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A review on potential technological advances for fashion retail: smart fitting rooms, augmented and virtual realities

Uma revisão sobre os potenciais avanços tecnológicos para o varejo de moda: provadores inteligentes, realidades aumentada e virtual

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[Abstract] This technical paper will assess new technological advances that could change the way we buy clothes, exploring existing solutions that are still commonly confused with each other: Smart fitting rooms (SFR), interactive mirrors (IM), Virtual Reality (VR), and Augmented Reality (AR). The methodological approach based on an exploratory research will start with a literature review on SFR and IM, comparing the main differences between these two technologies and addressing their unsuccessful attempts in retail. Our research will also assess daily technologies, which could possibly improve the customer's experience with online shopping, as well as customers with reduced mobility.
With smart gadgets in every corner, consumers are more difficult to convince with innovative products. We will propose future possibilities for fashion retail, where results will be presented as a first approach, in hopes of creating innovative solutions for the future. Moreover, sustainable implications related with this approach will be addressed in our additional considerations. This technical study considers only two basic solutions that were eventually too complicated to fit into fashion retail, exploring additional solutions that could change these limitations.
Although explored and researched in the last years, solutions like IM and SFR were once part of what was considered the future of fashion retail. However, poor business models and lack of technological advances at the time limited these solutions. New technologies such as Augmented Reality (AR), Virtual Reality (VR) and Mixed-Reality (MR), combined with the latest smartphone evolution could relaunch solutions like these.

[keywords] **E-commerce. New technologies. Fitting room. Smartphones. Fashion Design.**

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[resumo] Este artigo técnico avaliará os novos avanços tecnológicos que podem mudar a forma como compramos roupas, explorando soluções existentes que ainda são comumente confundidas entre si: provadores inteligentes, espelhos interativos, Realidade Virtual (RV) e Realidade Aumentada (RA). A abordagem metodológica baseada numa pesquisa explora-tória terá início com uma revisão da literatura sobre provadores inteligentes e espelhos interativos, comparando as principais diferenças entre essas duas tecnologias e abordan-do as suas tentativas de implementação malsucedidas no varejo. A nossa pesquisa também avaliará tecnologias diárias, aquelas que possivelmente poderiam melhorar a experiência dos clientes com compras online, bem como de clientes com mobilidade reduzida.

Com dispositivos inteligentes em cada esquina, é hoje mais difícil convencer os consumi-dores com produtos inovadores. Neste contexto, propomos algumas possibilidades de fu-turo para o varejo de moda, com os resultados a serem apresentados numa primeira abor-dagem, na esperança de que a partir deles possam ser criadas soluções inovadoras para o futuro. Além disso, as implicações sustentáveis relacionadas com esta abordagem serão abordadas nas considerações adicionais. Este estudo técnico considera apenas duas solu-ções básicas, que, eventualmente, eram muito complexas para caber no varejo de moda, e explora soluções adicionais que poderiam mudar essas limitações.

Embora exploradas e pesquisadas nos últimos anos, soluções como os provadores inteli-gentes e os espelhos interativos já fizeram parte do que se considerou o futuro do varejo de moda. No entanto, modelos de negócios deficientes e falta de avanços tecnológicos na época limitaram essas soluções. As novas tecnologias, como a Realidade Aumentada (RA), a Realidade Virtual (RV) e a Realidade Mista (RM), combinadas com a mais recente evolu-ção dos smartphones, podem relançar estas soluções.

[palavras-chave] Comércio eletrônico. Novas tecnologias. Provadores. Smartphones. Design de Moda.

Introduction

In the era of big data, and as fashion has entered in the 4th industrial revolution (ABNETT, 2016), it is time to address the information missing on consumers, even though we have clearly evolved in terms of technology. Our smartphones are more than ever capable to track us at any moment (CASE *et al.*, 2015), and our information that is being kept by apps, social media websites is used for many commercial purposes (BENDONI, 2017). On the other hand, our smart devices are now capable to do more than keep tabs on our lives, they can also calculate sizes and distances, as cameras are now equipped with in-depth sensors and focal-length lenses.

