lifecycle management (CLM) tools to build standardized templates, or to analyze data to identify risks, costs, and abnormalities boosting efficiency.

The application of NLP technologies can help to determine the contract type, even drafting new contracts using existing documents as templates, make predictions based on data within existing contracts.

Moreover, AI tools can automatically send specific contracts to relevant legal bodies for review, and once approved, get a notification of their approval. [43] As a consequence, the administrative work of lawyers is relieved and organizational efficiency is boosted.

Contracts powered by AI are far more efficient in every aspect, making for a better experience for you, your clients, and every party involved and expand your contract management capabilities.

The last part to analyze to have a clear frame of supplier management is RFX automation, which refers to the use of technologies to automate the various stages of the procurement process. It allows organizations to efficiently create, distribute, and manage documents, reducing manual effort and errors. The software should include features for supplier communication, bid evaluation, and supplier selection, simplifying the entire procurement cycle.

RFx's meaning stands for Request for Anything. Its documents typically outline a procurement project's specifications, terms, and conditions. They are then sent to suppliers who submit their bids, quotes, or proposals in response[44]: afterwards, organizations are able compare and evaluate different solutions by inviting multiple suppliers to submit their offers. The direct result is that organizations will receive the best value for their procurement needs.

RFx solutions typically involves:

1. RFP (Request For Proposal), which is used when an organization has a specific project or requirement and is seeking detailed proposals from potential suppliers or service providers. RFPs are typically more structured and outline the project's scope,

[43] Juang, R. (2024, April 22). *What is AI for Contract Management?* Ironclad. https://ironcladapp.com/journal/contract-management/ai-contract-management/
[44] Maheshwari, H. (2023b, November 3). *What is RFx? (Definition, Benefits, & Process) – Blog*. https://www.beyondintranet.com/blog/what-is-rfx/

objectives, and requirements in detail. The potential vendors are requested to submit comprehensive proposals that include technical solutions, pricing, timelines, and other relevant information. In this case, automation tools help by standardizing the proposal requests, managing submissions, and enabling faster analysis and comparison of responses.

2. RFI (Request for Information) instead, is used when an organization is exploring potential suppliers and wants to gather general information about the capabilities, experiences, and qualification that different vendors offer. RFIs are usually less formal and do not require the specific pricing or detailed proposals needed in the RFP. Here, automation allows companies to create and distribute RFIs to multiple suppliers simultaneously, collecting structured responses in a centralized system.

3. RFQ (Request For Quotation) is used when an organization has well-defined product or service requirements and is seeking price quotations from multiple vendors to make a purchase decision based primarily on cost. [45] Since they are typically focused on pricing and the automation, in this phase, automation allows buyers to easily solicit and compare quotes from multiple suppliers, leading to quicker decision-making and better pricing transparency.

Overall, the benefits of the RFX software are many, and some of them have already been previously discussed: the reduction of manual work, robust security features to protect sensitive data and documents by allowing only authorized users to have access, and cost saving due to the improved procurement efficiency, vendor evaluation, and negotiation support. RFX automation plays a pivotal role in supplier management, as it fosters collaboration among procurement teams, suppliers, and stakeholders through real-time communication and document-sharing tools. This enables smoother interactions and better teamwork when preparing bids and tenders.

[45] Ivi, page 35

Finally, RFX software's reporting and analytics tools provide valuable insights into vendor performance, helping organizations to optimize supplier relationships. These features make RFX automation an essential component of efficient and effective supplier management.

3.2 PRODUCT LIFE CYCLE MANAGEMENT

PLM:

Product Lifecycle Management (PLM) is a systematic process and a structured approach for managing the entire lifecycle of a product from its initial concept and design, through manufacturing and use, to its eventual disposal or retirement.

