Integrating Bespoke Avatars into Digital Fitting Methods to Improve Fit

Penelope NORMAN *, Jonathan BURGESS, Kyra GIBSON.
Arts University Bournemouth, Poole, UK

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Abstract

With the increasing reliance on digital technology globally, the adoption of industry 4.0 within the fashion industry has accelerated. The full 3D digital production process is at the forefront of fashion innovation, however legacy issues such as traditional size charts persist.

Inclusivity of diverse body shapes is a major issue for the fashion industry. By adopting a new approach, this research introduces a new process that has the potential to improve customer satisfaction and reduce waste.

This study evaluates the traditional size chart by comparing the industry standard to 3D body scan data from participants, focusing on the use of avatars and body scanning to improve the fit process and challenge the existing sizing system implemented throughout the fashion industry. This provides the foundation for a pilot study of a novel virtual fitting room which explores digital process as an alternative to the traditional size charts.

The result of this research is a prototype for the avatar library 'fitting room', that contains the 'real women' avatars from body scans. 3D avatars can be beneficial in both improving fit and reducing waste within the fashion industry. Further development of the avatar fit library will be available for industry to utilise in the fit process from design through to sampling and production stages. This prototype demonstrates a means to disseminate this research in an innovative and engaging way.

Keywords: 3D body scanning, Digital fashion, fast fashion, Fitting, Deadstock waste

1. Introduction

Digital technologies represent a major growth area in the global fashion industry and have become well established for certain processes such as digital pattern creation [1]. Although 3D digital technologies are widely available, the fashion industry has been slow to incorporate 3D data for design and production [2].

3D body scanning has been proven to improve the fit of garments at the source of design through to production [3], however, bespoke customised garments produced from 3D scan data have not translated to mass produced fast fashion due to discrepancies between current conventional sizing system and 'real body' sizing [4]. As a result, the best practice system to use digital avatars as a tool for mass production has yet to be established. Integration of digital avatar libraries in garment design and production processes presents an opportunity to positively impact the fashion industry. A proposed alternative digital system of virtual reality (VR) fitting rooms is discussed in this study with the aim to reduce waste, increase efficiency and cut costs associated with poor fit.

1.1. Fashion Industry challenges

The term 'fast fashion' has been applied to the mass production of cheap garments that continue to dominate the fashion market [5]. The waste, short lifecycles and environmental impact of fast fashion is a considerable challenge [6].

'Deadstock' refers to product that has been manufactured and remains within the business but has very little value. Levels of deadstock are important as an indicator for some of the major challenges facing the fashion industry [7]:

1. Customer returns - which has increased with online retailing [8]
2. Overproduction - leading to excess out of season stock, this has increased with faster product cycles [6]
3. Physical samples – used during product development across global supply chains [9]

* pnorman@aub.ac.uk; +441202363069; www.aub.ac.uk

Issues around fit and dead stock are recognised at all levels of the fashion market, however because of the volumes it is a more significant issue in fast fashion [7]. Digital technologies such as 3D body scanning are a potential solution to improve fit and reduce returns and waste [10].

1.2. Digitisation of the fashion industry

The fashion industry is turning to digital sampling and production methods to make their production cycles more cost effective and consistent [9]. New digital technologies are also critical in keeping pace with consumer expectations and online market growth. Digital pattern creation has been a longstanding production technique used as a lean method of working within the industry for pattern development and alteration [1]. It is now at the forefront of industry practice to fully integrate the technologies to speed up the sampling process and provide more control and autonomy during the production cycle [9].

The 3D aspects of digital fashion software and the use of avatars are well established [2], [11], however, the use of these virtual sampling and fitting tools are often side-lined in favor of more traditional physical processes due to several barriers identified by Papachristou and Bilalis [2]:

- Lack of 3D digital skills and knowledge within the fashion industry.
- Initial cost of equipment and software providing perceived poor return on investment.
- Limited libraries of 3D digital assets – not only fabrics but also trims.
- Complex feel and performance of physical fabrics not being reflected by virtual models.

