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Data Analytics & Application Challenges in the Childrenswear Market- a Case Study in Greece

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Abstract. Integrating technology solutions like PLM, 3D Prototyping, digital printing, automatic cutting, AR & VR into the fashion product development process can deliver continuous improvement in everyday business and empower fashion companies navigate the challenges and opportunities of Industry 4.0. Leveraging powerful artificial intelligence capabilities that guide the discovery of next-generation - in popularity- fashion product designs, can improve innovation and conceptual design exploration to the clothing companies. This study focuses in the market of childrenswear which is the fastest-growing and one of the most lucrative markets in the garment industry; a growth that had overtaken both menswear and womenswear. At the same time, childrenswear product consumers are fashion conscious, demanding more fashionable designer clothing. Predicting the best appealing and selling product maybe the recent demand of applying AI tools in the design generation phase or decision making process, however comfort, fit for play, rest and safety most of all, are requirements that childrenswear must comply with. This paper aims to identify the challenges that AI technology applications face regarding childrenswear, due to safety restriction and standards by taking into consideration a Greek childrenswear manufacturer and retailer.

Keywords: Childrenswear, Data Analytics, Machine Learning, Safety standards

1 Introduction

Integrating technology solutions like PLM, 3D Prototyping, digital printing, automatic cutting, AR & VR into the fashion product development process can deliver continuous improvement in everyday business and empower fashion companies navigate the challenges and opportunities of Industry 4.0. Leveraging powerful artificial intelligence capabilities that guide the discovery of next-generation - in popularity- fashion product designs, can improve innovation and conceptual design exploration to the clothing companies. This study focuses in the market of childrenswear which is the fastest-growing and one of the most lucrative markets in the garment industry; a growth that had over-

taken both menswear and womenswear. At the same time, childrenswear product consumers are fashion conscious, demanding more fashionable designer clothing. Predicting the best appealing and selling product maybe the recent demand of applying AI tools in the design generation phase or decision making process, however comfort, fit for play, rest and safety most of all, are requirements that childrenswear must comply with. This paper aims to identify the challenges that AI technology applications face regarding childrenswear, due to safety restriction and standards by taking into consideration a Greek childrenswear manufacturer and retailer. It is organized in six main sections.
Section 2 addresses the importance of childrenswear market in the clothing sector, the interest that this segment shows in fashionability which leads to fashion conscious and demanding fashionable product consumers, and the product safety restrictions and standards that designs must comply with. Section 3 summarizes the latest projects on artificial intelligence technology applications in the clothing industry, and more specifically in fashion product design, with aim to predict future market preferences and high buy rates. Section 4 presents not only the academic work conducted in the distinct domain of the fashion and apparel industry but a literature review focusing on the supply chain stage of the design of new products. Section 5 illustrates how a Greek childrenswear manufacturer and retailer develops fashion products taking into consideration comfort, fit for play, rest and safety regulations and restrictions. Finally, the research concludes with the challenges that arise when applying AI technology methods in the design process of such specialized products and the potential of new approaches rising from these challenges.

2. The Childrenswear Market

Childrenswear and babywear are outperforming the overall apparel market in Europe, presenting exciting opportunities for exporters from developing countries. The childrenswear market is the fastest-growing and one of the most lucrative markets in the garment industry [1], and in 2016 this growth had overtaken that of both menswear and womenswear [2]. Especially in Europe, this segment market shows interesting fashionability since the influence of social media and celebrities on younger children – and their parents – has caused children's clothing to evolve into a trend leader, with kids more aware than ever of trends [1].
Parents may be eager to give their children the best possible appearance but children's clothing basic requirements are comfort, fit for play and rest as well as safety. Product safety is one of the legal requirements that childrenswear must comply with, to be allowed on the European market. However, designers, when developing a child's garment, keep in mind special characteristics like growth features. Children grow rapidly, therefore features that allow for growth are important. Design for this specifications usually include sleeveless designs, adjustable shoulder straps, elasticised waistlines or wrap styles. Closures, which are on the front of the garments so children can see the fasteners and manipulate them easily, are carefully selected by the designers based on the age and the ease of manipulation by the wearer (child). Zippers, buttons, hooks and loop fastener tape, gripper snaps are not only functional but sometimes decorative. Enhancing a basic design style with decorative trims and accessories like motifs, ribbons, buttons and zippers trying sometimes to imitate an adult's style, is a usual practice. Adding value to a clothing product with decorative accessories is as much a commodity

in modern children clothing as are the guidelines on the standards of such items for safe use.