As we are now keeping track on the customer's every move, why not keep track of their fit and measurements? Why would consumers keep on buying online without knowing if the items they bought will fit them until they arrive at home? Moreover, why would fashion continue to sell clothes with standard sizing when they can provide unique sizing, without purchasing extremely pricy body scanning booths? We will first assess the difference between smart fitting rooms and smart mirrors. Secondly, we will understand why each solution is lacking a real purpose, as these two technologies are still targeting the offline customer's experience, creating gadgets for a more pleasing experience. In this research, we aim at exploring potential ways to implement already existing technologies, patents, and adapt them to obstacles faced in fashion retail. As in 2020, the world counts over 3,5 billion smartphone users in the world, and a projection of 3,8 billion by 2021 (NEWZOO, 2019), whereas AR and VR consumer spending are expected to reach 18.8 billion USD in 2020 (STATISTA, 2020). Such numbers are highly relevant to what is expected by consumers, in terms of retail, as people are embracing technological solutions as day-to-day tools, solutions like these must be seen as more than entertainment.

We also question the lack of a proper solution for online shoppers and people with reduced mobility, as a 2019 Global Data survey based on 10K consumers stated that the first reason for online shopper to return their clothing items was related with fitting (ARNETT, 2019), however, e-commerce still lacks real solutions to improve their customer's experience. From size charts being different from brand to brand, as to fabrics being difficult to judge on photograph, to the simple fitting and draping of clothes being different on the website's model compared to customer's average bodies, issues related to online fashion shopping are many. However, in an era where our smartphones know us better than ever, and cameras are used to measure, calculate depth and sizes, how can we apply these new technologies to the smart fitting room issue?

Methodological design

The main objective of the investigation was the collection of data that would allow us to understand how the fashion retail has been working around new technologies, namely its use for the dissemination of fashion products and its online acquisition. Thus, and in line with previous works (FERNANDES, 2013), in methodological terms, a literature review

was started by collecting a set of articles that, in recent years, have sought to assess the true potential of technologies such as augmented reality, virtual, but also, a set of tools that started to be introduced in smartphones. In addition to the literature review, where a survey is made, especially of academic works, whether in the form of articles or in the form of chapters of books and books, another type of mapping was also carried out, in the logic of an exploratory observation of a set of solutions developed or several companies or brands that have already been applied and tested in the market. The objective is to cross those that have been the main conclusions in terms of academic research, with the results already obtained in the experiments carried out in the store, and from there, gather a set of clues, which can help from this work, to build a new solution for this area.

In sum, this study will firstly present a literature review on smart fitting rooms, smart mirrors, comparing the main differences between these two technologies. Secondly, we will approach new technologies that have been implemented in our day-to-day lives and could possibly change the game and improve the customer's experience with online shopping, as well as customers with reduced mobility. Based on this exploratory research, hints for future possibilities for this market will be presented as a first approach, in hopes of creating a better solution for the future.

Main solutions on the market: an assessment

To begin this research, an assessment on recent technologies will be made, beginning with smart fitting rooms, smart mirrors, and the technologies that shaped the retail industry, promising new solutions for consumers. Microsoft's Kinect, as well as other depth sensors have been weapons of choice, used by retailers for all sorts of *gadgety* installations, as well as body-scanners.

In recent years it has not only been the Kinect sensor or the ability to control the movements through gestures that stood out. A number of other technologies have gained more followers and are now part of the marketing and sales strategies of many companies (YOUSEF, MOHD, AL-OMARI, 2019).

Augmented Reality (AR) is one of the cases innovative technologies that are already widely used. This system consists of introducing a 2D or 3D image that can be animated from a standard marker, recognized by a computer system, smartphone application or tablets. The idea is for users to watch a virtual simulation of a certain reality. Pointing the phone for example to a teapot, with this technology would be possible to see it virtually in operation.

This technology has conquered many brands and is already used in domains such as games and robotics, but also clothing. Augmented reality has even been one of the solutions that brands have been turning to when they want to design prototypes of "Virtual closet" or "fitting room". The main use has been in storefronts, trying to make them more appealing. Although this technology is only used at certain times, it has a major impact on consumers (FERNANDES, 2013), as we can see from what happened to net-à-porter, which created a pop-up store at New York's Fashion Night Out in 2011. In this context and in others, such as event promotion, augmented reality has been a success, with major brands such as Hugo Boss, for example, also making use of this.

