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UDK: 004.42 ShapeMate

Personalised Virtual Fitting for Fashion

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Abstract
The aim of this research is to develop and test the garment size recommendation app, ShapeMate, embedded within a fashion e-commerce site. Not finding the correct garment size causes the high return rate of 30%-40% (According to interviews commissioned by the research project with leading fashion e-commerce and retailers in the UK), in fashion e-commerce. The app captures a single image with minimal user input, to estimate and classify the 3D body shape, in order to generate body measurements and using this information, to match with garment data for size recommendation.
An extensive user-experience study was conducted. The developed app was empirically tested through semi-structured focus group interview and questionnaires, to validate results and obtain further insight. This research offers a major innovation for low-cost size recommendation generated from a single image for fashion e-commerce. It enhances the online apparel shopping experience, by matching body measurements with a personalised recommendation for garments.

Key words: *Mass Customisation and Personalisation, Fashion, 3D Body Scanning*

1. INTRODUCTION

In the last decade, we have become accustomed to digitising our letter (via email), our books (via eBook) and music (via iTunes) - even our social connections (via social media). Why not the human body? We understood the possibilities of a personalised world, if the services were achievable in a simple and accessible way to everyone.

At present, most 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 [1] [2]. The fashion, social and economic benefits that body scanning offers are, therefore, inaccessible to the majority of the general public.

The present research aims to exploit low-cost webcam/cameras for providing personalised size recommendation. The solution proposed in the present article does not rely upon specialist hardware and allows to place the personalization experience into the customer home, away from the controlled retail environment [3] [4].

This low-cost, personalised size recommendation offers significant potential in terms of allowing individual customers to realise 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 online fashion. Personalised size recommendation is becoming increasingly advantageous to customers and companies alike. Nonetheless, consumer trust and privacy concerns exist, which are currently inhibiting adoption.

2. CURRENT TECHNOLOGIES AND MARKET FOR GARMENT SIZE RECOMMENDATION

In the US market, the average garment returns regarding items bought online are 25% or 1-in-4. Rates vary from 15% up to 40%, depending on the garment type and returns policy of the retailer in question [5]. According to interviews commissioned by the research project with leading fashion e-commerce and retailers in the UK (ASOS, Net-a-porter and L.K.Bennett), not finding the correct garment size causes the high return rate of 30%-40%, in fashion e-commerce. Drapers also found that fit was by far the most likely reason for returning a garment bought online, as about 70% of garment returns result from clothes not fitting as the customer had expected [6]. All of these created waste and a proliferation of similar products [7]. It's estimated that 350,000 tons of used clothing, worth £140 million, goes to landfill in the UK every year.