Das [3], discussed the importance of safety issues and possible hazards associated with the application of different accessories in children garment and the guidelines on the standards of such items for safe use. Indeed, assisting the suppliers with the right guideline through the product development process, helps not only to establish the required safety standards, but also to produce apparel products that will limit potential hazards. Children's' safety through clothing has been the research focus also of Esrafilian & Nazari [4], who considered simultaneous and stable design of colourful diversity and announcement of protective alarms on child's garment against ultraviolet utilizing photochromic dyes.

To prevent children from (fatal) incidents, children's clothes must meet the requirements on cords and drawstrings laid down in the EU standard EN 14682:2007 [5]. Another voluntary, ASTM F1816-18 [6], is the current Standard Safety Specification for Drawstrings on Children's Upper Outerwear.

According to the studied Greek childrenswear company and to the study of Chatterjee [7], the value-added works in children garments mostly consist of:

1) Embroidery
2) Patchwork
3) Attachment of accessories
4) Printing and decorative painting

Trim can make a garment special to a child. Decorative machine stitching, embroidery, smocking, ribbons, braid, appliqués, ruffles, lace, and bias binding are some trimming possibilities [7].

Below, in the Figure 1 we explain the restrictions on embroidery and accessories

Fig. 1: Restrictions for Trims' use in children's clothing

3. AI Technology Applications in the Clothing Industry

Since childrenswear product consumers are fashion conscious, demand more fashionable designer clothing. They also follow the adult apparel trends and as a result, brands and manufacturers need to analyse customer's intentions, so as to determine the trend of future products and business development direction [8]. Most of the production and distribution processes of clothing product cycle have been automated in a high level, based on customer preferences and new trends. Lately however, we see several projects that combine Artificial Intelligence technology in fashion product design, since it can effectively enhance the product development process, which is long and high in cost., being difficult to grasp the market's preference. Zalando a on-line fashion platform, team-up with Google who trained a neural network of 50.000 datasets, to analyse the style preferences of 600 fashion influencers, and predicted what kind of fashion people might like and created designs that match them [9]. Amazon's Lab126 [10], has developed an algorithm that learns about a particular style of fashion from images, and can then generate new items in similar styles from scratch—essentially, a simple AI fashion designer. Reimagine Retail, a project from Tommy Hilfiger, IBM and Fashion Institute of Technology, uses natural language understanding, computer vision as well as several deep learning techniques trained specially with fashion data, to create completely new designs by incorporating the trends of other designs into the ones already existing in the

Tommy Hilfiger database [11]. Stitch Fix, an upstart e-commerce service, uses data science and combine popular attributes from past items to create pieces that will have predictably high profit margins and buy rates [12]. Gap Inc. [13], in order to shorten the cycle from design to sale and find the right trends, utilizes a data mining approach to extract the market trend for the next season's collections instead of relying solely on the Creative Director's vision [14].

4. Academic Relative Work

In the last decade, the fashion and apparel industry has drawn the attention of AI academic researchers and specialists to not only respond quickly to constant change of consumer demands and behaviour, but also to predict the best trend, colour combination, fabric and fit. Guo et al, [15] identified 95 research issues for AI application in apparel industry, with 26 of them in apparel design and more specifically in apparel CAD system, fabric-related issues, color-related issues, pattern design and garment evaluation. The work of Ngai et al [16], although a review of 77 papers related to the application of decision support and intelligent systems in the textile and apparel supply chains, showed only 4 in product design and development. The study of Hsiao et al [17], chose grey theory and used Fuzzy C-Means algorithm to investigate fashion colour prediction, by automatically recognising colour clusters among digital images. The same year, Mok et al [18], developed a customised fashion design system to create fashion designs and make corresponding patterns by using interactive generic algorithms and fuzzy set theory to model design knowledge. Researchers from UC San Diego and Adobe [19] have outlined a way for AI to learn an individual's style and create customised computer-generated images of new items that fit that style; a first step towards building systems that go beyond recommending existing items from a product corpus, but which can be used to suggest styles and aid the design of new products [20]. Yildirim et al [21], presented a survey on how Data Mining methods can help the decision making processes, but it was restricted in textile applications and not in apparel or fashion design. Hong et al, [22] presented a knowledge-based open performance measurement system (KBOPMS) in big data environment, in order to support complex industrial decision-making for new product development to address the current market pressures that drive firms to adapt new design process in product development (PD) processes. Zhu et al [23], proposed a new approach to discover popular fashion product styles from product images and transaction history without supervision by training a CNN-based deep attribute model. In the second phase, new "must-have" fashion products are automatically designed by Variational Autoencoder with images of discovered popular styles. Generating new products based on popularity information with AI technology, may have not been considered in previous fashion design studies using generative models [24], but a forecasting model which was trained to represent fashion trends over time and predict their popularity in the future was introduced by Al-Halal et al [25].