Artificial Intelligence (AI) can play a significant role in enhancing various aspects of Product Lifecycle Management (PLM), from product conceptualization, to manufacturing, maintenance, and eventual retirement. Here are several ways through which fashion luxury businesses can decide to implement AI into PLM:

the first application of AI tools in PLM regards collaborative product development, which is a powerful capability that enables project and design collaboration for globally distributed teams. In today's world, discrete manufactures are dealing with globally dispersed teams, and stakeholders involved in the product development process don't have access to the most up-to-date product data. These are considered as collaboration barriers, and they are not only creating delays in product development, but also lead to higher costs due to the duplication of communication costs, issues in production that impact quality, slow feedbacks times from design and manufacturing partners, and multiple service visits to the customer.

The solutions to this issue are AI-powered NLP tools: they can facilitate communication and collaboration among cross- functional teams involved in product development.

Collaborative product development delivers increased productivity, self-service, governance, accuracy, and visibility while minimizing manufacturing disruptions, poor product quality, and production cost. For everyone in the value chain who relies on real-time product data, there are several benefits.

The first benefit is for the production planning area, in that collaborative product development allow to see up-to-date product data coming from a single source of truth. The second aspect

regards manufacturing, as you can validate production processes and build accurate prototypes with access to latest documents. The last aspect is the facilitation of submit problem reporting before going into full scale production.

As a consequence, the supplier-manufacturer interaction is enhanced, assuring the supply of the required parts at the best price/quality, implicitly benefiting also in the design process. [46]

AI is integrated in PLM also to provide a better supplier chain integration, as AI technologies help assess supplier performance, identify potential risks, and optimize supplier relationships, ensuring a smooth flow of materials and components, as we have already discussed and pointed put in the previous section. Mapping complex supply networks becomes an easier task for fashion luxury businesses: for example, many fashion brands have adopted Locus's supply chain optimization platform, which uses AI to model end-to-end production.

AI can analyze historical data and real-time sensor data from products to predict when maintenance is required. In the product lifecycle journey, this predictive analytics leads to more efficient maintenance planning, minimizing downtime, and extending the lifespan of products.

Additionally, AI-driven predictive maintenance systems monitor equipment performance in manufacturing facilities and warehouses. By detecting potential issues in real-time, these solutions ensures smooth operations throughout the supply chain.

PLM software is being used by many fashion luxury firms across the world to increase visibility and data flow throughout their company and the whole supply chain. A practical example of PLM software is Techpacker, which is a data management system that maintains data throughout the product development process, from idea to manufacture. Its primary goal is to provide a central location for managing the product lifecycle efficiently and cost-effectively. Techpacker contains all essential PLM features including rapid design tools, integrations, component libraries, reporting, communication, and custom sections. Its specialized manufacturers' hub, which is used by factories all over the world, provides a platform for brands to easily onboard their chosen vendors. [47]

[46] *Collaborative product development*. (2024, August 4). https://www.ptc.com/en/technologies/plm/collaborative-product-development

[47] C. Giri, S. Jain, X. Zeng and P. Bruniaux, "A Detailed Review … page 1

3.3 QUALITY CONTROL

Quality control in fashion product development refers to the systematic process of ensuring that the products being developed meet predefined standards and specifications. It represents a critical aspect of the entire product lifecycle, starting from the design and prototyping stage to manufacturing, distribution, lastly reaching the end consumers. Quality control aims to deliver products that not only meet but surpass customer expectations in design, craftsmanship, durability, and overall performance. By leveraging machine learning techniques, AI tools analyzes large datasets identifying patterns and automating tasks, leading to more efficient and accurate quality control. Here are several ways in which AI tools can contribute to quality control: first of all, a huge improvement is made possible through the automated control. Manual inspection of textiles is tedious, and repetitive work is prone to human error and inconsistency.

AI-powered computer vision systems can automatically inspect and analyze visual aspects of products, also identifying defects, irregularities, holes, spots or variations in color, stitching, and overall workmanship: many times this kind of inspections are done with high-resolution cameras. Automated inspection, in this sense, reduces the reliance on manual labor, speeds up the process, and provides consistent results.

AI can analyze also another type of data: the fabric usage data. After this kind of analysis, the advanced technologies will provide for the most efficient cutting patterns for every different apparel types[48]. By optimizing the layout and minimizing waste, AI-powered cutting systems reduce excess usage of textiles, lowering material costs for manufacturers, consequently being more environmental-friendly.