This has opened a wide area for research as companies strive to understand the potential of 3D body scanning for mass manufacturing [12] as well as investigating how it can be used for greener, less wasteful practice and improve the interaction between fashion brands and their customers. New innovations are changing the industry from design [9] through to the customer experience [13] and developing 3D body scanning applications present an opportunity to overcome barriers.

1.3. Fitting

As 23% of product returns in the US are due to poor fit, improving garment fit is of critical importance for the fashion industry [14]. The 'standard' sizes are based on population statistics and differ greatly across manufacturers, and this variability within the market is confusing for consumers [11]. Defining a good fit is complex [4] and as traditional industry sizes rely on a limited number of basic measurements this makes achieving good fit on mass produced garments very difficult – leading to criticism that "one size fits nobody" [15]. The discrepancies between industry standard sizes and real body shapes is also well documented [4]. The problem is further compounded by the reliance on industry sizing when purchasing online and consumer behaviors such as vanity sizing [16].

A virtual fitting room [14] provides an approach that removes the onus of 'finding' a garment that fits from the end consumer and could enable manufacturers to create an industry standard approach based on descriptions of body shape such as the Fitlogic system [15].

2. Method

This study uses a mixture of quantitative data to inform a novel 'virtual fitting room' proof of process pilot study [17] to assess the use of 3D body scanning technology for use in the fashion industry.

2.1. Quantitative data comparison

To enable this study to provide comparison between 'real' and 'standard' sizes, Size 12 has been chosen across the data collection. Size 12 is a typical fashion industry standard for fitment during design and manufacture. It is also representative of a common high-street fit and available commercially across most product ranges. Two data sets were gathered for comparison:

1. Industry 'standard' size data
2. 'Real body' 3D body scanning biometric data

2.1.1. Industry standard size

As sizes vary across manufacturers and markets [16] it is necessary to develop a nominal size 12 for this study. To generate a representative 'size 12', data was gathered from 28 size guides across the range of UK high-street and online fashion retailers.

2.*1.2. Real body*

A sample size of 7 participants allowed proof of process while providing a range of detailed anthropometric data to be gathered and processed. 7 Female participants who self-identified as a size 12 'high-street fit' were ethically recruited. In a preliminary questionnaire to gather participant details and self-perceived size [16], participants were also invited to self-describe their body shape.

Participants were 3D scanned in underwear to allow body shape to be accurately captured. The Sizestream scanner system was used to collect and Clo3D was used to process the 3D body scan data into avatars. The scan data presented within this study has been anonymized, days of the week have been used as pseudonyms for each participant. The data presented in this paper has been limited as a comparative measure to the nominal size 12.

2.2. Pilot study – Digital fitting room

This research uses a pilot study methodology [17] to propose and implement an industry 4.0 system – a digital fitting room [13]. The quantitative data - 3D body scans of the size 12 participants is fed into a virtual reality, digital fitting room environment to investigate the use of 3D body scanning in fashion industry workflows.

The digital fitting room is assessed through a trial fit of a fast fashion size 12 garment. This mass manufactured size 12 garment data was supplied by a UK supermarket brand. The data included production patterns, fit notes, specification sheets and images of the garment fit process for this research project. This proprietary data is subject to a confidentiality agreement.

3. Results

This research demonstrates a process for creating a virtual fitting room, this process flow is shown in the figure 1 diagram.

