

STATE OF THE ART OF PRESENTATION OF CLOTHING TEXTILES IN E-COMMERCE WITH SIZE MATCHING ISSUES

Jarosław Wojciechowski^{1,*}, Renata Lisowska², Ewa Skrzetuska¹

¹ Faculty of Material Technologies and Textile Design, Institute of Material Science of Textiles and Polymer Composites, Lodz University of Technology, 116 Zeromskiego Street, Lodz, 90-924, Poland

² Department of Entrepreneurship and Industrial Policy, Faculty of Management, University of Lodz, Matejki 22/26, Lodz, PL-90-237, Poland

*Corresponding author. E-mail: Jaroslaw.wojciechowski@p.lodz.pl

Abstract:

“According to Lingaro’s analysis, the return of a product generates 5 times more CO₂ than the purchase itself. Thus, the optimization of online e-commerce purchasing processes is a serious challenge not only for business, but mainly for the protection of the environment and our global health.” Presentation of textiles and clothing in e-commerce in Poland has remained unchanged since the beginning of e-commerce (the setup of Allegro auction site in the early 2000s) until now with little exceptions of new technology trends powered by EU funds. In Poland, WearFits introduces an R&D solution in the form of a virtual fitting room presented in augmented reality (AR) view to decrease returns of textile clothing bought online. It uses an avatar of human size and shape of the customer’s body for fitting the three-dimensional models in AR view. The purpose of the article is to review the state of the art of presentation of clothing textiles in e-commerce in the world and in Poland for selling textiles online and to emphasize the problem of size matching in the context of returns.

Keywords:

Augmented reality in textile clothing e-commerce, clothing web fit quiz, cloth size matching

1. Introduction

About 1/3 of products purchased in online stores are returned by consumers, and this ratio often exceeds 50%. More than 64% of customers who happen to return products explain it with a mismatch, and at the same time 19% buy multiple versions of a single product just to find the right size. Returns generate real business losses of up to 10% of income, affect product prices, overall costs of running e-commerce, and have a much stronger negative impact on the environment [1]. The dynamics of e-commerce development in the world has been high for many years, and during the COVID-19 pandemic it has significantly increased, in particular in the textiles segment [2–4]. We like “hunting” for valuable textiles that can be purchased online at a bargain price. However, what looks nice in the photo in the store does not always look good on our figure. Ultimately, therefore, such goods are returned. The problem of unsuccessful purchases was even more acute during the pandemic. As a result of the introduced restrictions, customers only bought online, and at the same time stores had to massively introduce and improve online sales solutions, but, as it turns out, not enough. In this case, one of the most important things is not only the customer and his satisfaction but also optimization of purchasing processes to decrease the rate of returns in e-commerce, that is, to improve matching the clothing sizes to persons. Therefore, online stores with textile clothing should be designed in such a way that the process of adjusting the sizes of clothes will be as precise, easy, and comfortable as possible for users.

The aim of this publication is to present the state of the art presentation of garments in e-shops worldwide and compare to

Poland with respect to the size matching issues. Fortunately, the development of technology makes it possible to introduce certain processes and ways of presentation on the web to achieve the goal of perfect matching of garments when shopping online. One of the state of the art solutions is augmented reality (AR), but its actual implementation in textile clothing e-commerce is hardly seen. AR is an interactive experience of a real-world environment where the objects that reside in the real world are enhanced by computer-generated perceptual information. AR adds a digital layer to, or replaces, physical reality which is, for example, seen in Figure 1 where there is a dress presented on the mobile phone with a background of home wall [5]. Other solutions are existing in the web, such as a fit quiz for the customer and narrowing down the offer to sizes, but in this case the customer may buy nothing because the manufacturer does not have such body sizes in basic production. Thus, the solution to create a new extended body size table, for example obtained by three-dimensional (3D) scanning of body shapes in order to update the current trend of human body shapes, is a matter.

2. Research methodology

Uncertain, uncomfortable shopping for clothes on the Internet due to the repeatedly incorrectly chosen size when buying is the reason for starting this research according to the following methodology:

- Identifying trends in clothing textiles in e-commerce [6] including market analysis of e-commerce solutions for the sale of clothing;





Figure 1. A dress presented in AR technology at home with WearFits technology [5]. Image taken from ref. [31].

- Size matching issue (searching for the best solutions when it comes to matching the size when buying clothes);
- Comparison of Polish market of textile clothing-based e-commerce solutions with trends;
- Conclusions.

3. Clothing textiles in e-commerce

Foreign publications and research on markers on clothing for AR technology (Germany) [7] or the system concept based on infrared and RGB camera scans for the presentation of clothing (South Korea) [8] was just a try without a breakthrough to the market. There is one actually implemented solution for the sale of clothing in AR with the real person at the center of the presentation (India) [9–11], but not taking precisely the customer's body size and shape and none in the virtual reality (VR), like not started yet Metaverse [2]. A few of e-commerce solutions are using an avatar with size and shape of the customer's body [15] and most of the e-commerce solutions use two-dimensional (2D) images of textiles as at the beginning. E-sale centers (India solutions since a decade ago) [9–14] use avatars but without taking the exact human size and shape of the body and with the exact body size (Taiwan) [15]. Numerous sellers (Poland) [16,17] from the native fashion industry take advantage of 2D images for selling clothes, not taking into account the

actual physical features (size and shape of the body) of consumers based on a photo or scan of the client, or they do not allow precise product selection on the basis of all traits in Business to Customer (B2C) contacts [18]. For example, one item in e-commerce store [16] sells nearly the whole assortment, the problem being the entire B2C transaction because the customer pays for the item immediately, but it is not known, for instance, what color is chosen. The customer must send a message later to make the transaction precise.

In Poland, WearFits (an extension, because it is not a whole e-commerce platform, but only a script to be implemented in an e-store after suitable preparation) [24] introduces an R&D solution in the form of a virtual fitting room. It uses an avatar of human size and shape of the customer's body for fitting the 3D models of clothes, but without showing the person itself in the presentation in AR view. WearFits uses mobile devices such as smartphones to present a preset human size and shape of the body avatar with textile in AR, showing a proposition of a new perspective on textiles presentation [19,20].

