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IMPROVED FIT: DESIGNING 3D BODY SCANNING APPS FOR FASHION

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Abstract: *Current research on 3D body scanning is mainly focused on technology development. Personalisation is seen as paramount, while development is influenced more by technology, than design. This research was designed to investigate the 3D body scanning service (BSS) of the current fashion market and to build a framework comprising predicting those factors influencing consumer adoption of 3D body scanner applications for a particular personalisation system. The framework considers acceptance factors, plus user journey factors and their combined effect. Thus, an extensive user experience study was conducted, which was empirically tested through semi-structured focus group interviews and self-reported metrics, to validate results and obtain further insight.*

This research project offers a major opportunity for innovation in the fashion industry, enhancing understanding of adoption factors and also providing a starting point for further research into branded BSS apps or services, such as m-commerce through branded apps.

Key Words: ***Mass Customisation and Personalisation, 3D Body Scanning, Fashion, User Experience.***

1. BACKGROUND

This research project was conducted under the framework of a successful grant application to the Engineering and Physical Sciences Research Council (2011). The research opportunity allows exploration of some of the ethical and psychological barriers around body scanning and video recognition, promoting a user-led design process, to enhance user adoption. Through knowledge transfer, the research team will develop additional user interface skills and knowledge through the development of the technology and its application with actual users, 'in the wild'. This will enable real and significant feedback to influence development and it is anticipated this will progress the likelihood of rapid adoption and impact amongst consumers. The research team is based at the Fashion Digital Studio at the London College of Fashion, which has been established with the intention of bringing together both the academic researchers and technical experts with the creative end users and consumers, designers and thinkers, to challenge existing models of technology development. In this paper, we aim to identify the key outcomes from the development of user experience design for 3D Body Scanning Applications in the Fashion industry today.

2. INTRODUCTION

At present, the majority of body-scanning technologies deployed in retail environments are expensive and require dedicated technical support, confining their use to high-end department stores and specialist sports retailers. The fashion, social and economic benefits that body scanning offers are, therefore, inaccessible to the majority of the general public. This project aims to exploit low-cost webcam/cameras, to reformat this technology into a service that is not reliant upon specialist hardware, and to re-programme the experience away from the controlled retail environment and into the home.

This low-cost BSS offers significant potential in terms of allowing individual customers to realize their body size and shape in their own home, using a standard digital camera/webcam. The personalised service is opening a whole new chapter in brand communication, especially with the meteoric rise of mobile devices, such as smartphones and tablets. BSS is becoming increasing advantageous to customers and companies alike. Nonetheless, consumer trust and privacy concerns exist, which are currently inhibiting adoption.

2.1. MASS CUSTOMISATION: INTEGRATION ISSUES

Bodyscanning has had a significant impact on the development of digital tools for commercial clothing production, in relation to incrementally improved efficiencies in the product development process applied to current mass-manufacturing methods. The integration of the needs and desires of the individual consumer, as epitomised by the model of mass-customisation proposed by Pine and others as the next consumer revolution, has so far failed to have the significant impact expected by many 10 years ago, when the first 3D sizing surveys were undertaken [1,2]. This approach proposes that consumers become co-designers, enabled by online platforms such as product configurators, to enable them to better specify products that are personalised to their own style and fit requirements, prior to manufacture. For example, Piller currently lists apparel in the top 3 of online configurator databases, with 176 apparel product configurators listed on this International Configurator Database, consisting of the following product types [3]:

- 105 T-Shirts/sweatshirts
- 42 Shirts
- 5 Jeans
- 5 Underwear
- 7 Sports clothing and accessories
- 12 Clothing including business suits, corporate wear, skirts and pullovers.