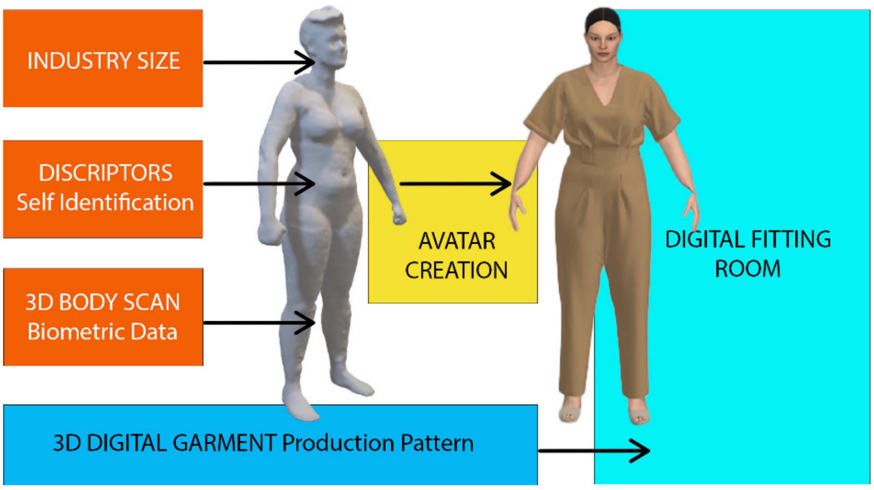


Fig. 1. Digital fitting room process flow

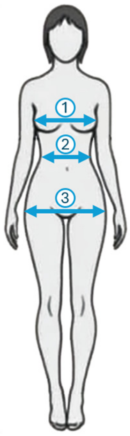
A number of inputs are required to achieve the fitting room prototype: industry size from commercial size guides; descriptors of body shape as communicated by participants; and 3D body scan biometric data of participants. These 3 inputs allow an avatar to be created. The avatar and 3D garment data can then be fitted in the VR environment – the digital fitting room.

3.1. Size 12 - Industry Vs Scan data

The initial measurement study will investigate the differences between the industry sizes and the measured size 12 women. This quantitative data will demonstrate the differences and variation within the current system – both from an industry and customer perspective.

3.1.1. Industry size 12

From 28 high-street and online size guides, the following nominal size 12 guide displayed in figure 2 was created.



	UK High-street size 12 (inches)		
	Average	Maximum	Minimum
1 Bust	36.5	38	35
2 Waist	29.6	31	28.8
3 Hips	39.5	40.9	38.3

Fig. 2. Average UK high street size 12 bust, waist and hip measurements taken from 28 high-street and online size guides.

The variance of size 12 measurements demonstrates the difficulty of fit for consumers as all 3 measurements vary by at least 2 inches across the high-street sizes.

3.1.2. Size 12 participants

Participants completed a questionnaire and were asked to self-describe their size and body shape. How participants 'identify' their body shape and clothing size is displayed in table 1.

Table 1, participant self-identifying descriptions.

Participant	Age	Gender	Clothing size (UK)	Body Type Description
Monday	20s	Female	12	Tall
Tuesday	20s	Female	12	Average height, curvy, broad
Wednesday	20s	Female	12	Average height
Thursday	40s	Female	12	Tall, curvy, broad
Friday	20s	Female	12	Short, small, top heavy
Saturday	20s	Female	12	Tall, curvy, Athletic
Sunday	30s	Female	12	Average height, curvy

Participants were each scanned using a Sizestream body scanner. Avatars were created using both manual manipulation of the standard avatar rigging and the clo3D auto convert function. Figure 3 displays the avatars created using the 'auto-convert' function as this gave the most accurate rigging for both visual representation and real-world measurements.