However, when we talk about augmented reality and its application in projects of virtual dressing room, we find that this is very limited since the clothes are images in two dimensions, and the silhouette, recognized through a Kinect sensor, requires the users to adjust to the screen image, often without success. Jennifer Van Grove (2011), a social media reporter, says in an article published in Mashable that after testing two applications, called Zugara and Swivel, she became quite disappointed with the results, not only for the lack of re-alism of both systems, but also for the platforms malfunctions. In this sense there are several examples that point to above all to be a good chance for product promotion at storefronts. In addition to augmented reality, QR Codes and RFID are also two technologies whose levels of use, notably at the level of the fashion industry and the clothing, deserves to be mentioned, as both have been used to keep track of inventory and data on consumer behavior (HAUSER *et al.*, 2017), as well as automatic check-out stores (ARTHUR, 2017; THEO, 2018). Several studies have shown that consumers of fashion good might not be ready to purchase tech-nological fashion goods (LIANG, LEE & WORKMAN, 2019), yet they are already embracing technology applied to retail, as well as services improving the retail experience.

Apps and websites

Nike is one of the main brands that use Fit Analytics (ARNETT, 2019), a German com-pany specialized in fitting algorithms, that started in the 2010 decade with a webcam-based solution (FIT ANALYTICS, 2019). However, the company faced what many other solutions experienced: the whole process was too heavy on users. The company than developed an algorithm that can be used by retailers on their websites. Customers are asked for their height, age and weight, and sizes are presented to them based on that information. The user is than presented with different body shapes and must chose those that are most similar to them. Fit analytics is now supported by 17.000 brands.

Japanese fashion retailer Zozo created the ZozoSuit (FOX, 2019), a full bodysuit with dots to map the user's body, using a smartphone app. The concept was simple: the user or-ders the suit, downloaded the app, and "scanned" his/her body thanks to their smartphone camera, as the dots were placed in specific places in order for the algorithm to "track" and calculate the person's measurements.

The app would than propose a selection of clothing items that would fit the user perfectly and sent home in the following weeks. As simple as Zozo seemed to be, users were quick to point out major issues: fitting was still an issue, as many customers were not happy with the results when receiving their clothes, especially after having to use the infamous suit and pose for several minutes in front of their smartphones, as the app could fail and take several attempts to function properly. In November of 2018, the ZozoSuit project was termi-nated, after its creator, Star Today Company decided to pull the plug on its development and website, however, the parent company keeps Zozo products available on its website.

Nettelo is a body scanning app (NETTELO, 2019), available for Android and iOS, us-ing both front and back cameras on smart devices, such as smartphones and tablets. The app proposes an avatar of the user, after a full body scan, then, users can keep track of their

measurements each time they scan their body with their smart devices. The app is still lacking user's reviews to be certified as efficient, but user's comments are mostly positive, with 3,5 stars rating on the App Store (based on 11 reviews) and 2,5 stars on Google Play (among 35 reviewers). For reviewers, the main issues encountered are related with privacy concerns, as well as UX (User Experience) and UI (User Interface) problems. Moreover, apps like Nettelo are creating avatars based on the user's measurements, we therefore consider that they cannot be considered as a solution for our research problem, as they do not solve the smart fitting room issue for online shoppers and people with disabilities, who could highly benefit from a solution.

VR, AR, and MR

Per Olsson *et al.* (2013, p. 288), Augmented Reality (AR) is "to combine real and computer-generated digital information into the user's view of the physical world in such a way they appear as one environment". As per Bonetti, Warnaby and Quinn:

> VR utilizes a wearable device (typically a headset), which blocks out 'real world' sensory experiences to provide an arguably more engaging and innovative shopping environment by immersing users in virtual, entertaining 3-D worlds. For VR to succeed, the headwear needs to be comfortable and confer credible immersive virtual effects. (BONETTI; WARNABY; QUINN, 2018, p. 120)