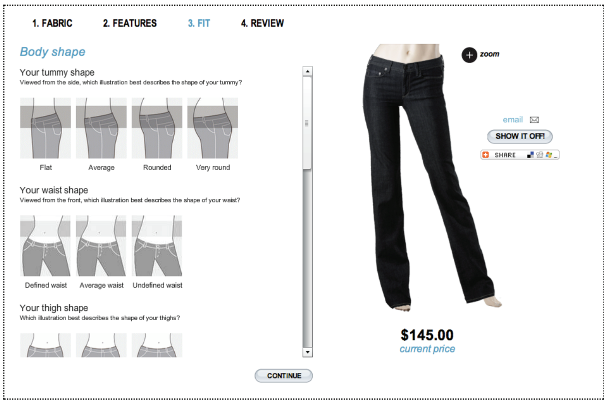

Fig. 1. *Online Jeans Configurator*

As we can see, a minority of these is concerned with fit customisation and these are reliant on customers supplying their own metrics or choosing from predetermined morphotypes. The majority allow customers to simply choose colour or print options, for mass-produced ready made garments such as T-Shirts.

Considering that US national statistics for e-commerce show apparel sales of $17bn for 2008, an 8.4% rise on the previous year, with 70% of all online sales being apparel [4]. This represents a huge marketplace that has not yet been given any significant consideration in terms of online fit, style and product advice, based on customer body shape. As a result, how can the future of clothing retail be further enabled by the technology developments which have happened in other fields, primarily in computer vision and user and experience design and how can body scanning enabled size and fit information be delivered to such systems, to enable consumers to find better fitting products?

2.2 USER EXPERIENCE DESIGN

There is more to buying clothes than knowing what size you are and body scanners provide valuable sizing information that can be used to create highly accurate, made-to-measure garments. Such accuracy is particularly desirable when producing functional apparel such as work-wear, uniforms and sportswear, however, in reality, achieving a perfect fit is only one of the forces that drive customers in retail situations [5,6]. To take full advantage of all that bodyscanning offers to the fashion and clothing industry, we need to appreciate that the experience of being scanned should resonate with how and why people consume fashion.

Recently, more emphasis has been placed on creating retail environments that offer a complete experience, where customers are led on a curated journey from the moment that they enter the store until they leave. The architecture, store layout, music, imagery and even the smell of the environment are carefully chosen, in order to create a narrative that strengthens both the brand and the take-home experience [7,8,9]. Associations are powerful influences on how we perceive these experiences and an ill-chosen stimulus can spoil the illusion and overall experience.

In essence, the fashion experience is more than just people clothing themselves. For many, it offers a means of self-expression and aspiration [10]. These are powerful human emotions and can entirely dictate how a product is perceived. As a result, the successful employment of body scanners within a fashion context requires a holistic appreciation of the entire experience, e.g. whether the technical nature of the device is in conflict with the rest of the experience, etc. [11] It is also important to explore the ‘personal service’ aspect of the tailoring / fitting experience, to see if it can be removed without compromising the customer’s expectations.

Augmented reality (AR) and virtual try-on can, however, be used to enrich the clothes shopping experience in a way that would have been impossible before body scanning and computer vision systems. Augmented reality offers a live view of a physical environment, which is composited with computer generated graphics and text, etc. AR’s potential for use in fashion is well understood and may provide a platform for people to simulate garments or body modifications, and ultimately provide an arena where fashion is consumed.

Fig. 2. *John Lewis’ virtual fashion mirrors bring a new shopping experience, by using augmented reality to enable customers to try clothes on virtually, as part of its multichannel offering[12].*

2.3 IMPROVED FIT WITH CUSTOMER NEEDS

In the fashion industry, the move away from creating designs tailored to the individual has created waste and proliferation of similar products [13]. In 2006 the (UK) clothing and textiles industry produced up to 2m tons of waste, 3.1m tons of CO_2 and 70m tons of waste water [14].

When a customer chooses to purchase a mass customised product, this will most likely provide an improved fit between the product's properties and the customer's needs [15], compared to purchasing a standard product.

One example of this from the fashion industry is presented by Hethorn & Ulasewicz [16]. Much apparel is so inexpensive that many customers purchase clothing, which may not fit. Clothes that do not fit are unlikely to be worn by the customer and the resources for producing those clothes are thus wasted. The resources for producing these clothes for that customer, from an overall perspective, could be reduced.