Still focusing on the fabric-sector, AI will be able to create “smart textiles” with capabilities like biometric monitoring, location tracking, and automatic adjustments for comfort. AI can detect signals from embedded sensors and respond accordingly. For example, a smart fabric could tighten or loosen certain areas based on the wearer’s movements or environment.

[48] Aiman. (2024, June 1). Artificial Intelligence AI in Textile Industry revolution. *Textile Mentor - Textile industry, Textile designing, Fashion industry and role of textiles*. https://textilementor.com/artificial-intelligence-ai-in-textile-industry/#:~:text=and%20improve%20quality.-,Automated%20Quality%20Inspection,mistakes%20on%20apparel%20production%20lines

This provides insights into overall product quality, allowing organizations to make data- driven decisions for continuous improvement.

In the quality control process, AI technologies can assist fashion luxury brands to assess and manage the quality of all the components and materials provided by the suppliers, smoothing the supplier quality management. Thanks to their capacity to analyze huge amounts of supplier performance data, AI tools help organizations in making informed sourcing decisions, ensuring at the same time that the selected materials meet their high standards.

The processes of documentation and reporting of the quality control is another crucial aspect to track the organizations' performance, and they become easier tasks if AI tools are employed. Companies can generate comprehensive reports improving efficiency, while providing detailed record of quality control activities for external and internal audit and compliance purposes.

The previously discussed PLM software Techpacker allows the just discussed automation of the reporting and documentation process, as it can create a range of visual reports with a single click: time and action reports are included.

Brands can perform in-house quality control, request modifications quickly, and never miss a manufacturing error by capturing fit remarks and points of measurement with Techpacker's Fit Sheets. [49]

3.4 INVENTORY MANAGEMENT AND LOGISTIC

AI technologies can play a crucial role in optimizing inventory management and logistics by leveraging advanced algorithms and machine learning capabilities. These AI solutions are integrated with existing systems to create an even more adaptive and intelligent supply chains, and requires collaboration across different departments of the firm.

By incorporating AI into inventory management and logistics, organizations can enhance accuracy, improve responsiveness, and reduce costs. Here are several ways through which the so discussed accuracy can be achieved:

[49] C. Giri, S. Jain, X. Zeng and P. Bruniaux, "A Detailed Review … page 1

AI algorithms can analyze all the historical sales data, market trends, and external factors to generate accurate demand forecasts. Demand forecast is a really important process that involves the anticipation of customer demand based on previously sales data, market trends and other relevant factors. There are various types of forecasting, each focusing on different time frames and market scopes. For example, macro forecasting examines broad market trends, while micro forecasting targets specific product demand. Additionally, short-term forecasting projects demand over a shorter period, such as weeks or months, whereas long-term forecasting predicts demand over several years.

Although this process of demand forecasting traditionally involves manual analysis of spreadsheets and historical data, the main limitation is that spreadsheets cannot account for a variety of external factors that influence product demand, such as weather, events, pricing, promotions, and more. This is the part in which AI tools simplify and smooth the process.

Businesses can prepare themselves for peaks and sales to plan and optimize inventory levels, reducing the risk of stockouts or overstock situations, and reducing also the industry's environmental impact.

Stock levels is, as we could understand, a focal point for the inventory management, but as we have already mentioned, the variables that affect fashion luxury brands and retailers are multiples, and few consumers industries move as quickly as fashion. This is why, in order to always and promptly respond to continuous and unpredictable changes in customers preferences and fashion market trends, fashion luxury businesses need a dynamic replenishment system. To provide timely inventory replenishment, AI technologies can predict lead times that, in supply chain management, represent the amount of time from the point that an entity (vendor, producer/manufacturer, warehouse, distributor, supplier, and retailer) processes an order, manufactures a product, or prepares an order, to the point it gets delivered to the customer.

This process implies transitioning products from storage areas to sales spaces, to meet customers' demands without experiencing stockouts or overstock issues. Inventory optimization can also be intended as the allocation of products across different locations and geographical areas: to deal with this geographic scope, AI enhances the businesses performance to meet regional demand, reducing shipping costs and delivery times.