The fashion industry companies use web and AR technologies [21–24] to help shoppers visualize the appearance of their textile products and at the same time to strengthen the emotional connection that the consumer can establish with their clothing. The use of mobile phones and tablets with augmented and virtual technology can significantly change the way the fashion e-commerce is perceived [6]. AR has been around for many years, but most consumers adopted the technology in 2017. In that year, smartphone integration reached a critical mass, and the smartphone is essential for using most AR applications. Snapchat [25] has helped pave the way for adoption of this technology by customers. Snapchat used to be the most common AR app out there.

AR technology uses the real image from the camera to maintain the position of objects in the real world, while improving the image with a number of additional graphic or sensory elements. In other words, AR is a real reality supplemented, or "augmented," with additional images, colors, and sounds. The result is a stimulating experience that invites users to the depths of a space or product. In the world of textiles nomenclature, the aforementioned functionality is not new, it is called "i-Fashion" and "Magic mirror" [8]. In ref. [8], the functionality is described in detail, or in fact it is the concept of implementing such a project.

However, the most impressive solution as a package of apps really implemented (India) [9–14] (only ref. [9] is based on AR) is for the presentation of textiles. Reference [9] is using AR at a stationary point e-sale center on Avatar. It seems that the exact human size and body shape are not taken into account, and the presentation is rather based on visual perception or alpha or numeric sizing [26]. The system is ca. 10 years old. This is presented by the "Tryon" system in Figures 2 and 3. The other apps from this package are "Style me" [12] (video presentation [13]) and "Tailor – i" [14]. These apps are complementary to the others. That means the systems complement each other with functionalities that one application would not be able to



Figure 2. Tryon by Textronics (India) – a mode of selecting garments on a touch screen. Image taken from ref. [9].



Figure 3. Tryon by Textronics (India) – a mode of presenting a virtual garment on an image of a real person. Image taken from ref. [9].

implement. And so the “Tryon” system – a virtual wardrobe based on AR – was implemented in India for the retail and e-commerce platform, especially for presentations of textile clothing with the use of AR at an off-line stationary point and sale with a person in the presentation area with AR technology (Figures 2 and 3). The implementation of AR for textile clothing initially involves selecting an item of clothing on the touch screen, and then filming a person standing in front of the camera of a dedicated set in a stationary showroom and then applying textures in the form of accessories from the AR virtual world, i.e., the e-shop database in the form of clothing such as blouses, pants, T-shirts or accessories for virtual clothing presented on the screen. The video presentations can be seen on YouTube [10]. Another web app, Tailor-I, allows you to include every detail of tailoring in the final design that the customer orders and the tailor makes. However, these last two applications of this manufacturer use neither AR capabilities nor the image of the buyer. According to “Fashion E-commerce Report: Consumer Trends & Strategies for Brands” from e-commerce marketing platform Yotpo (Israel) [27], it is recommended that online fashion retailers create a “fit quiz” that customers can take to help direct them to the most suitable items in order to influence the decrease of returns [28].

Another solution of Taiwan origin, with similar name to Indian “Style me” but with a dot in between in the form of an online store style.me [15], is a solution that is very interesting and accurate, focused on an accurate presentation on the Avatar preceded by entering the detailed body size of the buyer and declaring the shape of the body, which is presented in Figure 4.

It does not take into account an offline photo of a person or a video camera, nor does it use AR, but the solution has been known since nearly a decade ago. An interesting fact is that the e-shop shows the matching of a given wardrobe to the avatar character with the dimensions provided by the customer, which

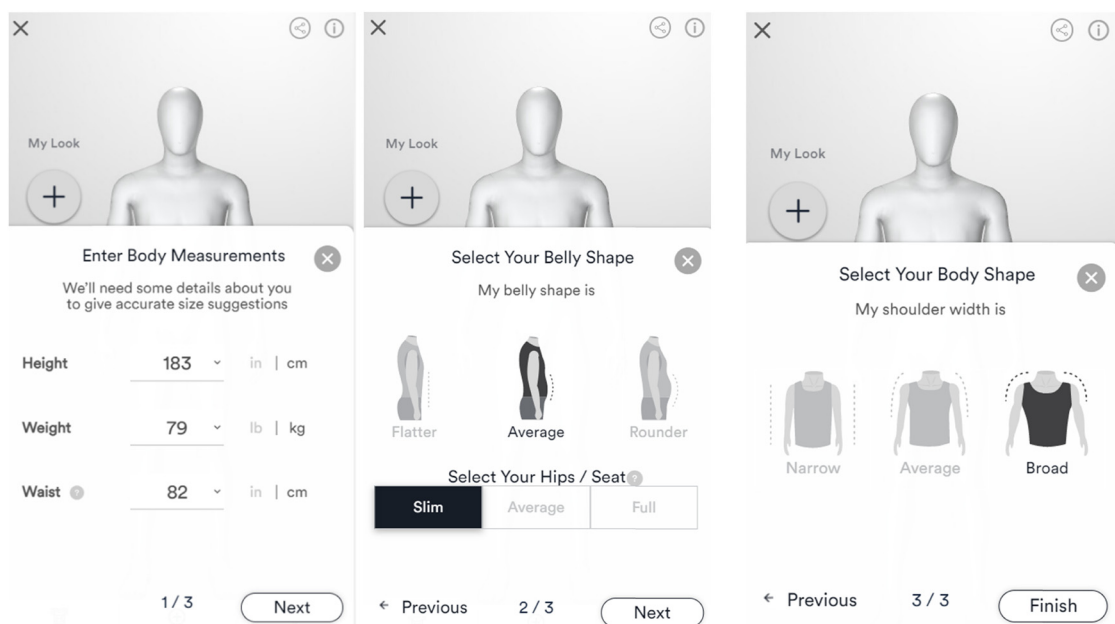


Figure 4. Style.me virtual fitting room for Avatar. It shows the clue fit to the body. Image taken from ref. [15].

should be the standard in all e-commerce shops, among others, for example, in Poland. The situation regarding the lack of a person in the center of the web scene is common. The algorithm of size matching is not showed by style.me.