The authors also consider that VR will probably be carefully and sparsely implemented, and will not be adjusting to any setting, brand, or store (BONETTI; WARNABY & QUINN, 2018), as VR is still a very high-risk investment to retailers, and a relatively unknown technology to the public, it is also deemed too complicated to implement in a fashion retail environment. AR is, therefore, expected to grow more than VR, as the first is reachable by anyone using a smart device, and is already commonly used in apps, whether gaming or geo-localization, whereas the second implies the acquisition of another device, that is not a day-to-day gadget consumer use for communication, work, or entertainment. According to Carmigniani *et. al.*:

> AR can potentially apply to all senses, augmenting smell, touch and hearing as well. AR can also be used to augment or substitute users' missing senses by sensory substitution, such as augmenting the sight of blind users or users with poor vision by the use of audio cues, or augmenting hearing for deaf users by the use of visual cues. (CARMIGNIANI *et. al.*, 2010, p. 342).

There is still plenty of room left for research on fashion retailers experience and consumer behavior with AR and VR, as these technologies are expected to grow in other markets such as tourism, retail and entertainment. Of course, for fashion retail, VR and especially AR can be game changers online as well as offline, in order to "provide an

opportunity to revive the high street by providing exciting, entertaining and useful experiences for consumers" (BOARDMAN; HENNINGER & ZHU, 2019, p. 165). For the authors: "AR in particular could help facilitate a better omnichannel experience for customers by bridging the gap between channels and limiting their drawbacks, such as in Specsaver's glasses try-on mobile app and website feature" (BOARDMAN; HENNINGER & ZHU, 2019, p. 165). For those reasons, the patents explored in the next phase are mostly related to AR and the use of smartphones, as these solutions have already been tested in retail, for the most part, but are still in early development.

Patents

A patent by inventor Jessica Couch proposes the "use of camera on mobile devices to extract measurements from garments" (U.S. Patent n. 20170270686A1). The project, proposed in 2017, aims at solving the online retail clothing issue, by cutting "down on human error and extract measurements from garments in order to compare garment-sizing data through existing virtual applications". However, this only solves part of the problem, as customers are many times considered to be one size but are actually different sizes when facing more than one brand. Furthermore, countries and continents have very different sizing charts, which can difficult even more international and online shopping.

Another patent, delivered in 2015 by inventors Jingsong Xu, Ying Cui, Qiang Wu, Jian Zhang, Chen-Xiong Zhang, Haibo LIU and Kui Fang proposes a *System and method for virtual clothes fitting based on video augmented reality in mobile phone* (US10373244B2, 2019). This second patent also proposes a mobile-based model, this time using augmented reality to simulate a fitting experience. After a few calibrations on the user's face and shoulders, a video is applied on the user's reflection, using AR to replicate clothing on the user's upper body. The downfall of this patent is probably its limitation on the user's face and upper body, which is only considering the user's shoulders and top torso. Moreover, the description of the project lacks information in terms of 3D rendering of the garments, as well as fitting purposes. Nevertheless, this project seems interesting enough to be implemented on a full-body dimension, as the upper-body could only be used to test hats, scarves and other face accessories. Both patents are promising enough to hope for future developments, however, we were able to detect limitations on both regarding our particular research problem. Finally, we also came across two patents specially addressing retail and are classified under the mixed-reality patent category.

The first patent proposed by Darrick Morrison and called *Augmented reality e-commerce for in-store retail* (US10235810B2) projects a system of virtual product displaying in the shop. The solution is broad and does not contemplate only one specific market, it is therefore possible to imagine its possibilities in a fashion retail environment. This is a highly interesting possibility, as it has great potential not only for online retail but also offline, as the patent specifically describes the possibility to create specific spots in the store, that could display a series of products, ensuring pre-sales and holds. In an online setting, this technology could be implemented on the website to show 3D versions of the goods in an interactive manner, also displaying future products and collections in pre-sale.

The second patent of this category was submitted by Robert Locke and Paul Rasband. The patent titled *Holographic Technology Implemented Retail Solutions* (US20180018681A1). The purpose of this project is to:

> [...] obtain information from various electronic systems/devices in the physical world, which devices are exemplified by security systems, and merge that information into a virtual world of policies and analytics that involve retail systems that generate analytical information regarding customers and their preferences and needs. (LOCKE & RASBAND, 2016, n.p)

The information generated by the implementation of such system could provide crucial data on consumer's behaviors, and benefit brands and stores on marketing and visual merchandising purposes, as well as increase sales. The data collected could help adapting visual merchandising in-store and online, to a specific customer, showing them the product, they could reach for, based on previous purchases, as well as online and offline purchases and returns. Although the patent also covers facial recognition systems that could be problematic regarding privacy issues, the system itself is clearly aligned with what is expected from new technologies to provide in terms of data collection and analysis, provided important information for fashion retail, marketing, visual and digital merchandising.