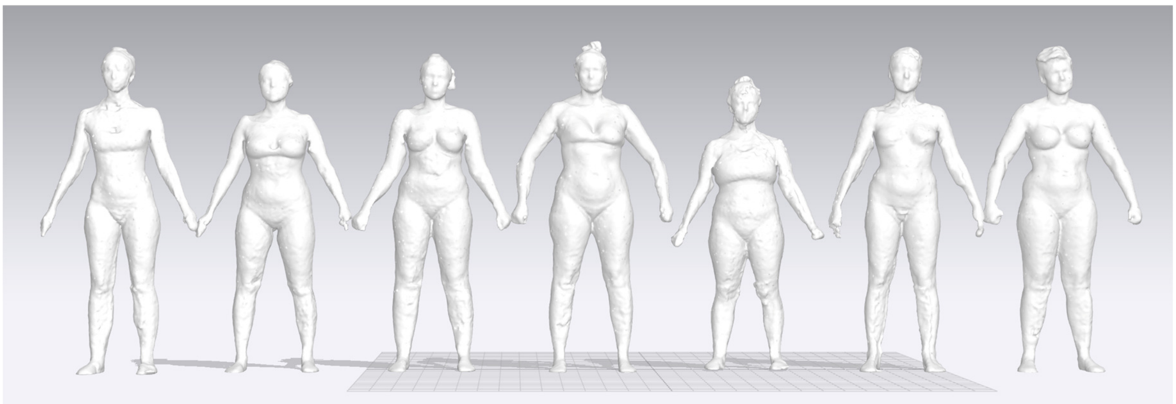


Fig. 3. 3D body scan rigging of the 7 'size 12' participants, from left to right: Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, and Sunday.

With a sample size of 7 women, the side-by-side line-up of the women in figure 3 presents the diversity of body shapes within the same 'size 12'. To compare the scanned participants to the size guide, measurements of the scanned data were taken. The bust, waist and hip measurements are displayed in table 2.

Table 2, comparative results of 'size 12'

Sample	Size 12 Bust (inches)	Size 12 Waist (inches)	Size 12 Hips (inches)
Industry size guide average	36.5	29.6	39.5
Monday	38.15	30.09	41.87
Tuesday	39.44	30.78	42.16
Wednesday	38.62	30.19	39.52
Thursday	40.07	30.31	42.00
Friday	40.19	33.15	45.27
Saturday	38.77	34.88	40.90
Sunday	39.40	31.53	43.46
Participant average	39.2	31.6	42.2

The scanned data from in this study clearly demonstrates the disparity between the size 12 guide measurements and the scanned data from participants.

This assessment of the size 12 fit demonstrates how 3D body scanning technology can progress sizing beyond the limited fashion industry size guides. To incorporate body shape and achieve a better fit, a diverse library of avatars is proposed - where fashion brands can see their garments on the individual 'same sized' but different 'shaped' digital avatars.

3.2. Pilot Study – Digital fitting room

The aim of the digital fitting room is to categorise body shape within the pre-existing standard size brackets. The intention is to provide fashion brands coverage for the diverse range of body shapes to efficiently try on their standard-sized garments. This pilot study demonstrates this with a selection of size 12 bodies in an avatar fit library that can be assessed in a VR environment. By using the scan data from the 7 participants, this pilot will be assessed by the systems potential to improve the inclusivity of size 12 for a more diverse range of shapes.

3.2.1. Standard size 12 mass produced garment

Size 12 mass produced garments are specifically produced to fit all 7 participants. To visually assess the accuracy of fit in the current industry size system, the avatars of the 7 participants were dressed in a size 12 production garment.

The visual representation in figure 4 displays how one mass produced size 12 garment looks on 2 size 12 women (Thursday and Friday) These were the tallest and shortest of the participants and represents the limitations of assessing fit using only size guides with 3 measurements to describe real bodies.

Fig. 4. From left to right Image of garment being taken off one size 12 woman and placed on another size 12 woman

Figure 4 provides a clear visualisation to demonstrate the issues around body diversity that are not being addressed by standard fitting practice. There are many differences in body 'types' even for women who identify as the 'same size' (a UK size 12). However, as a tool for the fashion industry, this data needs to be presented in a more familiar context by referring to the current standard size guides for reference.