Presentation of textiles and clothing in e-commerce in Poland has been the same since the beginning of e-commerce (the setup of Allegro auction site in the early 2000s) until now with little exceptions of new technology trends powered by EU funds. WearFits [5] which is a part of the S5 – 5 G Technology Accelerator in the Lodz Special Economic Zone [29] and with the support of Ericsson specialists [30] uses AR technology to create the so-called virtual fitting room extension, which is presented in Figures 5–7.

It offers the so-called size matching that is a fit quiz, i.e., selecting the optimal size for an individual body structure and

3D visualization of clothes in AR. By providing their gender, basic dimensions: height, chest, waist, and hip width, reflecting the silhouette, the consumer receives a virtual model of his figure, fitted with 98% accuracy. Thanks to this, when shopping online, we can check what size of a particular garment will be good for us, or whether it will not fit us. We get clear, visual information about how the garment will look like and where it can potentially be too big or too small with checking the comfort option shown in Figure 8. Thanks to the AR technology, one can put a virtual Avatar in real size in one’s own room and see it in the selected clothes, from all sides. The QR code which we scan with mobile is presented in Figure 9. When we open camera of our mobile, the app pops up the opening of the user agent with AR view (Figure 10). The technique behind the scene is digitization of products with a die in specialized CAD software using the 3D Zpac model [32]. The algorithm of size matching is not shown by WearFits.

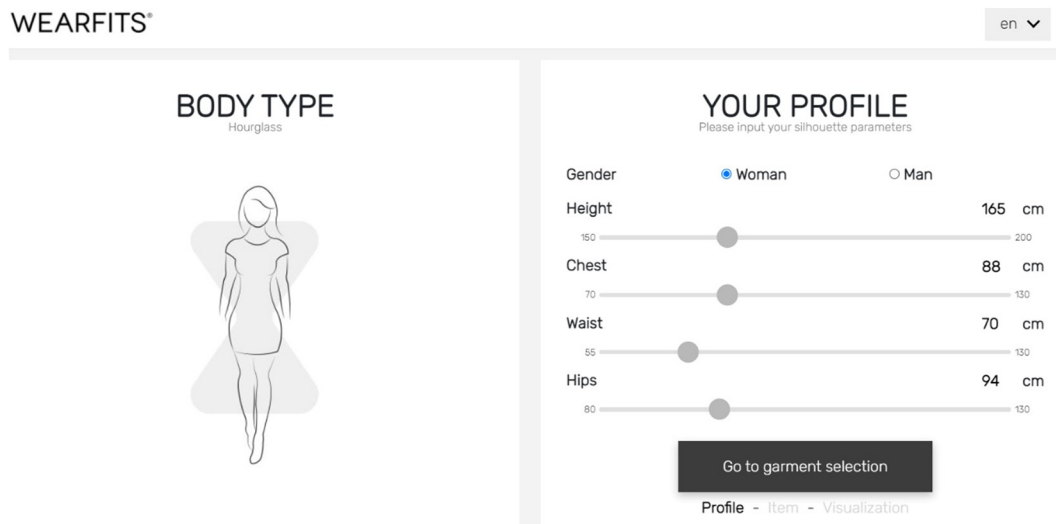


Figure 5. WearFits body parameters. Image taken from ref. [31].

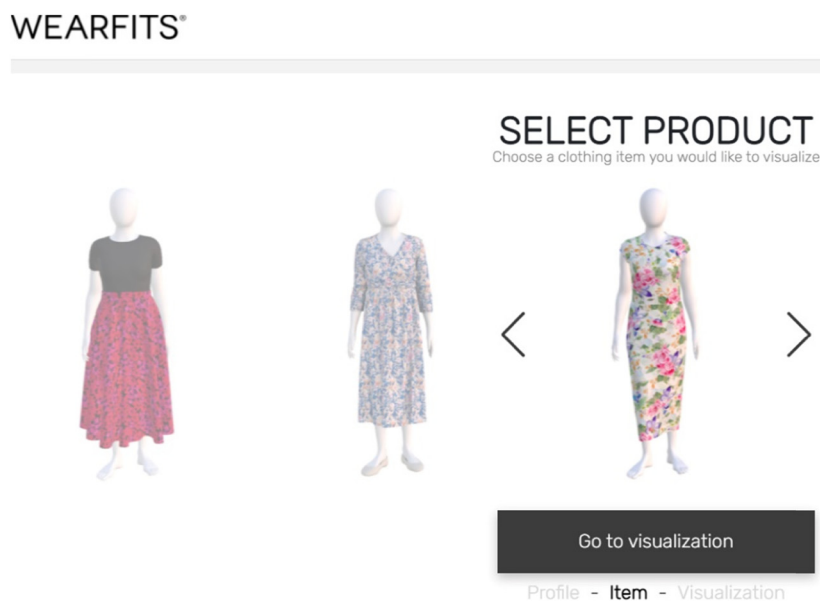


Figure 6. WearFits product selection. Image taken from ref. [31].

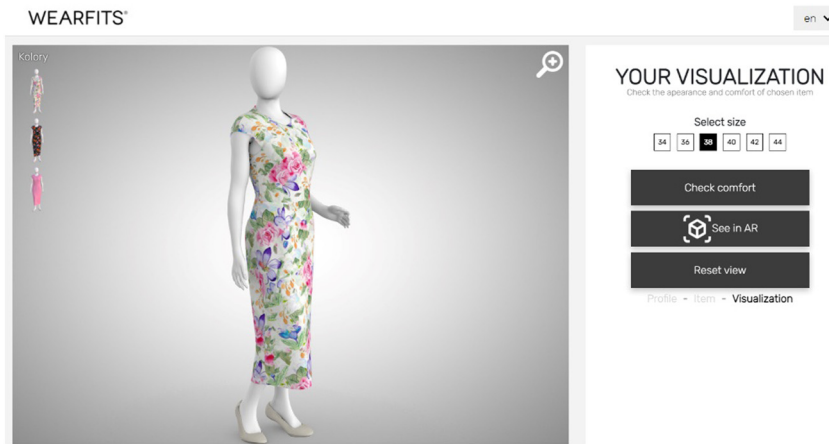


Figure 7. WearFits visualization. Image taken from ref. [31].