The solutions explored in this study are only a small part of what has been recently patented in transdisciplinary categories, that could be announcing what the future of fashion retail might look like in the next few years. As we will be tackling in the following parts, consumers of fashion goods are eager to try new ways to shop online and offline, however, they are also very exigent in terms of technological solutions and have pouted many digital interfaces that were deemed too complicated, too time-consuming, or even because of their lack of affordance and readability from customers and retailers.

**Smart fitting rooms, magic mirrors, etc.: what is the difference?**

At this point and after analyzing several projects that are somehow already present in the market, we are able to present a definition of each concept. The notions commonly used are three: magic mirrors, smart or virtual fitting rooms, as well as virtual closets. However, although often used as equivalents and even presented by companies themselves, in unclear ways, there are significant differences between each system. In fact, we believe that much of the confusion is due to the fact that these are relatively recent concepts and therefore difficult to define, especially when there is no helpful model or categorization where they can be framed (FERNANDES, 2013). It was in this context that we sought to establish a delimitation at the level of functions of each of the systems and thus contribute to the understanding that defines what is a "magic mirror", a "virtual dressing room" and a "virtual closet". We understand that a magic mirror (figure 1) is defined by the use of a screen, dubbed as "mirror", to promote different products through images or animations, with which the user can interact thanks to motion recognition through a Kinect sensor (or equivalent) or even using a touch screen (FERNANDES, 2013).

FIGURE 1 – EXAMPLE OF MAGIC MIRROR OR INTERACTIVE MIRROR
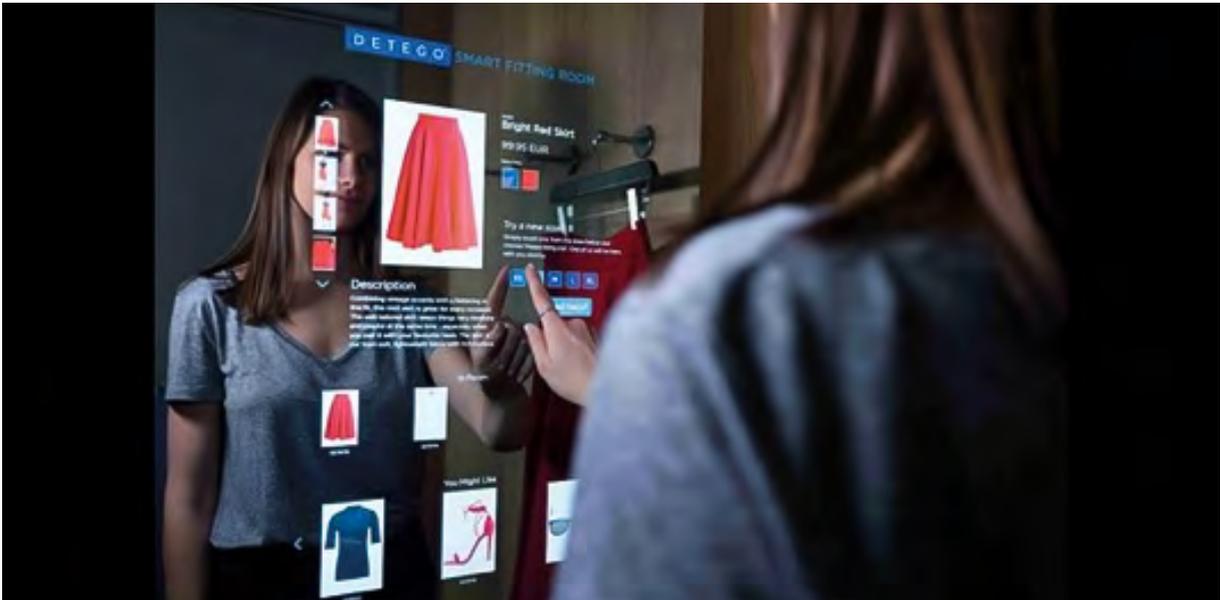
FONTE: https://pyramid-computer.com/product/polytouch-interactive-mirror/. Accessed on: 5 may 2020