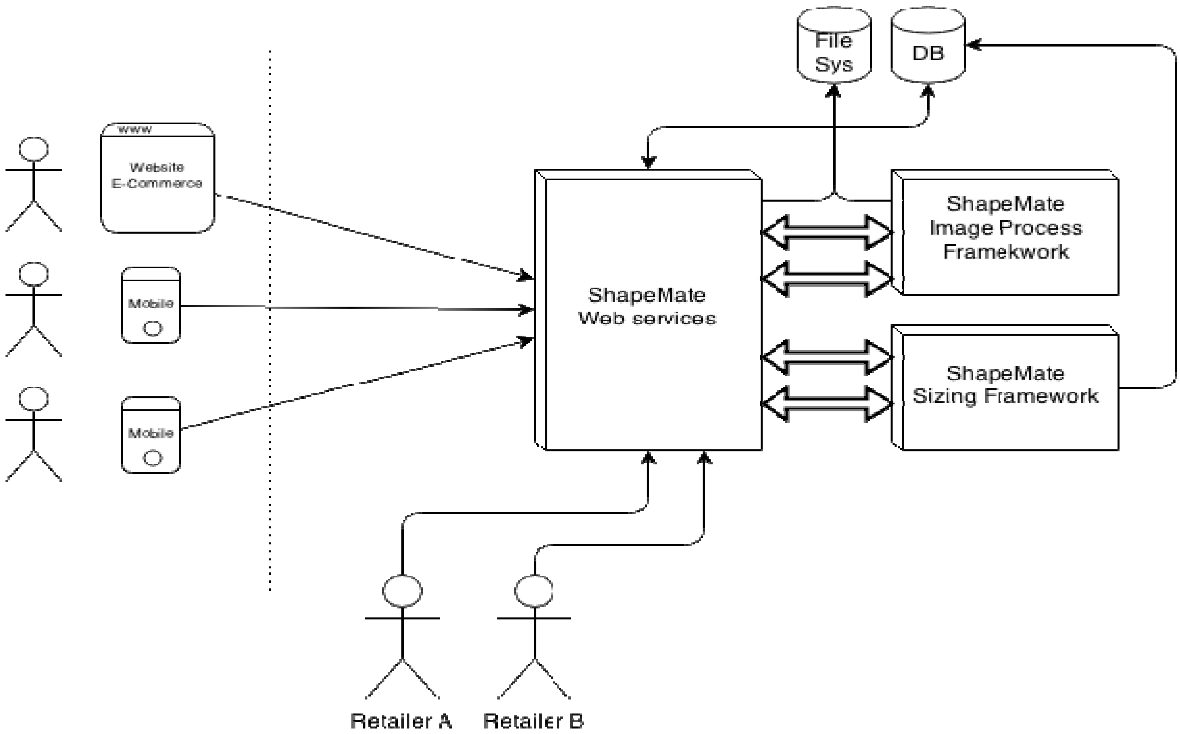

Figure 1. ShapeMate workflow diagram of the system architecture.

Extending the average life of clothes by just three months of active use per item, would lead to a 5-10% reduction in each of the carbon, water and waste footprints [8].

For the fashion industry, creating online tools that help customers to match their body shapes with a specific garment, could thus reduce the return rate of online shopping and reduce the waste relating to unused and discarded manufactured products [9]. A low-cost 3D body scanner provides the opportunity to do just that, since the better fit that customers achieve by choosing a personalised product, embedded by a home body scanning service, would logically reduce the probability of the product being returned through online shopping and thus, the resource used for custom service being wasted. A product not used and the resource used therein, are thus wasted.

Hence, a 3D body scanner helps the mechanism of mass customisation in providing a better fit, plus introducing the opportunity for such mass customised products to reduce the waste indicated above [10].

Most body scanning technologies are based upon specialised sensors and expensive rigs. The democratisation of 3D scanners for fashion will depend on the entry-level costs, as well as their technical complexity being reduced. There is, however, one specialised sensor that has become ubiquitous namely, the digital camera. Most modern mobile phones contain at least one scanner and webcams have become standard peripherals on computers and laptops [11]. They can produce images with 0.25-1 million (coloured) points, at rates of around 30 frames a second [12]. While these images are two dimensional, there are several software methods available to calculate the relative 3D information that is contained within the 2D image, i.e. stereoscopy is widely used in reconstructing 3D scenes, by using 2 cameras (this simulates how our eyes see the world) and is used in 3D television broadcasts.

Photogrammetry, where geometric properties are evaluated from photographic images, is a sub-field of Computer Vision science (where computers are programmed to recognise objects and patterns algorithmically). Computer vision has begun to touch many lives, from facial recognition on digital cameras, to Augmented Reality applications on mobile phones. The techniques are not new but the ability of computers to process the images and the quality of cameras used to capture these images, have only recently caught up, to allow the systems to become useful to the general public.

Computer vision will have a most profound impact on many lives in the near future and is an example of 'true machine intelligence'. In the future, we will learn to offload many of our daily tasks to machines, which sense the world using computer vision techniques and we will have to accept many cameras in our world and acknowledge how they interpret our environment. Recognition engines are constantly improving and the open source community is accelerating the development of this field, by ensuring that the technology does not remain isolated within a cocoon of knowledge.