Maintaining optimal inventory levels is tied to the strategic goals of a company, like the need to clear inventory at the end of the season by placing the right products in the right places. [50]

With advancements in technology, fashion luxury businesses are increasingly moving towards automated stock replenishment systems where AI powered systems can dynamically adjust reorder points and quantities based on real time demand fluctuations. AI technologies are implemented to predict stock requirements, re-ordering and re-balancing for every product, as they provide for real-time visibility into both inventory levels and logistics operations.

This creates greater efficiency, while minimizing manual work which is incredibly time consuming and error prone, as well as transparency to track movements of goods and inventory in transit.

Another application of AI algorithms in the logistics is the optimization of routes, taking into consideration factors such as traffic conditions, delivery schedules, and transportation costs. Overall the advanced algorithms improve the efficiency of product distribution, reduces transportation expenses, and enhances overall logistics performance.

When we talk about inventory management, we should also focus our attention on warehouses: their functioning is, in fact, necessary to have optimal logistics processes. AI-powered robotics and automation systems can streamline warehouse operations with tools that enhance productivity, maximize efficiency, minimize errors due to manual product handling, foster a safer working environment and avoid stockouts.

The automation technologies used in warehouses are robotic material handling systems to improve material handling and movement. A practical example are autonomous mobile robots (AMRs) that can be used to transport goods around a warehouse, freeing up human workers to focus on other tasks such as picking and packing. One method to improve order distribution is by using picking assistance systems, such as pick-to-light or voice picking. Pick-to-light systems make use of visual cues, like lights and displays, to guide operators to the proper items and amounts. Similarly, robotic arms and grippers can be used to handle delicate items in tandem with AMRs or conveyors, reducing the risk of damage during transportation

[50] Centric Software, Inc. (2024, April 18). *The power of AI inventory replenishment for fashion retailers*. Centric Software. https://www.centricsoftware.com/blog/inventory-replenishment-for-fashion-retailers/

and storage. Studies have shown that a single picking mistake reduces order profitability by as much as 13 per cent. [51]

Another application area of AI technologies in the logistics is the optimization of reverse logistics processes, by analyzing return patterns and reasons for returns: organizations can improve return management strategies and reduce associated costs. Reverse logistics is the process of returning goods and materials back to the original manufacturer or supplier. In retail and ecommerce, customers may return a product for many reasons, such as damage, defects or simply because the customer changes their mind.

Businesses, especially in luxury retail and online shopping, often face these extra costs in dealing with returned items. How a company handles these returns can impact on its money and resources. If not done well, it can make customers lose trust and loyalty towards a fashion luxury brands, whose standards are always thought to be superior compared to others. .

The solution lies in the implementation of AI tools: both augmented reality and chatbots represent a valid solution to the reverse logistic process: in the former case, as we have already discussed, the use of AR will let the customer to concretely visualize the product he/she wants to purchase, making him/her more sure about the item, while in the latter, chatbots can provide accurate product description and establish a formative communication with the customer, avoiding misunderstandings.

The last important topic to analyze in the inventory and logistic sphere is the maintenance of vehicles: the fashion luxury industry is mostly capital intensive and AI technologies can help textile companies to save time and money through predictive maintenance of equipment like looms, knitting machines, and spinning frames. [52] The data analyzed by AI advanced technologies are sensor data that provide insights on vibration, temperature, and noise. Machine learning models are able to analyze data and detect anomalies that could indicate impending

[51] *Master your inventory: Top 5 proven warehouse management techniques for immediate results | Zoho Inventory*. (2024, July 2). Zoho Inventory. https://www.zoho.com/inventory/academy/warehouse-management/top-5-ways-to-streamline-warehouse-operations.html

[52] *Predictive Maintenance - Maximo Application Suite | IBM*. (n.d.). https://www.ibm.com/products/maximo/predictivemaintenance?utm_content=SRCWW&p1=Search&p4=43700080617779195&p5=p&p9=58700008757604281&gad_source=1&gclid=CjwKCAjw3P-2BhAEEiwA3yPhwFVPZ4Rc3xPGC6PGRyPmhbvY0Z7QjRRqHdnfKWcOYDveKKv2hAQCOhoC8DwQAvD_BwE&gclsrc=aw.ds

mechanical issues, sending alerts to plant managers so they can schedule maintenance and repairs before a costly breakdown occurs. Predictive maintenance reduces unplanned downtime and improves operational efficiency.