The main problem in systems that present themselves as "Magic mirrors" lies in the fact that they do not show the user's reflection, which ends up being a contradiction, since it is called a "mirror". Virtual closet is what most projects look like but not any can effectively be considered as such. A virtual closet is, for us, the one in that, as the name implies, there is a virtual representation of the clothing pieces that are present in a closet. Apps and websites like GlamOutfit (Android, iOS) (figure 2) or Pureple (iOS), are good examples of virtual closets.

FIGURE 2 – EXAMPLE OF VIRTUAL CLOSET (GlamOutfit)
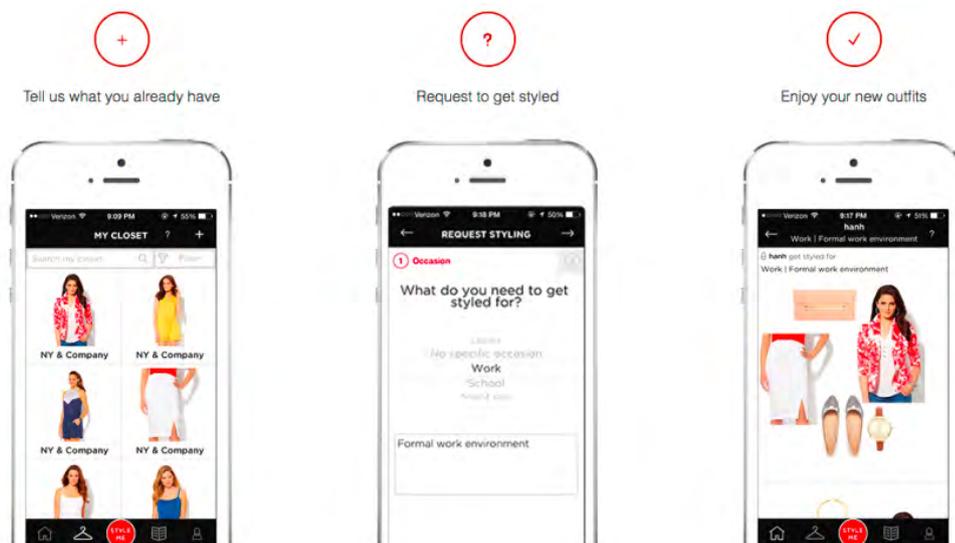
FONTE: https://newscentre.vodafone.co.uk/app/uploads/2017/08/glamoutfit-1024x540.png.
Accessed on: 5 may 2020

However, the term is many sometimes used for applications that make use of augmented reality or use magic mirrors, losing in these cases what is the main feature of a closet that is related to the reproduction of the pieces in the closet (FERNANDES, 2013).

Finally, the virtual fitting room (figure 3) should be understood above all as a platform that lets you try out pieces in a virtual way. The possibility of testing clothes resides in the aspect of their digital image, which distinguishes it from other systems. In this sense, the projects like Styku and Zugara are examples of virtual dressing rooms. This means that from the moment the system allows to check the look of a clothing item by applying 2D or 3D images to the user, we are facing a virtual dressing room. However, these cases are not isolated, as when measures a user's measurements are taken and presented to him virtually in an avatar form, we are also facing a virtual fitting room (YOUSEF, MOHD & AL-OMARI, 2019).

FIGURE 3 – EXAMPLE OF SMART FITTING ROOM

FONTE: https://www.youtube.com/watch?v=rMUsVIB-anY. Accessed on: 5 May 2020

Being this one such a broad definition, especially since its understanding changes according to the methods and resources used, it is more important than any other to clarify what is our understanding. Therefore, we consider that it would be important to find new terms to define the different systems understood as virtual fitting rooms.

A true virtual fitting room should be one that allows the user, regardless of his context, to recreate the experience of trying on clothing, only virtually, not using an avatar, but through the user's reflection on a screen, with live-rendered 3D animation.