Computer vision-based scanners are particularly appealing because they only require a single piece of equipment with which many familiar - a digital camera. While a rig of cameras surrounding the subject to be scanned is preferable, there is the potential for a single camera to capture sufficient information because computer vision techniques are much more dependent on the software and algorithm, than they are on hardware.

The major challenges to overcome before suitable photogrammetry based scanners are available include: automatic segmentation of the subject from the background, automatic calibration of the scene and camera lens (focal length, lens distortion, etc.), and consistent tracking of features on the scan subject, as the camera moves around (or as the subject rotates).

Besides the computer vision technologies, garment-sizing varies between different brands and retailers. Consumers who find a fit in a particular size for one brand, cannot necessarily select the same size from another brand. Having no garment-size standard, as well as a lack of current anthropometric data to describe the consumers, has provided a challenge for companies in providing an accurate personal fit, without first trying on the physical garment [13]. Some companies have tried to solve this issue by providing online tools, such as What Size Am I? (http://sizes.darkgreener.com/) to translate and teach the existing sizing to consumers, based on guides published online by each shop.

In the current market, there are various size and style recommendation/mapping services using a low-cost webcam, including Upcload[1], Metail[2], Fits.me[3] and Poikos[4]. These services /apps require a minimum of two photographs – a front view and in profile. They also require detailed preparation regarding the calibration and segmentation, thus making them difficult to use.

According to the Technology Acceptance Model (TAM), there are two types of technology acceptance – perceived usefulness and perceived ease of use [14] [15]. Most of the size and style recommendation services fit into one category only, rather than combining both. In terms of ease of use, Metail, for example, uses a virtual try-on (VT) to attract the users, where the latter have control of their body shape, hairstyle and skin tone. Towards perceived usefulness, webcams have been used by other services where users are required to take multiple images to improve the accuracy of body measurements. Among all these services, the research team found that Upcload provided the most accurate measurements, while their entire process took an average of 20-30 minutes (since 2014 Upcload rebranded itself with a new name and new user journey where they ask the user for height, weight and age instead of using webcams).

3. DEVELOPMENT AND PLATFORM INTEGRATION FOR SHAPEMATE

Based on the market research, we have identified a gap for in the market for garment size recommendation that can combine ease of use and perceived usefulness. Therefore a new technology and application have been developed for this research. It has been taken the form of an online service – ShapeMate, which can be plugged in to fashion e-commerce platforms, to enhance the user- experience and recommend the best garment size, when shopping online. One of the main goals is to make the technology appeal to a wider audience, by responding to the general demand for low cost and ease of use, as expressed by our initial focus group.

ShapeMate also needs to be scalable and run on various devices and platforms. Hence, the core system is implemented as a web service, for the benefit of cross- platform support (see figure 1).

3.1. The workflow

As a result of the advantage of using web services, ShapeMate can potentially run on any platform or device, be it a website, mobile app, etc. As shown in the system workflow diagram (see figure 1), once the user interacts with the service, the core system receives all the data and photos generated, then processing and passing them on to the Image Process Framework, where the measurements are extracted. The body-measurements are subsequently compared with relevant garment sizes, to produce accurate recommendations.

The Image Process Framework takes the single front-facing photograph and separating the body from the background, creating a silhouette, which is then compared with a database of existing 3D scans of various models.

Our Sizing Framework uses guidelines set by the retailers, themselves, on how they intend their clothes should be worn. The retailer specifies and rates which garment elements are important for fit and style. This is then cross-referenced with the body measurements, to generate a rating for each element.

Integrating the ShapeMate sizing service to fashion e-commerce platforms requires minimal effort, as only a single line of Javascript code is needed in order for any web platform to take advantage of the service.

```
<script src="http://.../scripts/sizing-plugin.js"
type="text/javascript"></script>
```

ShapeMate will be displayed as an icon that sits within the e-commerce platform. Once the user clicks on the icon, we aggregate the content the user was browsing through the metadata, to understand the product and to keep the user within the same environment.