Colour and material decision is every season's designer's headache. AI Color Trend, a database on color fashion trend analysis and guidance, was released in 2017. [26] analysed data from international fashion weeks, brands as well as the most popular colours and fabrics in the domestic market of China. More recently, Google Arts & Culture unveiled a machine learning project, in partnership with Business of Fashion, called Runway Palette. The tool, open to the public, maps out 144.000 runway looks of almost

1000 designers from the past four years, and allows users to upload their own photos to find dozens of similar runway outfits [27]. With this experiment, designers from clothing brands can discover not just the seasons, but also the trends that come from fashion weeks worldwide.
The latest development of Li et al [8], introduced MixNMatch, a conditional generative model that learns to disentangle and encode background, object pose, shape, and texture factors from real images with minimal human supervision. Although not applied to fashion design yet, its proposed applications show many potentials.
Despite valuable contributions to the previous literature reviews, when observed, the reviews studied show several limitations (in total or separately):
1) The studies are restricted to specific product categories like T-shirts [23] or skirts [18]. T-shirt clothing in manufacture, in particular, is considered the most basic clothing product. Our case study childrenswear brand usually develops 180 initial T-shirt designs and 14 skirt designs, out of which 156 and 11 respectively, go to production.
2) The above mentioned studies of Section 3 are not applied in the real world of fashion retail sales or are not proposed for nonprofessional users, therefore the effectiveness and accuracy of the proposed model and method is not verified
3) Materials or decorative items are not considered separately as they do in the design phase
4) Safety factors of used accessories and components in children apparel are not considered either in any of the pro-mentioned academic research

5. Children Clothing Manufacturer and Retailer - A Greek Case Study

In order to produce and deliver safe, sustainable, and environmental friendly products to the customer, adherence to the appropriate specification, standard, law and regulation applicable for the merchandise is important [3]. The primary purpose of this research was to explore the complexity of today's fast-fashion product development process in the childrenswear market and the challenges that the creative team behind new product development face keeping in mind restrictions on safety. This section investigates how the childrenswear brand company in our case study, tries to be successful by achieving that. The researchers conducted field observation and interviews with 10 professionals who work in the Greek childrenswear brand. It was stated that the research and development of new production procedures are directed towards three main goals:

- Quality improvement

- Cost reduction in favour of the consumer

- Respect towards the client

A special focus was given to identify the product development model of a kidswear company with 500 selected children's clothing stores in Greece, Cyprus and other European countries. Our investigation resulted that it follows a traditional push system where:

- the new product development department —> develops the designs and technical specifications of the fabrics and the garments to be produced (Figure 2)
- the sales department along with the managers —> provide the manufacturers in Asia with information of the above as well as the volume of the products and sizes in which the garment is to be produced.
- the manufacturer —> follows the instructions to create multiple samples, which upon approval by the company, are converted into finished products and are transported to the company's headquarters in Greece. Figure 2 shows an example of a boys-set design accompanied with all the relevant instructions that reassure the construction of the garments based on the safety measures according to EU 14682. The company is also certified for ISO 9001:2008 by TUV.

Fig. 2: Design & Technical Specifications of a boy's clothing set

The company, acts as a wholesaler and as a retailer. In the case of the wholesaler, the garments are sold through:

- an intermediate to brick-and-mortar stores of multi brand retailers
- an intermediate to four (4) retail stores with consignment stock arrangements
- one (1) shop-in-shop retail point in a department store
- company's web store in retail price
- company's owned brick-and-mortar stores in Greece and abroad (13 stores)