CHAPTER 4 - CHALLENGES AND ETHICAL CONSIDERATIONS

4.1 BENEFITS FO THE COMPANY: SUSTAINABLE PRACTICES

The integration of AI in the luxury industry brings numerous benefits. First and most relevantly, it enables brands to reduce their carbon footprint by optimizing processes, improving resource efficiency and consequently minimizing waste. AI enhances transparency and traceability in the supply chain, allowing brands to verify sustainable sourcing practices and provide customers with accurate information about the products they purchase.

Predictive analytics, that we have discussed in detailed in previous chapters, can combat overproduction; other AI technologies allow for sustainable materials sourcing, for example in the process of environmentally- friendly and ethically-made materials selection.

Moreover, AI algorithms can lead customers to discover sustainable fashion brands suited to their personal preferences.

Lastly, since AI can help enhance the shopping experience through virtual assistants, chatbots, and AI-powered platforms, customers will be more satisfied about what they buy and, ideally, they hold on to those pieces longer.

As a result, the amount of cloths and textiles that would have otherwise gone to landfills and produced losses of billions of dollar is reduced, and there's less harm done to the environment, less waste, and collective production should slow down over time.

In conclusion, AI plays a huge role in empowering sustainable fashion: from supply chain management to personalized recommendations, designed with positive impact in mind, it can help the industry embrace and adopt sustainable change at every stage. [53]

However, it is essential to consider potential concerns and ethical or technical implications. In the following sections it will be provided an analysis of how luxury brands try to reach a balance between AI-driven automation and human expertise, ensuring that not only sustainable decision-making, but also cultural and ethical norms remain at the forefront.

[53] Journal, S. (2023, August 2). How AI could help sustainable fashion. *SANVT*. https://sanvt.com/blogs/journal/artificial-intelligence-in-sustainable-fashion?srsltid=AfmBOoots1bTimr8dfWHVdZYe3ZO3muXn2u7Ky2paBQHLIcZxa7kwj7L

4.2 TECHNICAL CHALLENGES

Luxury brands design products reflecting the highest levels of human creative. The brands build their competitive advantage in the marketplace relying on authenticity and person-to-person connections that build trust. Rather than enhancing those qualities, the irresponsible use of GenAI can threaten them, and this happens especially when GenAI moves beyond internal operations, like forecasting demand and driving operational efficiencies, and reaches more consumer-facing applications that it gets tricky.

AI tools, in fact, still come with technical limitations. AI algorithms still exhibit limited capabilities when dealing with complex, ambiguous, or subjective fashion design tasks that need to promote both unique visual and cultural attributes.
While areas like image recognition and natural language processing have had huge development and have increased their own efficiency, when it comes to fashion design AI may struggle to fully replace human aesthetic discernment and creative abilities. [54]

Furthermore, the process of training AI algorithms requires a substantial amount of data to enhance their accuracy and forecasting capabilities.
However, in the fashion and luxury industry, data annotation is costly, and are costly also the professional human annotators that work for the acquisition and processing of such data. In contrast to other industries, fashion and luxury datasets are typically smaller in scale and this is why the the application scenarios and effectiveness of AI technology can result quite limited.