Additional metadata is required, in order for ShapeMate to learn about the product. We use both Facebook's OpenGraph protocol[5], as well as our custom metadata.

[1] http://www.upcload.com/
[2] http://metail.com/
[3] http://fits.me/
[4] http://www.poikos.com/

[5] http://ogp.me/

```
<meta property="sm:garment_brand"
      content="Retail Name">
<meta property="sm:garment_type" content="Shirt">
<meta property="sm:garment_sizes"
      content="14H|15|15H|16|16H|17|17H">
<meta property="og:title" content="Shirt Name">
<meta property="og:description"
      content="Shirt Description">
<meta property="og:type" content="product">
<meta property="og:image"
      content="http://example.org/imgs/s1.jpg">
<meta property="og:url"
      content="http://example.org/shirts/s1">
```

4. DESIGN OF THE USER EXPERIENCE ARCHITECTURE

The main goal for ShapeMate is to enhance the shopping experience and reduce the confusion of sizing across different fashion brands. Since there is no well established standard of garment size for fashion industry, each brand uses its own standard to design and create the garment, which cause the confusion when purchasing from multiple brands. In order to create a wider appeal, it was important to keep the user in the same shopping environment and make the interaction between the e-commerce platform and ShapeMate transparent and simple. This should boost the engagement and increase the confidence and satisfaction when shopping online.

process, in order to receive more accurate results. The result is that we have divided the user experience for ShapeMate into two steps, the second of which is optional, for those who want more accurate size recommendation and willing to spend a bit more time on the process.

The first step asks the user for three basic pieces of information; height, weight and date. This will be used to match users with our sizing database, to swiftly calculate and estimate the body measurements. The second step is where we take a single front-facing photograph of the user, to generate more accurate measurements.

Giving users the comfort of only taking a single image was more of a challenge in terms of providing accurate results, however, it was worth it, in order to provide the user with a much simplified experience. We also allow the users to take the photo in their natural environment, without any restrictions as to how busy the background is or what the user is wearing. The processing and segmentation of the photo is, however, particularly rapid and in order to speed up the algorithm, we ask the user for additional information about the photo, to enable us to more easily locate e.g. the hands and the feet.

After each step, the user is presented with the sizing recommendation generated in a spider web graph, to link the available sizes for the garments with the fit-rating calculated based on the user's measurements.