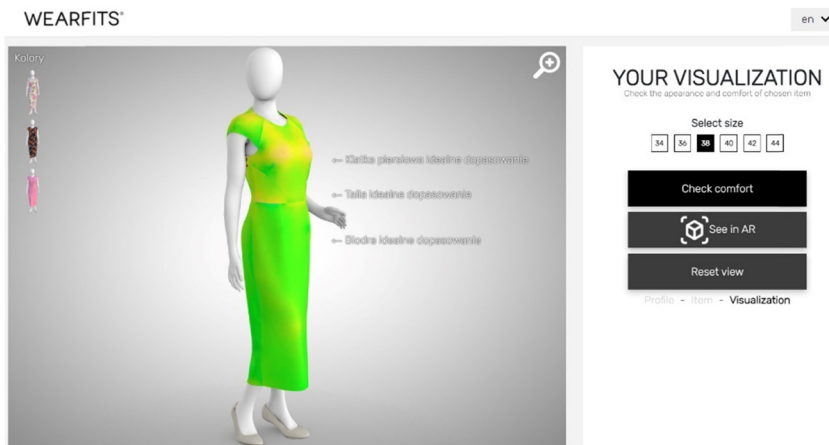


Figure 8. WearFits checking comfort option. Image taken from ref. [31].

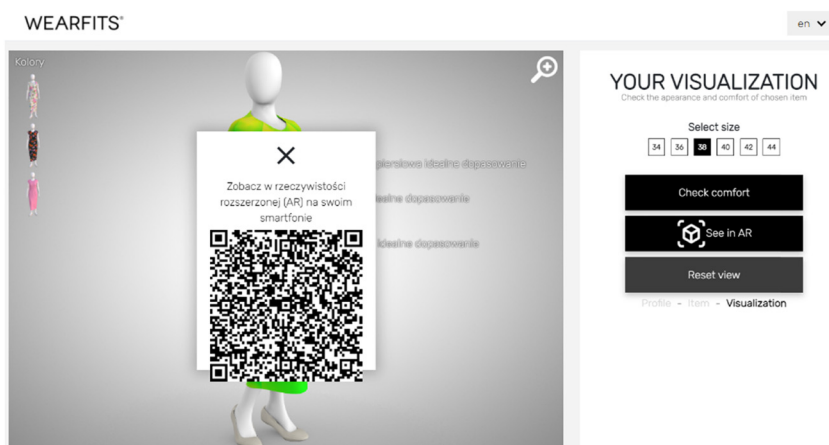


Figure 9. WearFits see in AR option. Image taken from ref. [31].

On the other hand, there is no shortage of e-stores on the market with products other than clothes, which do well with the use of AR in mobile applications or e-commerce websites [23,33,34] (i.e., Ikea). “Such solution lets customers view products in their own homes, to check how a new sofa or table

might fit with their existing décor by offering augmented reality tools that superimpose computer-generated graphics onto real-world images.” IT companies are currently developing fashion retail applications using VR and AR, anticipating an increase in VR and AR purchases [35,36].

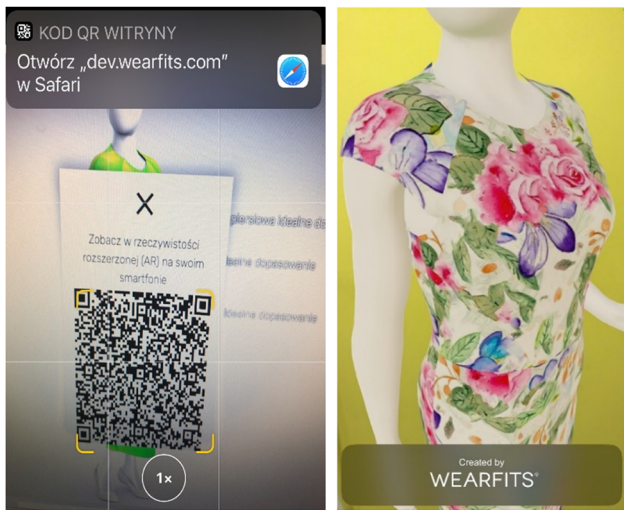


Figure 10. WearFits view on mobile in AR at home. Image taken from ref. [31].

4. Size matching issues

We distinguish two kinds of sizing in apparel industry: alpha and numeric sizing. Alpha sizing is the size range defined by letters such as XS, S, M, L. This lettering is mostly universal. In most cases, letter type sizing applies to knitwear. The specific knit category garments such as T-shirts, Sweatshirts, Leggings, Active Tank Tops/Sports usually have an alpha sizing range as alpha sizing chart can cover a broader range of body sizes. The standard grading rule for Alpha Sizing is 2 inches circumference between sizes (all around). For larger clothing sizes, the grade rule will go up to 3 inches (all around). Numeric sizing is the size defined by numbers. In US sizing numbers such as 0, 2, 4, 6, 8, 10, and so on are used. European equivalent uses numbers more related to the actual body measurements such as 34, 36, 38, 40, 42. Numeric sizing is commonly used for clothing made of woven fabrics in specific fit essential styles. Clothing items include dress pants, shirts, structured jackets, and fitted dresses. The standard grading rule for Numeric Sizing is 1 inch all around or circumference. For sizes above 10 and 12, the grade rule goes up to 2 or more inches all around [26].