The Federal Trade Commission mirrors some of the concerns raised by customers, along with potential biases and inaccuracies that could result from machine learning rather than human interaction.
“The introduction of AI presents new layers of uncertainty and risk. The technology is altering the market landscape, with companies moving to provide and leverage essential inputs of AI

[54] Dou, J. (2024). The application and challenges of artificial intelligence in the fashion and luxury industry. *Applied and Computational Engineering*, *42*(1), 90–96. https://doi.org/10.54254/2755-2721/42/20230694

systems – opening a window of opportunity for companies to potentially seize outsized power in this technology domain," write FTC authors Simon Fondrie-Teitler and Amritha Jayanti. [55]
A Forbes Advisor survey among 2,000 Americans polled by OnePoll found some interest results on customers sentiment and how they feel about the potential manipulations they face by businesses using AI.
For example, 70% of consumers are concerned about AI being used in product descriptions and 60% in product reviews. Nearly two-thirds (64%) worry about personalized advertising, 58% find chatbots answering questions problematic and 76% are concerned AI can cause misinformation on a company website.
On the other hand, consumers are less concerned about companies using different personal data to enhance the customer relationship, for example 48% of them approve of it for past purchase history and actions, while 55% have little problem with retailers tracking their social media usage and engagement. However, fewer are comfortable with AI analyzing their text messages (33%) and phone conversations (21%). [56]

The value of luxury brands will be realized once AI technologies and algorithms are strategically employed to maximize synergies across brands and geographic areas while recognizing their distinctiveness.
However, successfully implementing AI in the luxury market will not be solved by technologists who passively use these advanced algorithms, but by forward-thinking and proactive executives and staff members engaged in creative, marketing and customer service roles.
"Luxury is about people. AI is a tool that can shape and improve certain marketing efforts. It doesn't replace the personal side of business, and a full-on luxury AI experience doesn't exist yet," observed luxury market research expert Chandler Mount of the Affluent Consumer Research Company.
The use of AI poses also legal challenges in the spectrum of intellectual property rights, where ownership of intellectual property created by or in part by AI is uncertain and where the efforts of intellectual property owners can be easily replicated.

[55] Danziger, P. N. (2024, April 24). *LVMH sees the AI challenge for luxury is not technology but the human element*. Forbes. https://www.forbes.com/sites/pamdanziger/2024/04/24/lvmh-understands-the-ai-challenge-for-luxury-is-not-technology-but-the-human-element/

[56] *Ibis*

Copyright is another area which is covered with respect to the interaction of AI and intellectual property rights, and it raises potential issues of ownership. The main feature of AI analyzed in the fashion industry that raises copyright questions is AI application to generate fabric patterns, colors, and silhouettes. To the extent that AI-generated designs include contributions from both a human and a machine, the question is whether and at with respect to what threshold the design is jointly owned or is solely owned by the human who contributed to the design.

At present, there is no clear protection for fashion designs created using AI under U.S. copyright law and no specific law that addresses the ownership of works created by machines.

If AI-generated designs are not eligible for protection, they may become more susceptible to copying, potentially harming luxury fashion companies and brands in the future.

4.3 ETHICAL IMPLICATIONS

The use of Al in the fashion and luxury industry raises concerns about social acceptance and ethical considerations.

Prioritizing fairness and transparency in AI applications has become a significant concern, because if algorithms rely solely on historical purchase for making product recommendations while ignoring individual consumer preferences and changing needs, it can cause discomfort and frustration among consumers.

To address this issue, it is essential to establish relevant ethical guidelines and regulatory mechanisms. Balancing the potential benefits of AI in terms of efficiency and innovation with its societal impacts, such as job displacement, is a complex ethical challenge, because as automation and Al-driven processes become more prevalent, certain roles within the industry may become redundant and obsolete, resulting in job loss for workers. [57]

This is why this technological advancement should also emphasize strategies such as reskilling and upskilling to prepare employees for a changing industry landscape.

[57] Giovanola, B., Tiribelli, S., Frontoni, E., & Paolanti, M. (2023). Ethical implication of Artificial Intelligence in the Fashion Industry: A comprehensive analysis. *Fashion Highlight*, (2), 22–28. https://doi.org/10.36253/fh-2497

Another area of concern that has arisen with respect to the use of AI in the fashion industry is the impact that AI technologies may have on consumer privacy. By relying on vast datasets screening and interpretation, AI tools allow companies to adapt to the market, identify trends, track competitors' activities via the Internet and social media, and improve consumer experiences and target consumer demands. However, consumers may not be aware of how much and what type of information is being collected from the Internet, and might be exposed to situations in which some of their sensitive data are dispersed.