Big data & consumers' body shapes

Other companies have focused their attention on creating body scanners, and collecting data on a massive scale, in order to get more information on consumers, and perhaps, solving the issue on poorly fitted clothing items. However, body scanning is expensive, and not every customer can have access to it, since not every retailer can offer it to its clients. Body scanning machines are not new, as they have been introduced under several names and shapes on the retail market approximately since 2011 (DANIEL, 2018).

The potential of this instant 3D modeling is huge and the fields where it can be used are numerous and varied. E-commerce is one of the sectors that can benefit most with this solution and in particular in the sale of garments. The truth is that as we'll see later, there are already some projects in the market that take advantage of technology. In this regard, and briefly, we highlight the Bodymetrics (ROMMELLYN, 2012), project which consists of a booth entirely equipped with a total of sixteen Kinect sensors, which capture each point of the human body in an attempt to take measurements of consumers. Based on these measurements, the system will search a database for in-store items that best fit the user's body. However, Bodymetrics is no longer leading the body scanning market, as this offline solution was not efficient enough in terms of time, money and results. Other projects like Bodymetrics have failed to find their real market, as the body cabins were deemed to be too expensive for retailers, as well as too laborious for shoppers (YOUSEF, MOHD & AL-OMARI, 2019).

New solutions have since entered the body-scanning game, as companies like Body Labs, acquired by Amazon in 2017 (LOMAS & CROOK, 2017) and BodyBlock have promised to solve the complex fitting problem, as well as starting a data collection on more than a million bodies (BODYBLOCK, 2019).

As pointed out in December 2018 by GlobalData, apparel returns, mostly caused by incorrect sizing should cost UK retailers as much as £3,6 billion by 2023 (GLOBALDATA, 2018). The well-known problem of online retail is still here, and customers have yet to be presented with an accessible solution.

Now that smartphones can capture the user's body measurements with a few pictures, body scanning cabins seem to have become obsolete. Projects like 3Dlook (SCARANO, 2019) and Nettelo aim at providing solutions with smartphones, and have solved a massive part of the problem, as they allow the user to take a body scan without purchasing any additional accessory or special device.

The main issue with databased measurements is the information itself, as one cannot guaranty that a user's measurement and personal data are not going to be used for other purposes once harvested. The apps guarantee better results when users take pictures of themselves with form-fitting garments such as underwear, but how can they be sure that their pictures are not being used for other purposes? Moreover, do we want for our measurements and personal body data to be sold to marketing companies? These are some of the inconveniences of these services, and as we saw before, they solve a part of the problem, but not the issue itself. According to The State of Fashion:

> In the mobile consumer journey, the gap between discovery and purchase has become a pain-point for a more impatient fashion consumer, who seeks to purchase exactly the products they discover, immediately. Players will focus on bridging this gap through shorter lead times, improved availability of advertised products and new technologies such as visual search. (THE STATE OF FASHION, 2019, p. 16)

All signs point to a desire for change in the fashion market, as fashion consumers embrace more than ever new technologies and online shopping, as well as virtual display solutions implemented in offline shopping settings. As inclusiveness of people with reduced mobility is also a major concern in the fashion industry, virtual fitting rooms also open a door on creating a more inclusive and comprehensive environment and shopping experience. We believe some of the solutions previously assessed should be revised, in terms of user experience, services and consumer and retailer affordance, as well as combined, in some cases, to procure better results for fashion retail in general.

Additional considerations

Smart fitting rooms should be about convenience for consumers, not a mere gadget, yet new technologies seem to be failing at serving customers with choice and continue to acquire and partner with marketing-oriented solutions (BAZAKI & WANNICK, 2019), as well as fashion gaming (DONATIELLO *et al.*, 2018).

Nevertheless, the problem remains the same, as the main reason for online clothing returns are inappropriate fitting (BODYBLOCK, 2019). Smart mirrors and smart fitting rooms continue to be used as gadgets to get a more "innovative" in-store experience but fail at solving anything when it comes to improve a customer's online experience (BLÁZQUEZ, 2014). The importance on providing a solution is clear, as well as the need to CREATE a real and effective 3D rendered animations of garments, however, AR solutions are often based on 2D and 3D static images (BLÁZQUEZ *et al.*, 2005). Other AR solutions are still time-consuming and laborious for users, as they use markers in order for the cameras to track movements (YOUSEF; MOHD & AL-OMARI, 2019).