For the fashion industry, creating products that have a better fit with the customers' body shapes and needs could thus reduce the return rate of online shopping and reduce the waste that is involved by manufacturing products that are never used. A 3D body scanner provides the opportunity to do just that, since the better fit that customers achieve by choosing a personalised product, embedded? by home body scanning service, would logically reduce the probability of the product being returned through online shopping and the resource used for custom service being wasted. A product not used and the resource used for manufacturing it, are thus wasted.

Hence, the 3D body scanner helps the mechanism that mass customisation provides a better fit, introduces an opportunity that mass customisation products could reduce the type of waste presented above.

3. METHODS AND METHODOLOGY

Primary data has been generated by means of focus group interviews. A focus group consisting of five participants (female, MA Fashion and Fashion Management students, age between 20 and 39 years) was used for the study. Participants were selected based on convenience sampling on the criteria that all were related to the fashion industry, owned a mobile phone and regularly used online shopping. This allowed for deep immersion into the fashion apps users, with regard to the development and design of body scanning apps for the fashion industry.

The focus group took the form of semi-structured and free-flowing interviews. Such in-depth, rich information from a small number of samples will be invaluable in ensuring the validity of the qualitative research methods [17]. The main proposed outcome of this research consists of a methodological approach, which will support designers and engineers in developing a 3D body scanning application for fashion.

The focus group interviews were divided into two sections. In section A, the participatory diagramming method was employed to explore and compare participants' reaction and attitude to the three different 3D body scanning services in the current fashion market. Section B was designed to investigate the user journey of BSS. This approach seeks to develop an in-depth understanding of the research problem, through collecting multiple forms of data.

Numerous methods for acquiring shape information have already been established in both the academic and industrial context. This study briefly classifies them into three user scenarios:

USER SCENARIO 1: TC2 (BODYMETRICS) IN THE RETAIL ENVIRONMENT

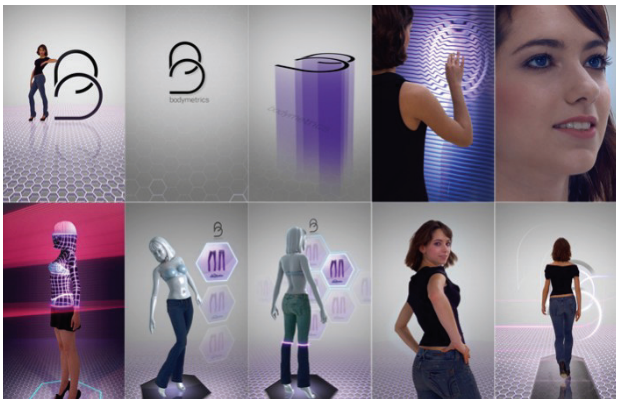

Fig. 3. *3D body scanning service at Bodymetrics[18] (Bodymetrics is an collaborative industry partner with Fashion Digital Studio. The collaboration promotes knowledge transfer through academic partners London College of Fashion and the retail, e-commerce and technology expertise of Bodymetrics@Selfridges, provides a team with extensive knowledge in this area, and significant and diverse relationships beyond the project, to increase impact)*

In this scenario, the users visit Bodymetrics at Selfridges, scan their body shapes, then choose and try on jeans, according to their body shapes. (Bodymetrics used its expertise in Body-Analytics to derive the optimal body-shapes after analysing body-scans and the corresponding perfect-fit jeans from made-to-measure, made from body-scans. The body-shapes are classified into three categories, these being Emerald, Sapphire and Ruby [18])

USER SCENARIO 2: KINNECT / HOME SCANNER

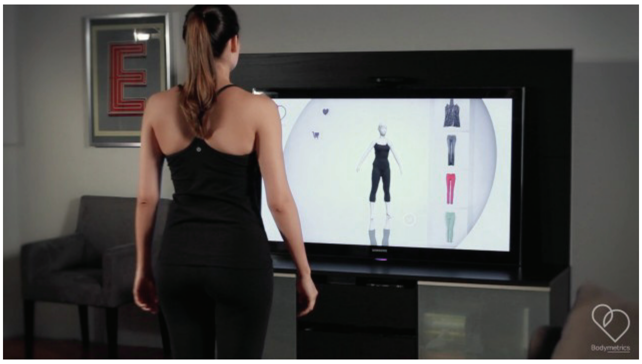

Fig. 4. *Bodymetric's home scanner*

In the near future, Smart TV will have the capacity to body scan customers by using a depth sensing camera (eg Microsoft Kinect). This digital experience connects cross channels for personalised TV commerce. The users stand in front of TV, the Kinect camera then carefully calculates and maps every contour and curve of the body. Once a customer account is created, users can virtually try on garments from partner retailers, to determine whether a garment fits and flatters their body. Users can then order clothing in their living room.