Regarding the ethical considerations, it is also worth to cite the issue of lookism, which is the discrimination based on a person's aesthetic characteristics, including aspects of appearance and ethnicity. As AI systems are tasked with designing, marketing and personalizing fashion products, there is a significant risk that these systems could reinforce societal biases, including racial and ethnic discrimination[58], as well as the adoption of 3D samples regarding virtual reality, that might consider only certain body shapes. This concern goes beyond mere aesthetics and touches on deeper issues of representation and inclusivity within the fashion industry.
Addressing these biases requires a conscious effort to diversify data sets and implement checks to prevent discriminatory outcomes.

A study conducted by the university of Macerata by Benedetta Giovanola, Simona Tiribelli, Emanuele Frontolo and Marina Paolanti, has provided some very useful and interesting insights that, put together, paint a comprehensive picture of the current state and future trajectory of AI in fashion; [59] their results are all synthetized in the following table:

[58] Giovanola, B., Tiribelli, S., Frontoni, E., & Paolanti, M. (2023). Ethical … page 48

[59] *Ibis*

Category	Technical Aspects	Ethical Concerns	Challenges
Machine Learning and Deep Learning	- Predictive analytics - Image recognition - Consumer behavior analysis	- Bias in algorithms - Over-reliance on data-driven decisions	- Ensuring accuracy - Diversifying training data
Image Recognition and Processing	- Use of CNNs for fashion item identification - Visual search in e-commerce	- Privacy concerns with image data - Accuracy in diverse contexts	- Handling diverse fashion styles - Balancing efficiency and privacy
GANs in Design	- Generation of new patterns and designs - Prototype visualization	- Originality and intellectual property issues - Over-dependence on AI for creativity	- Defining authorship - Encouraging human-AI collaboration
NLP for Customer Interaction	- Chatbots for customer service - Sentiment analysis in customer feedback	- Privacy and data handling - Misinterpretation of complexities in language	- Developing context-aware systems - Protecting consumer data
Supply Chain Optimization	- AI in inventory management - Predictive analytics for demand forecasting	- Impact on employment - Ethical sourcing and production	- Balancing automation and human labor - Transparent supply chain practices
Sustainability	- Resource optimization - AI-driven material selection	- Environmental impact of AI operations - Promoting sustainable practices	- Reducing AI's carbon footprint - Implementing eco-friendly solutions

Table 1. Overview of AI in Fashion: Technical Aspects, Ethical Concerns, and Challenges.

4.4 REGULATIONS

The adoption of AI in the luxury fashion industry is governed by a variety of legal frameworks and regulations at both national and international levels, that cover areas just discussed, such as intellectual property, data protection, ethical AI use, supply chain transparency, and consumer rights. Because it does not exist a single global law governing AI in fashion, there are various regional and international regulations that collectively address the different aspects of the industry's operations.

For example, Intellectual Property (IP) are protected by IP Laws: IP Laws at European Level make reference to the EU's Design Directive and Regulation, which states that designs can be protected if they are new and have individual character. However, whether AI-generated designs qualify for these protections is still debated.

With respect to the U.S. Copyright Office currently does not extend copyright protection to works created by non-human authors. This means AI-generated designs may not receive the same level of legal protection as human-created designs.
However, the Compendium of U.S. Copyright Office Practices specifically has a human authorship requirement in section 306, which states that "[t]he U.S. Copyright Office will register an original work of authorship, provided that the work was created by a human being. . . . [T]he Office will refuse to register a claim if it determines that a human being did not create the work." [60]
At the international level, WIPO (World Intellectual Property Organization) is exploring the implications of AI on IP but has not yet issued binding regulations.

Although there is no federal regulation or law in the United States that addresses consumer data privacy, a number of states, such as California, have passed consumer privacy laws that impose specific duties on companies or individuals collecting data and also includes provisions that address individual consumer rights. [61]
A particularly mindful regulation for global brands, is the recently enacted General Data Projection Regulation (GDPR) entered into force in May 2018 that governs the collection, use, transmission, and security of data collected from any residents of the European Union. In China instead, The Personal Information Protection Law (PIPL) and the Data Security Law (DSL) regulate how companies collect and process personal data, especially regarding AI in e-commerce and fashion.