The idea of garment matching problem is not new and is not easy. Size fitting problem is a main obstacle to large-scale garment sales and online sales because it is difficult to find the fitting garments by the general size information [37]. The difference between sizing is in the manufacturing company's grading or grade rule. Grading refers to pattern grading. Grade rule submitted in the full-size range spec sheet will guide the factory or the pattern maker on how to grade the pattern to match the size range. That is why the sizes of one manufacturer are different in the actual garment size of those from another manufacturer. Businesses have tried to solve the size matching

problem by giving all measurements based on actual body sizes and assigning them alpha sizing, the example of which is shown in Table 1, and not by the garment measurements. For example, a Fruit Polo with size to fit chest of 92–97 cm/36–38" will fit someone with such chest measurements [38].

On the market (Allegro, Olx) [16,17], there is a worked out description for the sizes of the clothes in metrics corresponding to the size from the label (alpha or numeric sizing), in order to increase the chance of size matching fit, e.g., for a shirt it will be the measurement from armpit to armpit.

For companies from the textile manufacturer market, a model of size adjustment can be recommended to implement in their e-commerce platforms by assigning a specific product in the e-sales system to the scope of matching in the actual dimensions of the buyer. To achieve this, the system needs at least three definitions of data structures and many records of fit data to specific preferred fit vector by the customer to go on. E-commerce solution should allow for setting the groups of properties (Table 2) to each textile clothing vector of properties (Table 3), and setting "fit vector of properties of the person" (Table 4) for a preferred fit. The final step is a fit quiz. This would allow in the final setting to increase the textile clothing fit for a person and to decrease the rate of returns. For example, if the manufacturer/seller sells clothes, then the e-shop should allow for creating the vector (Table 3) for each garment with the following exemplary sets of properties for a dress in its structure, i.e.: "gender," "preferred fit," "height," "breast circumference," "waist," "hips," "width from armpit to armpit," "sleeve length," "length," and "corresponding alpha sizing." The e-shop should also allow for creating as many fit vectors for this garment with the range of properties from the sets of properties (Table 2) as many

Table 2. Exemplary sets of properties with available value ranges

Name of set	Properties
Gender	{woman, man}
Preferred fit	{very tight, tight, slightly tight, regular, slightly loose, loose, very loose}
Height	{160, ..., 210}; every 1 cm
Breast circumference	{90, ..., 140}; every 1 cm
Waist	{90, ..., 140}; every 1 cm
Hips	{90, ..., 140}; every 1 cm
Width from armpit to armpit	{30, ..., 50}; every 1 cm
Sleeve length	{2, ..., 110}; every 1 cm
Length	{90, ..., 140}; every 1 cm
Corresponding alpha sizing	{XS, S, M, L, XL}

Table 1. Exemplary unisex sizes for t-shirt taken from ref. [38]

	S	M	L	XL	2XL	3XL	4XL	5XL
Chest (cm)	89–94	96.5–101.5	104–109	112–117	119.5–124.5	127–132	134.5–139.5	142–147

Table 3. Vector of garment information with dimensions and preferred fit measured flat without stretching in JSON format

Exemplary vector of properties of the garment (in cm)
<pre>{ "GENDER": "woman", "PREFERRED FIT": "regular", "HEIGHT": ["-"], "BREAST CIRCUMFERENCE": ["88"], "WAIST": ["66"], "HIPS": ["90"], "WIDTH FROM ARMPIT TO ARMPIT": ["34"], "SLEEVE LENGTH": ["7"], "LENGTH": ["95"], "CORRESPONDING ALPHA SIZING": ["S"] }</pre>

variants are in sale for the preferred fit of sizes. Then the product is described precisely with dimensions, preferred fit information, and corresponding alpha sizing.

The last step is creating a “fit quiz” for a customer, which directs the customer to the most suitable product items. Of course, to match a perfect fit, each of the parameters should be within the values of pre-set range of the product vector. The logic should be implemented by e-commerce system. Such groups of properties and product vectors should be expandable to add other body shape properties such as weight, age, body shape (H-shape, O-shape, V-shape, X-shape, A-shape), proportions: belly (less, more), bottom (less, more), which is seen on the e-commerce site with the fit quiz [39], or height, weight, belly shape (flatter, average, rounder), chest shape (slimmer, average, broader), age, and fit preference (very tight, tight, slightly tight, average, slightly loose, loose, very loose), which is seen on another e-commerce site [40], or just follow the online store style.me described earlier [15]. The presentation in AR is an option.

However, it should be remembered that the currently used sizes of clothes were last modified in the 1980s. During this time, in most societies, not only our BMI (body mass index) has increased but also the body height in each subsequent generation. This is, among other things, related to our diet. The problem of matching sizes is minor when we want to order tailored clothing, because dimensions may be taken with measure or various 3D scanner solutions that can be implemented using

Table 4. One of many fit vectors to fit the potential customer with range of properties to fit the regular fit in JSON format

Exemplary fit vector of properties of the person to fit dress from Table 3 in size “S” (in cm)
<pre>{ "GENDER": "woman", "PREFERRED FIT": "regular", "HEIGHT": [{ "from": "165", "to": "170" }], "BREAST CIRCUMFERENCE": [{ "from": "86", "to": "90" }], "WAIST": [{ "from": "66", "to": "70" }], "HIPS": [{ "from": "89", "to": "95" }], "CORRESPONDING ALPHA SIZING": [{ "from": "S", "to": "S" }] }</pre>

a computer. The aim of perfect fit would also be achieved by 3D scanning of body shapes in order to update the current trend of human body shapes. At the same time, it is important to take into account whether it is, for example, a European, an American, or an Asian, due to the fact that in different regions of the world the anthropometric data differ significantly. The database of 3D scans would make it possible to create new clothing size tables that would better suit potential users. This would make it easier for consumers to buy online clothes that are much better suited to their body shapes, and it would allow manufacturers to reduce the costs associated with returns and production of garments remaining in warehouses due to poor matching of sizes to the current body shape of buyers. An updated base of sizes would also have a positive impact on environmental protection due to lower waste production [41].