USER SCENARIO 3: WEBCAM / CAMERA

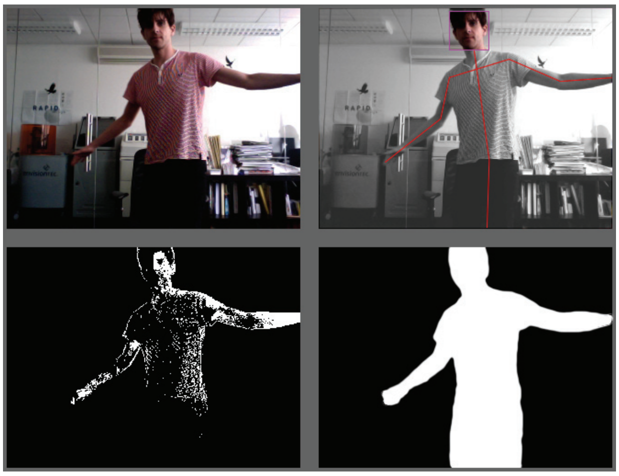

Fig. 5. *Development of low cost webcam/cameras home-scanning service at Fashion Digital Studio*

This scenario is focused on personalised online commerce. The users go to a website by using either a computer or smartphone. They take and upload their photographs, to obtain their measurements. They can then create looks by trying on garments and changing hairstyles and background. The app will indicate what size fits their body for each garment, so the users can then buy online with confidence. They can also share their looks and wish lists with friends online.

Five participants were invited to watch three video clips according to these user scenarios. They wrote down their 'feeling' regarding each scenario, in terms of positive and negative thoughts. They then responded to each scenario by co-operatively generating matrixes, flow diagrams and sketch maps which they are then invited to discuss and analyse in conjunction with the researcher. Diagramming thus generates both visual and discursive qualitative data.

The researchers were non-participant observers and not engaged in the process, or offering any comments. It's important that the person running the test does not influence the users. The researchers simply take notes and remain non-judgmental. When introducing the workshop, the researchers assure the participants that the test is to find problems with the service so the designers can improve it. This gave the participants time and room to experience aspects of different service and then record their initial thoughts.

In terms of comparing these user scenarios, the objective was to highlight elements that would effect user's preference, and ask invited participants how they 'felt' about the BSS which, in essence, was a portfolio of prototype/concepts, with no clear function. The open – ended nature of the invitation for engagement with the entire journey, was to observe how participants naturally react and engage in the user scenarios.

4. FINDINGS

Qualitative data obtained through the semi-structured focus group interviews was analysed using content analysis which involves interrogating the accumulated data for ideas and constructs that have been pre-determined [19]. The data was first categorised into relevant themes as per the dimensions outlined in the research hypothesis. Following this, a process of pattern matching was used to analyse the data collected from the focus group. Pattern matching 'involves predicting a pattern of outcome based on theoretical propositions to explain what you expect to find' [20]. The patterns were used to predict relationships between dependent and independent variables and seek alternate explanations for those that were found to be mutually exclusive through the deductive process [21]. Key findings can be summarised into five categories addressing the respective aims of the paper.

4.1 Function and Convenience

A key observation from these scenarios was the two directions of user experiences – perceived ease of use and perceived usefulness, (embodied by such qualities such as the accuracy of measurement, etc). There were participants willing to spend less than 30 minutes to go through the setup stage, in order to obtain accurate measurements, while some participants said they wouldn't spend more than 5 minutes to setup and wait for their body measurements.

4.2 Entertainment

This diagram analysis also indicated that perceived enjoyment is another determining factor in technology usage. User scenarios 2 and 3 are more playful in the view of the focus group, as Kinect has the function of linking with other kinds of game, while online / mobile application offers the opportunity to share and use the application with friends, through a social network.