3.2.3. Digital avatar library

To improve fit of fast fashion garments, this study proposes using 3D body scanning to create a new digital avatar library system. The process described in this study can be scaled to enable a series of 'real' avatars to be created based on 4 factors:

1. Industry standard 'size' - Although inaccurate, industry size guides provide an indicative point of reference for garment fit. In this study, participants that self-identified as a size 12 fit was the initial screen to provide comparative data.
2. Descriptors – information such as age, gender and height provide important parameters. In combination ('size' and age) descriptors can be used to more accurately refine body shape.
3. Self-identified body shape – 3D body scanning provides a shape as opposed to a size. As such, self-described body shape – 'curvy', 'broad' and 'small' - provide key prompts for the creation of more refined avatars.
4. 3D body scan data and rigging – collecting and processing the biometric data.

The description from the pre-scan questionnaire provides self-identities that if collated, can be used to categorise assumed body image to offset against the biometric data. This could then be used to define 'tolerances' or similarities that could be key in identifying different 'groups' of participants. In this way, the current industry size, the descriptors, the self-identified body shape and biometric data can be combined to refine an 'avatar library' to a defined set of avatars. This people centred approach can help to describe size and shape to both the industry and the consumer – enabling better fit.

3.2.3. Digital fitting room prototype

By providing a VR space to engage with the 3D data that is familiar for fashion industry professionals the digital fitting room is a novel concept for displaying 3D body scanning data. The concept demonstrated in figure 5 shows a commercial size 12 garment fitted to the size 12 avatars (created during this study) within a VR digital fitting room.

Fig. 5. Screen shot of the digital fitting room VR experience

The digital fitting room prototype shown in figure 5 will allow garments to be assessed on real women by utilising a digital avatar library.

As a tool for communicating the fit of garments the prototype fitting room provides a VR platform to demonstrate the concepts discussed in one simulation:

- Digital avatar library – using aggregated data from 3D body scanning to create inclusive 'real body' avatars.
- Technical garment simulation – using aspects of the Clo3D software to provide heat maps to check garment fit.
- Fitting room VR environment - designed to be inviting and familiar to the industry, with a focus on visualising how garments fit on a range of avatars

The heat map showing the 3D fit on the digital avatars is shown in figure 6 provides a layer of technical detail in addition to the visualisation.

Fig. 6. Stress map showing the distortion of the reference size 12 garment when fitted 7 avatars.

The stress map is displayed as a heat map with regions of excessive stress displayed in red. The proposed prototype fitting room concept combines the technical accuracy of the avatars and garments within an appropriate 3D environment for the fashion industry.

This proposed concept aims to challenge the ideas and misconceptions around the use and implementation of digital fashion technology into production cycles, the final visual representation is a fully immersive experience. This Virtual Reality experience is designed to highlight in an inviting and innovative way the possibilities and improvements that can be integrated into inclusive fashion production methodologies. The space is the prototype for the avatar library 'fitting room', a space that contains the 'real women' avatars and allows the viewer a personal interaction with them. That can be used to communicate both within the industry and the consumer in the retail setting.

4. Implications

The digital fitting room provides a route to adopting 3D body scanning within fashion. It is designed to be an engaging, visual representation of the issues faced around fit and sizing garments. The proposed VR fitting room has the potential to enable a number of industry 4.0 benefits such as reducing waste, reducing time to production, and better fitting products.

4.1. Improved garment fit

Expecting all different body shapes to be catered for within a range of 7 or 8 fixed sizes is unrealistic but could be resolved with the implementation of the proposed avatar library. Inspecting the fit of the garment while immersed in the VR space it becomes obvious that the industry size 12 garment sample fits the participants differently. The effect is much more powerful in 3D than using simply images and measurement data. Viewing the fitting process in 3D further highlights inadequacies with the current UK standard approach to size and fit.

The process of creating avatars from a dataset of real women provides opportunities to better categorise the size and shape of prescribed avatars that are more reflective of real body shapes than the current industry size guides. A larger sample size would enable this pilot study to inform the creation of an avatar library that represents a significant proportion of consumers.

If it is possible to identify 'tolerances' from biometric data it should be possible to provide mass producers with a guide to 'fit' based on real people from body scans. As such, digital libraries of both garments and avatars can become important and valuable assets for a fashion brand.