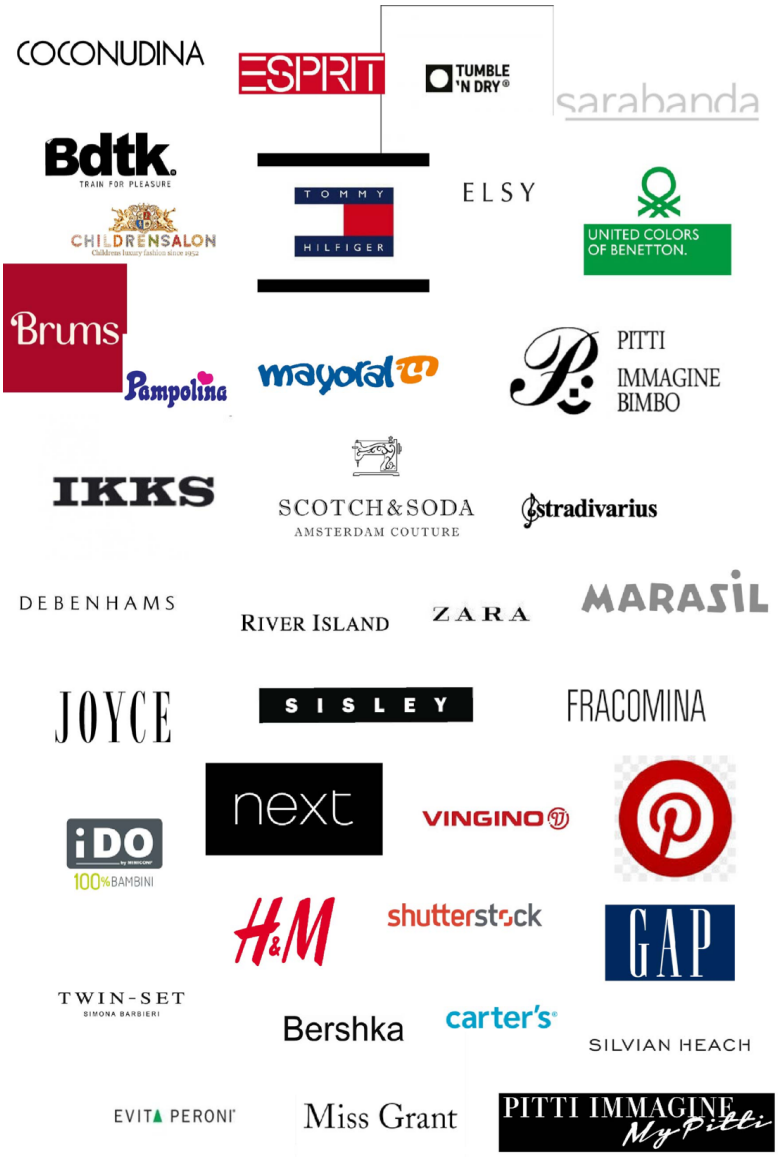

Fig. 3: Designers' inspiration sources

The designers employed by the company, are responsible for creating collections based on the current market and trend analysis [28], international trade show visits and participations, market research, previous collections sales etc. The Figure 3, shows a collection of brand logos where the designers collect their inspiration data from.

Importantly, based on the industry challenges and the opportunities that technology, and in particular AI, represents, the company is currently attempting to add smart applications into their existing product lifecycle. This AI approach will be similar to the one presented in the study of Pinquié et al [29], which utilizes a graph-oriented data structure that defined a design context based on its sub-elements: social, semantic, engineering, operational IT and traceability.

However, the company's approach will only be considering the semantic, engineering and traceability aspects of [29], and in contrast to the original work that uses the property graph to create proof designs that satisfy specific design rules, will utilize the application to derive design rules recommendation, and in association with its product lifecycle management (PLM) software, also produce as output similar items, that can be the basis of inspiration for new products. This will be done via natural language processing and machine learning text mining to obtain relevant keywords for the semantic context, data in terms of the engineering context directly derived from the PLM, and manual input in terms of the items as to the origin of the existing design items' inspiration by the product designers, as to the traceability context.

This will allow the company to obtain new designs in a structured way, faster than previously, as well produce designs that meet their clients' criteria and previous preferences, based on a semi-automated AI process.

6. Conclusion

Enhancing a basic design style with decorative trims and accessories like motifs, ribbons, buttons and zippers trying sometimes to imitate an adult's style, is a usual practice especially for childrenswear. However, while selecting accessories for children's wear, special attention should be given to the safety of the kids. Quality inspection and evaluation are required before purchasing any accessories by the garment industry [7]. At the same time, reports like the one of McKinsey [30], state that companies with the greatest overall growth in revenue and earnings receive a significant proportion of that boost from data and analytics. Yet, up to our knowledge, no research has been found on the application of Artificial Intelligence technology in the product development of children's clothing identifying, at the same time, critical indicators for achieving apparel safety. When applying AI techniques in decision making process in the design stages of apparel, safety technical regulations/standards related to apparels are not included. According to Chen et al [31], the introduction of apparel safety evaluation in apparel design and manufacturing process has the potential to minimize recall rates, and a further shift to pro-action and to prevention of losses will be made possible.

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