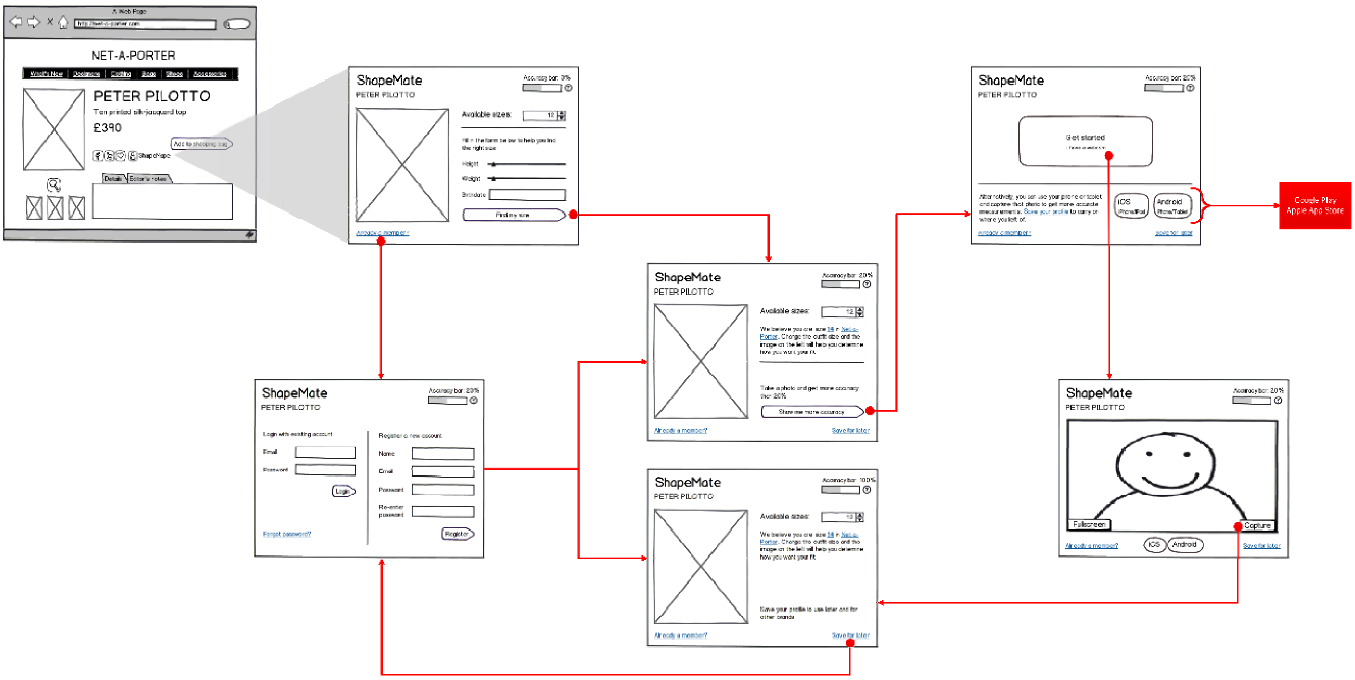

Figure 2. User experince diagram of the user journey.

ShapeMate is embedded as a web app within an e-commerce platform and is displayed as an icon on the user interface (see figure 2).

From the initial focus group, it was clear that some need the process to be quick, easy and were not too concerned about accuracy, while the other group did not mind spending slightly longer time to go through the

The sizing graph is designed to show the fit rating rather than a single size recommendation, as style is a factor when choosing a purchase. The garment size that fits the best is highlighted with the highest rating but the user picks the size based on how they personally like their fit, whether it is loose or tight.

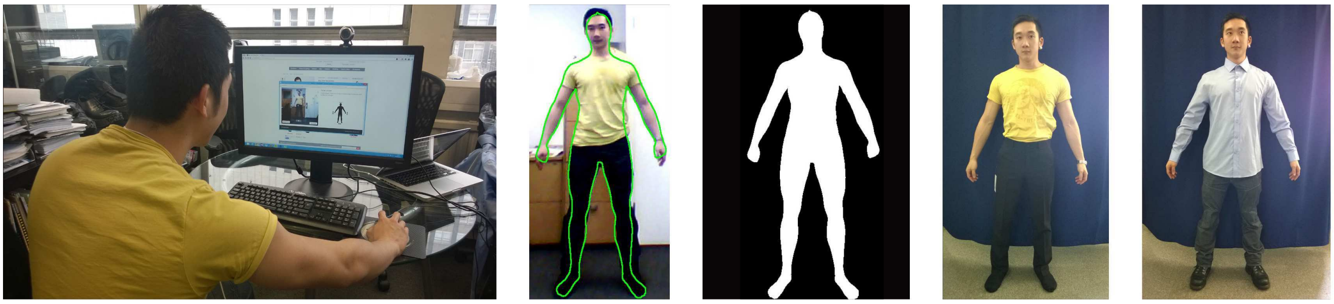

Figure 3. From left to the right: A, B, C, D, E and F. A: participant 1, B: segmentation of the font image that captured by using webcam. C: the generation of the silhouette. D: participant 1 is trying on the recommended trousers. E and F: participant 1 is trying on the recommended size of the shirt.