5. Ways of presenting clothing in Polish e-commerce

In Figure 11, a dress of approximate 42 XL size is presented. It has been found after seeking the text search “sukienki XL” (in English “dresses XL”) in the Polish Allegro online platform. A presentation is that a customer may switch between alpha sizing and numeric sizing, the numeric sizing pointing to equivalent alpha sizing and vice versa. No sizes table but one specific size of this item in centimeters is available. Figure 12 presents only one size (“Wymiary” means dimensions, biust:



Figure 11. A dress entry in the Allegro platform. Image taken from ref. [42].

ROZMIAR 42 XL	SIZE 42 XL
WYMIARY:	DIMENSIONS:
<ul style="list-style-type: none"> • BIUST: 104 cm • TALIA: 85 - 95 cm • DŁUGOŚĆ: 127 cm 	<ul style="list-style-type: none"> • BREAST: 104 cm • WAIST: 85 - 95 cm • LENGTH: 127 cm

Figure 12. Size of the dress from Figure 11 on the Allegro platform.

breast, talia: waist, długość: length.), no precise filtering nor “fit quiz” present.

Another textile clothing, fashionable sweatshirt sporty DRESS (in Polish “Modna dresowa SUKIENKA sportowa”) is shown in Figure 13. After entering the detailed description, there is a description of physical dimensions measured flat without stretching seen in Figure 14. The description of a deal has the following information: “available colors and patterns are visible in the pictures below: information about your choice should be included in the information for the seller.” This textile clothing presentation is similar to the previous one but somewhat poorer, because the customer must write the message to

WYMIARY
Mierzone na płasko bez rozciągania:
<ul style="list-style-type: none"> • długość całkowita: 90 cm • szerokość pod pachami: 50 cm • szerokość w biodrach: 49 cm
tolerancja błędów podanych wymiarów +/- 2 cm

Figure 14. Sizes of the dress from Figure 13 on the Allegro platform.



Figure 13. Entry of another dress in Allegro platform. Image taken from ref. [43].

the seller which color is to be sold in this case (Figure 15). Without the message, the seller will be contacting the buyer to enquire about his choice. The problem is the entire B2C transaction because the customer pays for the item immediately, but the color is not known, i.e., the entire contract is defective, and this is how most auctions on the Allegro platform with textile clothing work. This means that on one post the seller sells the whole assortment of this dress, but the platform does not operate this, allowing for sending an additional message to the seller only.

If we look into the PTAK Wholesale Center (Centrum Hurtowe Ptak) [44], we see a similar solution to the first Allegro item described in Figure 11, which means that one full B2C contract concerns one item (no additional messages after the transaction). By the way, Ptak is the clothing wholesaler in the center of Poland and is part of the City of Fashion – the only facility of this type in Central Europe, which functions as the largest clothing wholesaler in Poland. Over 2,000 manufacturers and importers operate at the Ptak Wholesale Center. In Figure 16,

DIMENSIONS
Measured flat without stretching:
<ul style="list-style-type: none"> • overall length: 90 cm • armpit width: 50 cm • hip width: 49 cm
The error tolerance of the given dimensions is +/- 2 cm



Figure 15. Each version of the dress in Figure 13 is presented as a separate image and written color in plain text – “błękit” – blue, “ciemna mięta” – dark mint etc.

MEDIUM LENGTH DRESS WITH STRAPS

Linen-cotton fabric dress. Straight neckline. Thin shoulder straps. Elastic at the waist. Side slits at the bottom. Closure at the front with coated buttons in the same shade.



KHAKI | 8372/073

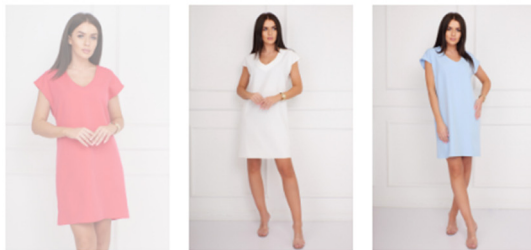
PLN 169.00 - 40 % 99.90 PLN

Items in your shopping cart cannot be reserved until your purchase is complete.

Sukienka z dekoltem V

55,00 zł netto

Kolor:



Rozmiar



Ilość



DODAJ DO KOSZYKA

Figure 16. V-neck dress in PTAK online clothing wholesale e-platform. Image taken from ref. [45].

V-neck dress items with three colors and two sizes are presented. A customer must look into the size table to choose a proper size.

After seeking the text search “sukienki” in the Google we find Polish e-commerce sites. We look into several randomly chosen sites: reserved.com, renee.pl, hm.com/pl_pl, emonnari.pl, zalando.pl, selfieroom.pl, bonprix.pl, born2be.pl, xl-ka.pl, and pl.shein.com, zara.com. The outcome is that they all offer the same poor model of size matching, that is, a size table below

XS	Last items
S.	Last items
M.	Last items
L.	View similar
XL	Last items
FIND YOUR SIZE	
SIZE GUIDE	

Figure 17. Zara buying form with find your size option. Image taken from ref. [46].

the alpha sizing in the select control (html) to add to cart. Only zara.com added a semi fit quiz, which is called “find your size” option (Figure 17) and size guide (Figure 18), but with no automatic match to products. In the “find your size” form, the customer provides only basic dimension data: height and weight, and chooses the “what style do you prefer” information, that is: fitted, perfectly lying, loose. The logic of the form based on (German) Fit Analytics GmbH gives the likely size as a percentage of all so far similar dimensions of the buyers. One may look into the size guide and check the corresponding dimensions of the example model photo with one’s own real dimensions (Figure 18) and pick the dimension in the buying form (Figure 17), which is quite complicated in comparison with, e.g., a “fit quiz” mentioned at the beginning in the style.me online store.

Online stores and e-commerce platforms in Poland (Allegro) are not at all adapted for AR, nor fit vector search in terms of data processing logic or data structures representing the entry of a textile product to narrow their offer to the dimensions of the buyer. A fit quiz of online store of textiles clothing has not been observed anywhere.

6. Conclusions

The presented solutions with acquisition of the body size data are quite new. The ones first introduced were from refs [5,15].

SIZE GUIDE

DRESS



Figure 18. Zara size guide – S size chosen. Image taken from ref. [46].