4.3 Cost

In terms of cost, the free service of a 3D body scanning service in department stores is deemed acceptable to the participants. Most of the participants would not be willing to pay the cost, in excess of £100, for a Kinect, or similar specialist depth sensing device, in order to obtain body measurements. A free service was an option for most participants but there were some who would prefer to pay for a premium service, which would suggest a better quality and fully functional application. The participants indicated from their previous experience that free applications are usually of lower quality and eventually may have hidden costs.

4.4 Privacy

Consumer privacy concerns existed but apparently do not inhibit adoption. The topic of 3D body scanning is not particularly controversial, the only concern being that the users may feel self-conscious about uploading personal image online and providing data regarding their body measurements. This suggests that brands must alleviate privacy concerns, indicating clear benefits of personalisation and value-added features in the proposal, to enhance overall appeal and enjoyment.

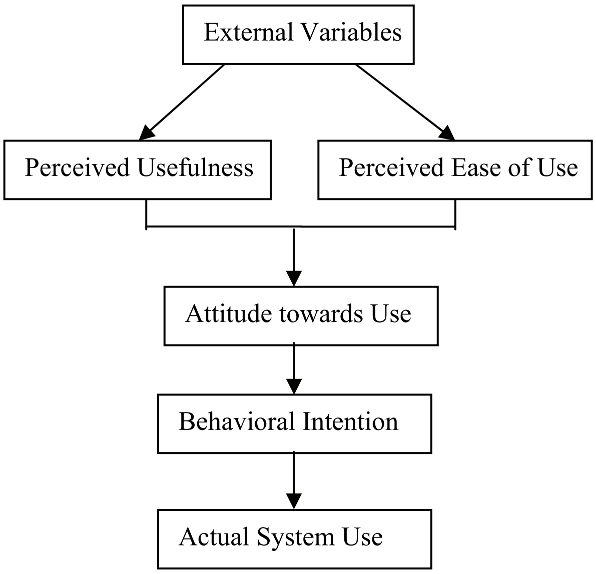

Diagram. 1. *Technology Acceptance Model (TAM) [22]*

The feedback from the focus group gave an insight into how and why people purchase fashion, Thus suggesting a framework regarding acceptance factors and adding new elements and ways of thinking to the existing theoretical model of technology acceptance (Diagram1).

In Section B of the workshop study, a refined approach to exploring the user journey of 3D body scanning, through the use of a webcam / still camera / smartphone to engage users in a personalised online retail journey was devised. There are many different services BSS can provide and many different ways of implementing them, so participants were invited to work with the researchers, to identify some of the more important considerations. The researchers were participant observers and engaged in the 'play' process, offering comments throughout.

This section of the study consisted of taking the participants through the user journey, illustrating the various scenarios which could arise when we employ different techniques of capturing the user's shape with a webcam, thus identifying the options that designers have at each stage.

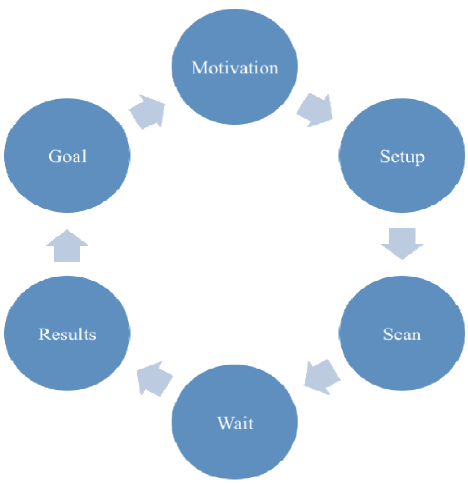

Diagram. 2. *the design process of BSS user journey*

4.5 Motivation

There are various reasons why a user might be encouraged to engage with BSS, some are more relevant to the current online shopping paradigm such as obtaining their size in a particular brand or discovering their waist, hips, bust measurements, etc. but there could be other benefits and motivators that have yet to be fully realised in the fashion industry. As shape is likely to be a more descriptive account than measurement of whether a garment will look acceptable on a person, a BSS could focus on identifying the individual curves of the user and communicate this using a shape classification system. A translator between each brand's sizing system was a popular solution within our test user group.