It was also important for us to enable the user to interact with the entire service, without the restriction of signing up, which often tends to deter users, while still capturing all the data required for ShapeMate to function. We can, thus, track all the interactions and data generated anonymously, using the cookies in the browser. Once the user decides to sign up, we capture all the historic data and attach it to the new account. This will allow the users to fully experience the advantage of the sizes recommendation, with minimal effort on their part.

5. METHODS

The present research has been conducted through the following three key stages:

1. Initial exploration into user acceptance of 3D body scanning services and data collection via Interview and questionnaires in order to understand the gaps and problems in the current market and why people might use 3D body scanning services.
2. User interface (UI) and user experience (UX) design and development.
3. Testing developed app and refinement.

Focus group interviews have been conducted at each stage.

Hereafter, the focus is on the final testing stage. The focus group, consisting of nine participants (male, age between 20 and 49 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 fashion apps users, with regard to the development and design of body scanning apps for the fashion industry.

In terms of the detailed user journey, figure 3 represented the entire process of a participant in the pilot study. The users first entered their personal details – height, weight and date of birth / age, the application would then generate the silhouette and calculate the body measurement. Once the body measurements have been created, the application can match the relevant garment sizes. The results are then presented in both text and diagrams, which clearly indicated the recommendated sizes. The recommendation of Shapemate is unlike other applications that give a visual presentation of the body shapes (see figure 4).

The visual of the body shape can have a negative impact on the user experience, which has been discussed and proven in the intial focus group.

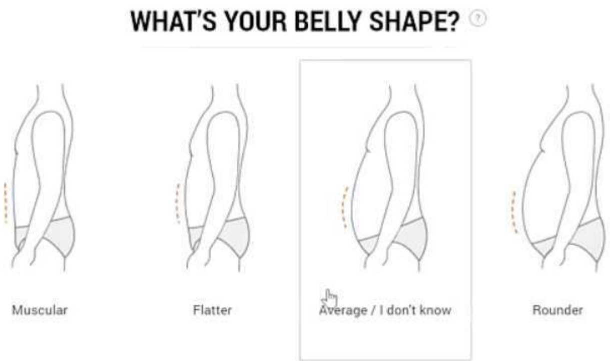

Figure 4. A visual presentation of the body shapes in Upcload application

6. FINDINGS AND DISCUSSION

100% of the participants found that Shapemate was helpful because of the size recommendation for online shopping. Most of the participant agreed with the recommended sizes after the image has been taken. They also found the experince to be easy and straightforward.

There is, nonetheless, room for improvement, for example, the process would benefit from having clearer guidance for using the webcam. One participant was under the impression that he had to stand in a precise position, as demonstrated in the guide, which is not the case. To enhance the user experince for future development, clearer guidance is required.

Table 1. Sample measurements from the focus group results -- comparison between the manual measurement of the body, automatic measurement by using the participant's height, weight and date of birth and automatic measurement by using the participant's single image.

No	Manual	Without image	With image
P1	**Chest:** 99cm **Abdomen:** 93cm **Stomach:** 98cm **Waist:** 100cm **High hips:** 110cm **Hips:** 107cm	**Chest:** 105.17cm **Abdomen:** 94.69cm **Stomach:** 96.88cm **Waist:** 91.27cm **High hips:** 107.33cm **Hips:** 102.22cm	**Chest:** 104.48cm **Abdomen:** 95.00cm **Stomach:** 98.04cm **Waist:** 94.39cm **High hips:** 109.39cm **Hips:** 103.68cm"

Our results show that selected body dimensions can be estimated and classified, within an average accuracy of < 3cm.

Table 2. Estimated measurements vs ground truth [16].