The WearFits uses the body sizes and shapes similar to web widgets. It generates accurate digital 3D human model. Then, while browsing the store's assortment, a short, high-quality animation is generated for each product, presenting the garment on a figure that reflects the silhouette of the buyer. Thanks to this, the customers can see exactly how a specific product of the selected size will look on their silhouette, also taking into account the type and tension of the material. The disadvantage for implementing, e.g., WearFits is that the phase of building the 3D CAD model from die-cut product digitization may be costly and time-consuming. That is an economic barrier for any online seller. Thus, the AR for textile clothing e-sale may be an option to leverage fewer returns.

Another barrier is that online e-commerce solutions are not prepared for operation of data structures behind the scene, which we proposed in Section 4. All open source and closed software textile sales software platforms might be completed to operate the functionality of the fit quiz. On the market, there are simple open source solutions so far as we see on actual implementations. An e-commerce platform should be developed with data structures which allow for detailed size capture. Such a platform could be licensed or sold as SAAS software (software as a service). Such a product is missing. Other body size and shape acquisition projects refer to web and Java Script animation for presenting purposes not using AR views, but they are

implemented in the way to work with the fit quiz, like the aforementioned style.me online store [15].

The new clothing size table will allow manufacturers to perform production to a range for the entire population. The aforementioned fit quiz provides tailored purchases, but people with a different figure than standard do not buy anything, because the manufacturers simply did not know that they should manufacture such a garment in a different design and they will make money on it.

All of the described factors such as AR, fit quiz, and new body size table may contribute to reducing the returns and the related carbon footprint.

Conflict of interest: Authors state no conflict of interest.

References

- [1] Blog RETAIL360.PL. (2021). *Cyfryzacja mody zmieni świat zakupów*. <https://retail360.pl/cyfryzacja-mody-zmieni-swiat-zakupow/> (Retrieved 6 June 2022).
- [2] Orendorff, A., Dopson, E. (2022). *The state of the e-commerce fashion industry: statistics, trends & strategies to use in 2022*. <https://www.shopify.com/enterprise/ecommerce-fashion-industry> (Retrieved 6 June 2022).
- [3] Mukthar, K. P. J., Asis, H. R., Carcamo, J. E. V., Zarzosa-Marquez, E. D., Soto, R. M. H. (2023). *Application of innovative technology in textile retail for enhanced customer service and business development*. In: Alareeni, B., Hamdan, A. (Eds.). *Explore business, technology opportunities and challenges after the Covid-19 pandemic*. ICBT 2022. *Lecture Notes in Networks and Systems*, Vol. 495. Springer (Cham). doi: 10.1007/978-3-031-08954-1_3.
- [4] Junzhi, D. (2021). *The development of e-commerce in China during the COVID-19 pandemic on the example of the textile industry*. *BRICS Journal of Economics*, 2(3), 54–69. doi: 10.38050/2712-7508-2021-3-3.
- [5] WearFits. (2019). *WearFits. Digital disruption of the fashion industry through 3D & Augmented Reality*. <https://wearfits.com/> (Retrieved 6 June 2022).
- [6] FASHIONTECH Berlin. (2009). *Augmented & virtual reality for the Fashion Industry* Anna Rojahn *Fast Forward Imaging*. <https://www.youtube.com/watch?v=smtrNTjBI> FU (Retrieved 6 June 2022).
- [7] Jonna, H, Colley, A, Roinesalo, P, Väyrynen, J. (2017). *Clothing integrated augmented reality Markers*. MUM '17: *Proceedings of the 16th International Conference on Mobile and Ubiquitous Multimedia*, November 2017. pp. 113–121. doi: 10.1145/3152832.3152850.
- [8] Kim, M, Cheeyong, K. (2015). *Augmented reality fashion apparel simulation using a magic mirror*. *International Journal of Smart Home*, 9(2), 169–178.
- [9] Textronics Design Systems (I) Pvt. Ltd. (2010). *Tryon*. <https://www.textronic.com/tryon.html> (Retrieved 6 June 2022).
- [10] Textronics Design Systems (I) Pvt. Ltd. (2017). *Virtual Dressing Room by Textronics for Mens*. <https://www.youtube.com/watch?v=qF6Jo1ro-mY> (Retrieved 6 June 2022).