Either of these above results could be used as filtering parameters in an online shop's search engine, so that only the most suitable garments are suggested to the user, saving them time, and possibly providing them with valuable style advice.

Another option could be to not interpret the data at all, but instead provide the resulting 3D model directly to the user so that they can use it with a virtual try-on system, allowing them to decide for themselves whether they like the fit of the garment as it appears on their own body.

4.6 Setup & Calibration

Most BSS's that are based on optical techniques of capture will require some degree of calibration in order to correctly measure the structures within the image. This calibration could be carried out through active user participation, or this calibration data could be implicitly sensed directly from the image - possibly with a consequential reduction in the accuracy of the scan, but likely to lead to an improvement in the overall convenience of using the system.

Some a priori information about the user's body shape/size could also help improve a scanner's accuracy. Details of their height, weight, age, sex, etc. could be used to both calibrate the captured image, but also used to feedback data into statistical models in order to improve the system for future scans. Indeed, other information such as another size (waist, hips, bust, arm length, or a known size that the user has in a known brand, or even a previously saved profile) can only act to improve the accuracy of the scans.

This extra information will improve the result, but the process of entering information (assuming that this data is known) will more than likely add to the inconvenience of a system. Discovering this balance between the minimum accuracy that the user expects, and the maximum effort which a user will entertain, is a key consideration of this study, and appears to be in the region of 3-4 key pieces of information.

As a better-calibrated scanner will return better results, we presented various techniques to the user group with which the user could actively participate in the process. Activities such as: printing a calibration card and showing it to the camera, or holding up a standard object such as a book, drinks can, ruler, CD case, etc, or selecting the camera lens from a drop-down list (to identify intrinsic camera parameters) were considered to be activities which were too technical to be associated with fashion applications. Users indicated that they would be happier to engage with the calibration process if it was fun to do so, perhaps if it was a game (i.e. walking around the room in a set pattern, etc).

Another issue that is critical to computer vision applications is the quality of the environment. Bad lighting, strong shadows and cluttered backgrounds can conspire to inhibit segmentation of the user from the background of the image, and therefore produce erroneous results. The user group was presented with the various activities involved in choosing the ideal environment, and adjusting the light levels etc, to maximize the system's accuracy. Some users were willing to put the effort into optimizing their environment in order to improve their results, though other users indicated they would wish for it to work regardless of the environment they are in.

The final consideration presented to the group was the process of adjusting the camera or webcam so that the user is as large as possible within the frame (though without any clipping of their head or feet). It is obvious that a simple means to orientate the camera and checking to see if the user is in the right position must be provided, however this is complicated by the fact that moving a laptop camera tends to move the display with it, affecting the ergonomics of the system. Something to note is that the human form is easier photographed in the portrait rather than the landscape orientation - laptop webcams are nearly exclusively provided in landscape format, while photographs taken with mobile phones tend to be more conveniently shot in portrait mode.

4.7 The scan process

Once the setup is complete, the user will be invited to scan themselves. In all cases, this will consist of standing in front of the webcam so that the subject is placed entirely within the camera view, but whether the user stands rigidly within a standard pose, or whether they stand relaxed, or move around casually will dictate the character of their experience. As mentioned previously, the public perception of 3D body scanning will likely be influenced by past experience of using similar systems within security or medical contexts, and therefore is prone to be associated with these neutral to negative experiences. Any possibility of distinguishing these from each other should be taken for this reason.

The users were shown potential scenarios which could be employed in a fashion orientated BSS, such as allowing the user to 'do a twirl' in front of the camera - like they would be used to doing when showing off a new fashion item to a friend, etc. This was balanced against a more formal approach where the user stands in standard poses, such as with their arms extended outwards, or stances orientated flat or sideways to the camera view. The more casual approaches were clearly preferred but require that the software be more intelligent to identify the users body shape.