4.2. Customer experience

Most consumers do not currently have access to their biometric data and neither can the high street producers body-scan the hundreds of consumers that purchase fast fashion garments from them to provide individual fit. However, using 'tolerances' from biometric data could firstly provide mass producers with a guide to 'fit' based on real people (in this case women) and also avatars that display these tolerances visually linked to the garments they are selling – this allows the customer and the company to share in a much more informed and inclusive process of making, selling and buying a garment.

Potentially the fitting room and avatars could become a visual way for fashion brands to communicate about fit with their customers. These avatars and VR experiences could be used to better communicate the fit of their digitised range of garments on different body shapes to the end consumer. Customers could view online which of the 'size 12' (if they are size 12) body shapes is most similar to their own and review the fit of the garment they are considering purchasing on this avatar. The platform allows other immersive environment tools to enhance customer experience, for example incorporating AI filters.

This offers the consumer a mass-customised experience that improves fit and additionally serves to reduce returns and improve the brand loyalty. Customers can identify with a brand that shows an empathetic and realistic approach to fit, inclusivity and diverse body shape. This would allows brands to offer the consumer the bespoke digital experience they are becoming accustomed too in other areas of life.

4.3. Digital workflows

This study demonstrates a platform that can be utilised from a conceptual stage through the development on towards commercialisation. Using digital avatars and VR fitting rooms presents an opportunity to create improved, more efficient workflows that rely less on physical samples in production and allow a better communication across the production process. The process flow diagram in figure 7 is an alternative industry 4.0 workflow for the fashion industry.

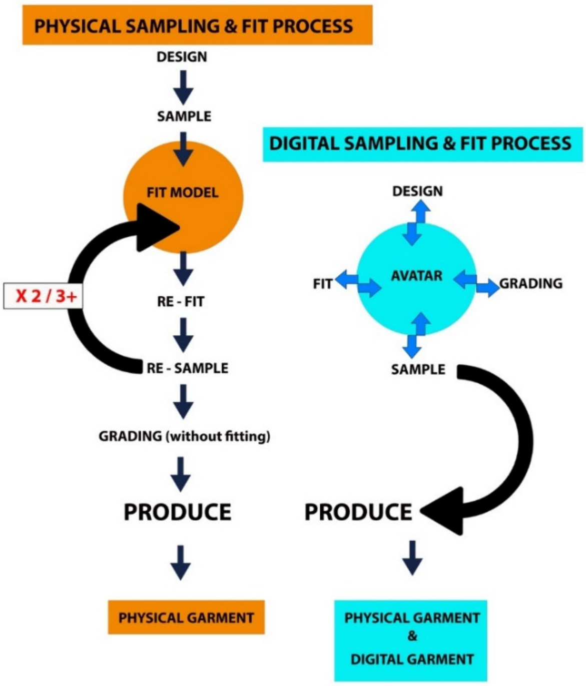


Fig. 7. Alternative digital workflow using digital avatars process.

An example of where the proposed avatar library is inherently more efficient and consistent than the current process is in the use of 'fit models' where consistency and availability are an issue. The process trialled in this pilot study provides a platform to enable faster and more accurate decisions to be made about garments in development.

Using a digital avatar library to improve fit will also cut costs in the sampling process. Many brands have access to 3D digital technology but do not fully utilise its capabilities as they are not currently aware of 'how' to use it and have yet to connect the full development process. By demonstrating the value of the full digital process (from concept through to the retailer) with a rational and practical tool, the digital fitting room can help to drive innovation. This tool can assist conversion to new practices with very minimal training in the first instance and once the benefits have been observed and acknowledged the process could be implemented fully with minimal disruption and proven assurances of the benefit.

Avatar libraries have the potential to be market specific and use AI to enable accurate representation of market-wide body shapes of consumers. These avatar libraries have the potential to be developed further for industry to utilise in the fit process from design through to sampling and production stages.