- [11] *Textronics Design Systems (I) Pvt. Ltd. (2010). 3D Showroom A Virtual Home Décor tool.* <https://www.textronic.com/3d-showroom.html> (Retrieved 6 June 2022).
- [12] *Textronics Design Systems (I) Pvt. Ltd. (2016). Mix & Match To Create Unique Ensemble.* <https://www.textronic.com/style-me.html> (Retrieved 6 June 2022).
- [13] *Textronics Design Systems (I) Pvt. Ltd. (2016). STYLE ME, tab version for Mix & Match.* https://youtu.be/8c6_fa5IJLc (Retrieved 6 June 2022).
- [14] *Textronics Design Systems (I) Pvt. Ltd. (2012). Tailor – i. Virtual tailor shop.* <https://www.textronic.com/tailor-i.html> (Retrieved 6 June 2022).
- [15] *Style.me. (2010). A new way to experience digital fashion. Taipei 11073, Taiwan, 185 Wythe Avenue 2nd Floor Brooklyn, NY 11249.* <https://www.style.me/> (Retrieved 6 June 2022).
- [16] *Olx. (2010). Darmowe ogłoszenia lokalne w kategoriach: Moda.* <https://www.olx.pl/> (Retrieved 6 June 2022).
- [17] *Allegro Group. (2010). The largest trading platform.* <https://allegro.pl/> (Retrieved 6 June 2022).
- [18] *Wojciechowski, J. (2019). Sposoby prezentowania odzieży w e-sklepach oraz rozwiązania informatycznych do wdrażania e-sprzedaży odzieży z wykorzystaniem rzeczywistości rozszerzonej (AR) w e-commerce. Przegląd Włókienniczy – Włókno, Odzież, Skóra. ISSN: 1731-8645, no.12, str. 36–40. doi: 10.15199/60.2019.12.3.*
- [19] *Forbes, Marr, B. (2021). Five smart marketing use cases for artificial intelligence.* <https://www.forbes.com/sites/bernardmarr/2021/07/02/five-smart-marketing-use-cases-for-artificial-intelligence> (Retrieved 6 June 2022).
- [20] *Blog RETAIL360.PL. (2012). Przymierzalnia.* <https://retail360.pl/przymierzalnia-online/> (Retrieved 6 June 2022).
- [21] *Blue Media. (2021). Na liście korzyści z zakupów online była dotąd jedna wyraźna rysa. Brak możliwości fizycznego kontaktu z produktem. Problem ten coraz skuteczniej rozwiązuje rozszerzona rzeczywistość.* <https://bluemedia.pl/baza-wiedzy/bloge-commerce/zastosowanie-rozszerzonej-rzeczywistosci-w-ehandlu> (Retrieved 6 June 2022).
- [22] *FashionUnited, Turk, R. (2019). Amazon developing a virtual fitting room app.* <https://fashionunited.uk/news/retail/amazon-developing-a-virtual-fitting-room-app/2019012941290> (Retrieved 6 June 2022).
- [23] *FashionUnited, Wightman-Stone, D. (2019). Asos launches its first augmented reality feature.* <https://fashionunited.uk/news/retail/asos-launches-its-first-augmented-reality-feature/2019061443676> (Retrieved 6 June 2022).
- [24] *TiBler, J. (2021). Augmented Reality in Marketing: 8 Current Examples.* <https://dmexco.com/stories/augmented-reality-in-marketing-8-current-examples-2/> (Retrieved 6 July 2022).
- [25] *Snapchat. (2011).* <https://www.snapchat.com/> (Retrieved 6 June 2022).
- [26] *taas.nyc. (2022). Alpha And Numeric Sizing.* <https://www.taas.nyc/alpha-and-numeric-sizing> (Retrieved 6 June 2022).
- [27] *Yotpo – eCommerce marketing platform. (2020). Reducing e-commerce returns: the 2020 report. Customer returns: A threat to brands of all sizes.* <https://www.yotpo.com/reducing-ecommerce-returns-report/> (Retrieved 6 June 2022).
- [28] *Ensemble, IQ, Berthiaume, D. (2019). Returns are rampant in online fashion retail, but counterstrategies exist.* <https://chainstoreage.com/technology/survey-apparel-has-an-online-returns-problem> (Retrieved 6 June 2022).
- [29] *S5 – Akcelerator Technologii 5G. (2021).* <https://startupspark.io/akcelerator-5g/> (Retrieved 6 June 2022).
- [30] *Ericsson. (2021). Ericsson in Poland.* <https://www.ericsson.com/pl/careers/global-locations/poland> (Retrieved 6 June 2022).
- [31] *wearfits.com. (2021). WearFits demo apparel.* <https://dev.wearfits.com/demo-apparel> (Retrieved 6 June 2022).
- [32] *3dcadbrowser. (2021). 3D CAD browser.* <https://www.3dcadbrowser.com/> (Retrieved 6 June 2022).
- [33] *IKEA. (2021). IKEA Place.* <https://apps.apple.com/us/app/ikea-place> (Retrieved 6 July 2022).
- [34] *Amazon. (2021). Shop at Amazon using Augmented Reality.* <https://www.amazon.com/ad/plarview> (Retrieved 6 July 2022).
- [35] *Magento 2. (2019). Magento 2 – Global4Net.* <https://global4net.com/magento2> (Retrieved 6 July 2022).
- [36] *Magento. (2019). Magento is an open-source e-commerce platform written in PHP.* <https://en.wikipedia.org/wiki/Magento> (Retrieved 6 July 2022).
- [37] *Yong-Sheng, D., Zhi-Hua, H., Wen-Bin, Z. (2011). Multi-criteria decision making approach based on immune co-evolutionary algorithm with application to garment matching problem. Expert Systems with Applications, 38(8), 10377–10383. doi: 10.1016/j.eswa.2011.02.053.*
- [38] *Fruit of the loom. (2021). Make yours fit.* <https://www.fruitoftheloom.eu/size-guide> (Retrieved 6 July 2022).
- [39] *Presize. (2010). Presize Journey – Quick Sizer.* <https://www.facebook.com/presizeAll/videos/presize-journey-quick-sizer/1389883484797517/> (Retrieved 9 Nov 2022).
- [40] *Fitanalytics. (2021). Solve Sizing. Sell Smarter. (10.2021).* <https://www.fitanalytics.com/fit-finder> (Retrieved 6 July 2022).
- [41] *Grogan, S., Storey, E., Brownbridge, K., Gill, S., Templeton, C., Gill, J., et al. (2020). Whole body scanning as a tool for clothing sizing: effects on women’s body satisfaction. Journal of the Textile Institute, 111(6), 862–868. doi: 10.1080/00405000.2019.1668127.*
- [42] *Allegro. (2022). ELEGANCKA SUKIENKA W GROSZKI MIDI GROCHY 42 XL.* <https://allegro.pl/oferta/elegancka-sukienka-w-groszki-midi-grochy-42-xl-11294655646> (Retrieved 6 July 2022).
- [43] *Allegro. (2022). Modna dresowa SUKIENKA sportowa KOLORY.* <https://allegro.pl/oferta/modna-dresowa-sukienka-sportowa-kolory-12182526838> (Retrieved 6 July 2022).
- [44] *PTAK S.A. (2022). Największe w Europie centrum hurtowe odzieży.* <https://ptak.com.pl/> (Retrieved 6 July 2022).
- [45] *PTAK S.A. (2022). Sukienka z dekoltem V.* <https://ptakmodahurt.pl/pl/women/sukienki/111394-sukienka-z-dekoltem-v> (Retrieved 6 July 2022).
- [46] *Zara.com. (2022). Sukienka sredniej dlugosci na ramiaczkach.* <https://www.zara.com/pl/pl/sukienka-sredniej-dlugosci-na-ramiaczkach-p08372073.html?v1=191005191> (Retrieved 6 July 2022).