We also were able to observe that Amazon is clearly entering the fitting room game, as the company has started to show interest in 2017 with the creation of Echo Look, organizing body scanning trials in 2018, as well as patenting a virtual changing room app with data-led style recommendations in 2019 (RYDZEK, 2019). However, this new patent proposed by the e-commerce giant still uses avatars instead of real live reflection of users, and is therefore, not the perfect fit for the true issue at cost here.

Returns are at terrible expense for our planet, since returned goods must be transported back to warehouses, an issue that could be avoided by providing the right fit and size to customers on the first attempt.

AR and VR could be great solutions for fashion retailers and customers, as they can be implemented both online and offline, and serve many purposes, from consumer behavior data collection, to improving the user's experience, increase sales by presenting the right

products to the right customer, etc. As we focused on technological solutions that could improve the fashion retail omnichannel experience, it is also clear that consumers are ready to embrace technology, but not ever customer is the same. According to Xue, Parker and Hart:

> Hedonically motivated consumers are more open to v-Commerce than utilitarian consumers, and Consumers aged 18–34 regard interactivity, personalisation, and social networking as critical to offering that a cost-efficiency shopping experience. (XUE; PARKER; HART, 2020, p. 1)

Hence the importance of testing these technologies on different channels, customers and behaviors, to comprehend the differences between fashion customers, towards technological solutions, considering characteristics such as age, wage, country, gender etc. (BOARDMAN; HENNINGER & ZHU, 2019). A study by Dugar, Blázquez and Henniger highlights that:

> Literature supports that the introduction of in-store technologies has a positive effect on enhancing the in-store involvement of customers. However, most of the interviewees mentioned that the technologies they have encountered do not work properly or are not very accurate with the exception of the ones implemented for pure hedonic purposes. Many customers did not notice technologies or found them obstructive or located in unsuitable locations. (DUGAR; BLÁZQUEZ; HENNIGER, 2020, p. 207-208)

The research emphasizes what is the common understanding on consumer's behavior, embracing more than ever new technologies, when these are implemented in simple, effective and user-friendly retail solutions, an idea also highly relevant for online retail as well (BONETTI; WARNABY & QUINN, 2018).

Conclusions

Following the work previously done and considering the assessment that was made on the existing solutions, we seek above all to update the state of the art, that is, to understand what developments have been made in the field. Starting from the knowledge acquired in the development of a virtual fitting room solution in a prior investigation from 2011 to 2013, and considering the technological evolution, namely in terms of the capabilities of mobile devices, we seek in a first phase to describe existing solutions, assessing their strengths and weaknesses. Then, in the future, we aim at presenting a new solution, under a mobile app form that enables consumers to have an innovative shopping experience, but most of all meets their needs without using any devices other than those we already carry with us daily. Promising full data protection is also key, as it was considered a main concern among users on many apps. Commodity is a must, as both users and retailers should find profit with these solutions.

We consider the thematic more crucial than ever as, at the time of the elaboration of this article, the world is experiencing and facing a highly limiting pandemic, not only worse

in economic terms since people were able to continue shopping online but also debilitating on many levels.

Moreover, the parallelism between sustainability and technological aid in the online purchase process is crucial, as returns are mainly caused by sizing issues, that could be prevented by the use of virtual fitting rooms during the online shopping process. Returns would therefore decrease, and brands would not only solve part of a highly costly issue, but also appear as efficient and sustainable to their consumers.

In the fashion sector, very dependent on the presentation of collections and novelty products in stores, if offline retail is out-of-reach, like it might become even more frequently in the future, products have to be digitally and virtually presented to the customer. Yet, in a low-waste logic, it is essential to find solutions for customers to virtually try-on or examine fashion goods as much as possible before purchasing them, avoiding returns, which would imply more costs for companies, as well as the environment. As Fashion is known as one of the most polluting industries in the world, implementing solutions that can benefit the customers' online shopping experience, allow people with disabilities to take part of the virtual fitting experience and decrease dreaded returns all-in-one is definitely something to be discussed and considered by brands that have the capacity to implement such solutions.

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