4.4. Reducing deadstock waste

The current barriers in place to introduce this technology to the high-street fast fashion brands come down to a return on investment. Levels of waste and in particular reduction in deadstock provide a realistic metric to measure the benefits of introducing new digital processes.

If a garment fits well, it will be kept and re-worn making it a more sustainable purchase. If a garment fits badly, it will most likely end up in landfill. Figure 8 demonstrates how better fit reduces deadstock and increase profits.

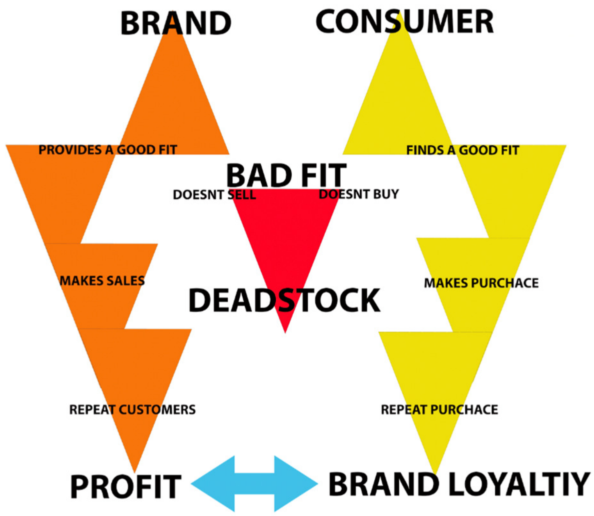


Fig. 8. Diagram explaining how good fit improves brand loyalty and Profit

Solving current industry wide issues with poor fitment creates a virtuous circle of reduced returns, increased customer satisfaction and therefore increased brand loyalty. A customer focused approach such as this would help to drive sales and decrease waste.

If a brand was to 'show' the consumer the garments on an avatar that represent the consumer's body shape this would strengthen a greener approach to buying and selling between consumer and brand.

5. Conclusion

The proposed digital fitting room presented demonstrates an approach to enable an improved garment fitting process for the fashion industry. By enhancing industry standard sizing through use of avatars in an appropriate VR environment, this study demonstrates an alternative fitting process using a combination of industry standards sizes, shape descriptors and 3D body scanning biometric data.

5.1. Fashion industry impact

By creating a VR fitting room, the system proposed in this research is designed to be an engaging and inviting interface that is more amenable to fashion industry professionals that lack 3D digital skills. By demonstrating how better fit can reduce returns and levels dead stock, this new industry 4.0 process is a viable commercial proposition. This digital fitting room pilot provides a platform for an improved library of digital assets and better simulation of real fabrics.

The pilot study demonstrates how 3D scanning can improve fitting and additionally reduce the need for physical prototypes and samples. By reducing destock and therefore waste, the digital fitting room can improve environmental sustainability of the fashion industry. The process proposed in the pilot study has the potential to:

- Reduce levels of deadstock and waste.
- Create smart and lean ways of working
- Improve communication both within the fashion industry and with consumers.
- Offer more inclusivity and fit diversity for the consumer
- Offer a solution to recognised ‘fit’ issues faced by both the industry and consumers.
- Improved fit – reducing customer returns and potentially improving customer satisfaction and therefore improved customer loyalty.

This pilot study provides the basis for a larger research project to introduce digital fitting rooms into commercial, mass manufacture production. This will allow the potential efficiencies and waste reduction to be quantified.

5.2. Further work

To implement the digital fitting room would require the development of a avatar library as a commercial commodity that could be implemented into an industrial production cycle. The knowledge gained and shared from this study is already being considered by and disseminated to brands for further research collaborations and their own internal discussions on the production practice.

Developing accurate avatar libraries is a key component to enabling a digital fitting process for mass produced garments. This pilot demonstrated the issues with fit and the findings from this study are in the process of informing commercial practice as a next phase of this research into garment fit and digital sampling using 3D body scanning.

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