Measurement	Average error (cm)	Max Error (cm)
Hips	1.49	2.88
High Hips	1.42	4.30
Abdomen	1.88	5.56
Waist	2.163	4.96
Stomach	2.97	6.11
Bust	2.88	6.907

From the initial focus group, we established that the participants were not too concerned about privacy issues [17]. Being able to use a service that would solve a problem confronting them was far more important than worrying about privacy matters. Those who had any concerns of the kind would be happy to abandon them, if the service offered was valid and appropriate to them.
Although privacy was not a concern within the focus group, we had to consider a wider user-base throughout the development stage of ShapeMate. It was important to build a service that captures and exchanges photos to be handled in a secure manner. After processing the photos and capturing all the required data, the images would no longer be needed and therefore deleted from the backend server.
Furthermore, ShapeMate was created to capture the user in their natural environment, rather than restricting them with requirements such as uncluttered background, tight clothing, etc. This reduces some privacy concerns, since the user would be posing fully clothed, resembling the type of picture that they would normally upload to a social network.
We also use the cookies in the browser to track all the generated data anonymously, in order to enhance the user experience and simplify the steps taken to use the system.
With regard to the measurements, the backend framework is currently producing six measurements (High hips, Hips, Abdomen, Waist, Stomach and Bust/Chest) that were considered important for the research and the garments we had for testing. Despite thae fact that, we currently only use six measurements, the algorithm can produce more measurements as needed, which could be useful for made-to-measure shopping experiences.

7. CONCLUSION

In this paper, we have presented a practical size recommendation service – Shapemate, which we developed for matching customised garment data with the personalised 3D human body data generated from a single image. At this stage, Shapemate was built upon a practical system that was trained on a small dataset of body measurements and tested on a small focus group of nine participants, thereby potentially limiting its capabilities of accuracy and having room for improvement
The present paper complemented to the research of user experience in 3D body Scanning in the Initial exploration of user acceptance of 3D body scanning[17].
ShapMate has been a success with the test users and the sizing recommendation results were satisfactory for all the participants. We have managed to offer a high level of tracking of body data for anonymous users and members in the database. We can also track how the body has changed over time, which could offer various different features to brands and retailers in the future.
The integration of ShapeMate into existing online fashion retails is straightforward and can increase the sales configurators capabilities of focused navigation in two ways – by using an improved body measurement and an easy comparison of the available alternatives. These two capabilities of the web-based sales configurators have been demonstrated to contribute the perceived benefits that a potential customer can derive from a customisation experience and / or from possessing a customised product [18].
Following this research project, a successful ESRC funding for E-size project has been granted. This provides the research team the opportunity to further develop the app and test it with a wider range of customers for online fashion shopping.

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Personalizovano virtualno pronalaženje veličine odevnih predmeta

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Rezime

Cilj ovog istraživanja je da se razvije i testira aplikacija za preporuku veličine odeće, ShapeMate, ugrađen u okviru modnog sajta za elektronsku trgovinu. Ne pronalaženje odgovarajuću veličinu odeće izaziva visoku stopu vraćanja iste proizvođaču i to 30% do 40% (Prema intervjuima sprovedenim u okviru istraživačkog projekta sa vodećim modnim e-trgovcima i prodavcima u Velikoj Britaniji), u modnoj elektronskoj trgovini. Aplikacija snima jednu sliku sa minimalnim unosom podataka od strane korisnika, procenjuje i klasifikuje 3D oblik tela, kako bi se generisale telesne mere i iskoristile ove informacije, kako bi se uparile sa podacima o odeće za preporučene veličine. Obimna studija iskustva korisnika je sprovedena. Razvijena aplikacija je empirijski testirana kroz polustruktuiranom intervjuu fokus grupe i upitnike, kako bi se potvrdili rezultati i dobili dodatni uvidi. Ovo istraživanje donosi veliku inovaciju za modnu elektronsku trgovinu kroz jeftino preporučivanje veličine odeće generisano iz jedne slike. To poboljšava online doživljaj kupovine odeće, uparivanjem telesnih mera sa personalizovanu preporuku za odevne predmete.

Ključne reči: *kastomizovana industrijska proizvodnje i personalizacije, moda, 3D skeniranje tela*