User confidence and privacy issues were discussed within this context, as optical-based BSS will invariably require the user to remove as much clothing as possible/ they feel comfortable with. Our user group indicated that they would be willing to comply with this requirement if the results were guaranteed to be accurate, and if they were comfortable with the knowledge that the images would not be distributed in any way. Cultural differences would likely influence the level of privacy that users demand and so a system that was less dependent on what the user was wearing could be an ideal solution to this problem.

4.8 Time to complete

When specifying a successful BSS with the aim of being widely adopted, most of the user experience decisions that can be made can be essentially distilled down to finding the balance between an elaborate yet accurate or a convenient yet less accurate service. There is a wide range of processing capabilities available to us – from the lightweight mobile platforms, to the more capable cloud server processing solutions. We wished to find out how long a user would be willing to wait for their body shape results to be provided to them once they completed their scan. Real-time was preferred, but up to 5 minutes would be considered acceptable.

4.9 Results

The BSS will have the ability to extract a 3D representation of the user's body, likely in the form of 3D mesh or point cloud. This information is valuable if the user wishes to view themselves draped with virtual cloth, but there will likely need to be a means to translate this into a format which is more in line with how customers currently understand clothing sizing systems. Shape classification, standard metric/imperial measurements or the standard systems which use sizes 8-10-12, etc., could all be communicated to the user, possibly with a built-in knowledge of how sizing systems differ between different brands, etc. Our user group were more interested in this aspect, where they can be confident that a size 10 in one brand is equivalent to a size 12 in another brand – this is likely to be a particularly valuable tool. An online account where the results could be stored and referred to at a later time was also seen to be a useful aspect.

Where there are manufacturing systems setup to create fully customisable garments, this 3D data could prove to be extremely valuable. The 3D surface could be flattened into the necessary 2D patterns so that each garment could be made to fit the exact contours of every user.

5. DISSCUSION AND CONCLUSION

This study aims to examine the nature and extent of user experience of 3D body scanning services. In addition to focusing on the low cost webcam/cameras home-scanning service in the broader context of the UK fashion market.

As described above, in essence, the experience of using a 3D body scanning service should aim to provide more to the user than just the correct size. To take full advantage of all that bodyscanning offers to the fashion and clothing industry, we need to appreciate that the experience of being scanned should resonate with how and why people consume fashion. The low cost webcam/cameras home 3D body scanning service should be able to better fulfill the customers' individual needs in terms of function, convenience, privacy, cost and entertainment in the personal fashion experience.

As a result, the successful employment of body scanners within a fashion context should require a balance of perspectives of business goals and user goals to create mutually successful e-commerce outcomes. This research project shares a way of thinking about the user experience from two levels: the factors that influencing consumer adoption of BSS and key elements at each stage of user journey.

The initial activity was to apply the methods of technology acceptance research to evaluate what were the barriers in the mind of consumers are, to the widespread adoption of these types of technology when applied to an industry, which has been traditionally light on technology.

The second level focuses on the usability and experience of effortlessness—the degree to which the service facilitates ease of use. Optimizing navigation, reducing clutter, keeping the customer focused on the product and services, and providing effective interactions are critical to success in this level.

No matter how accurate the measurement a 3D body scanner can achieve, users will not adopt it, unless it offers them a service, content, or features that provides them with something meaningful or a fulfilling experience. Our main finding with respect to the user journey, is that users can generally be split into two distinct groups: those that expect that the service be useful and accurate enough to justify the effort of setting up the system correctly – and those who may be willing to overlook a degree of accuracy error as long as the experience is quick, easy and fool-proof. In either case, a fulfilling user experience will be critical if we are to ensure a widespread adoption of any BSS.

BSS has the potential to enable further adoption of mass customisation and personalisation in the fashion industry, to increase the level of peronalisation within their shopping process, while reduce the return rate and waste in the manufacturing process. This user experience is designed to increase the level of innovation within the development, while currently extending cusomer participation and understanding of the product. The next step is to test the transferability of this new frame work, by working with technical aspects of 3D body scanning.

6. LIMITATIONS AND FUTURE RESEARCH

Data in this study was acquired from a sample of female postgraduate students at one university in one region of the United Kingdom. Therefore, caution needs to be made when generalizing the findings to other consumer groups. Future research should investigate the relationships among the variables using different consumer groups.

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