As we have previously mentioned, AI in luxury fashion must adhere to ethical standards, especially concerning non-discrimination, transparency, and consumer trust.
The EU's AI Act, still under negotiation, aims to regulate AI based on risk levels. High-risk AI systems used in sectors like retail and marketing might face strict scrutiny.
In US, while there is no comprehensive federal AI law, the Algorithmic Accountability Act proposes oversight on AI systems that make significant decisions affecting consumers.

[60] *Artificial intelligence and its impact on the fashion industry: Contemporary legal Considerations - Haug Partners*. (n.d.). Haug Partners. https://haugpartners.com/article/artificial-intelligence-and-its-impact-on-the-fashion-industry-contemporary-legal-considerations-2/

[61] *Ibis*

There are various laws that focus on responsible sourcing and reducing environmental impact with respect to the supply chain transparency and sustainability: in EU, Corporate Sustainability Reporting Directive (CSRD) requires companies to disclose detailed information on sustainability and supply chain practices, and AI tools can help meet these requirements by monitoring environmental and social data.
On the other hand, the U.S. has laws like the Modern Slavery Act that push for transparency in the fashion supply chain, especially in sourcing raw materials, where AI plays a role in tracking and verification.

AI-driven automation in manufacturing and supply chain logistics also raises legal issues concerning labor rights and the future of work in the luxury fashion sector. The International Labor Organization (ILO) is increasing scrutiny on ensuring fair labor practices, decent work conditions, and retraining opportunities, while the European Union has labor laws that could impact automation, particularly where jobs may be lost due to AI.

Wearable and smart fashion technology, including AI-powered luxury fashion items like smart garments, raises consumers safety concerns and is subject to product safety laws.
The EU's General Product Safety Directive ensures that AI-powered wearables comply with safety standards, while the Radio Equipment Directive regulates wireless devices, which could include smart clothing, while in the United States the Consumer Product Safety Act (CPSA) applies to AI-powered fashion items, requiring them to meet safety standards before they enter the market.

Lastly it is relevant to underly that national and regional laws require that AI-driven fashion platforms and algorithms that shape market behavior (e.g., pricing strategies, recommendations) must comply with antitrust and competition laws.
In Europe, the body entitled to monitor the use of AI in price-fixing, collusion, or market manipulation through automated systems is the European Commission, while in the United States the Sherman Antitrust Act can apply to AI systems that might foster anti-competitive behavior among fashion companies using similar AI tools.

CONCLUSIONS

In conclusion, this thesis has examined the enormous potential that artificial intelligence (AI) technologies have to revolutionize the luxury fashion sector, pointing out both the advantages and disadvantages of this change. AI provides the industry with strong capabilities to improve efficiency, inventiveness, and customization. Through advancements in deep learning, AI's understanding of fashion aesthetics and creativity can continually improve, while innovations in data annotation methods can make the process more cost-effective, enabling the development of richer and more comprehensive datasets.

Furthermore, new opportunities for improving consumer engagement and honing brand strategy arise from the integration of machine learning and natural language processing into numerous corporate activities, including marketing, product suggestions, and customer support.

Though encouraging, AI's impact on cultural trends carries the risk of homogenizing fashion expression and eroding the cultural diversity that is essential to the fashion industry.

From an economic perspective, AI-driven efficiency is reshaping the fashion industry's supply chains and marketing strategies, responding to modern consumer demands. Yet, these advancements come with trade-offs, including the risk of job displacement and an increased reliance on data-driven models, which may at times neglect the human-centric and emotional elements that make fashion an art form.

Unlocking AI's full potential will require overcoming its present constraints: as Gianni Versace once said: « I would not be interested in the past, if it wasn’t that it is the path for future».

Ongoing research and development will make sure that this technology not only enhances the luxury fashion scene but also helps to create a more diversified and sustainable future. Although the process of incorporating AI into the fashion industry is still in its early stages, it has the potential to be a potent driver for positive change in this vibrant and significant sector.

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