3D Technology and Tailored Clothing

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Abstract: Towards this end, 3D scanning is having gained popularity in the fashion industry as a fast and accurate way of collecting measurement data from customers and converting them into operation in real-time. The fashion market enjoys personalized service even in the advent of online shopping behaviors as the user experience has both continuity and credibility of the information. Human-computer interaction is well understood with language description and schematic diagrams. There is a gap where users need to learn how measurements are done before they can operate the 3D applications. The garment enterprises can provide more professional and perfect body shapes in their database, and the service should be accessed offline with unique features of their products. Other than the 3D digitization of the customer body, the fashion enterprises should create analog methods with manuals on how the body measurements are taken.

1. Introduction

The driving force behind e-tailoring is the online shopping trend that is preferred by the current generation of clients. People are buying clothes, food, cars, and even house online. E-commerce has become a primary marketing channel for every business as the manufacturers fight for the global share of the market. The emergence of 3D technology has made a delivery of customized items possible. Vancat and Flynn (2012) emphasize that those who want to succeed in the business world in the future have to customize their products to deliver according to customer specifications. Koepke et al. (2017) did a study on measuring the body size of 123 Swiss young men using both body scanners and manual means before drawing a comparison. The empirical evidence from the study concluded that 3D scanners were more efficient, faster, and reliable in carrying out anthropometric measurements, especially when dealing with a large group of people. Such organizations as E-tailor are committed to providing this service to their clientele to solve such issues from clients like sizing systems, fitting issues, cost of production, and marketing and privacy required from customers as they shop in virtual clothing stores (Hans-Christian, Thalmann, & Kartsounis, 2014). Common problems experienced by consumers like characterizing the garments online are the reasons behind which business-to-consumer (B2C) electronic commerce in the garment industry is moving towards 3D technology. Brick-and-mortar retailing has forced retailers striving to distinguish one from another as customers are stuck on the internet 24/7 with many options at their fingertips. Vancat and Flynn (2012) further highlighted that many European countries had adopted the made-to-measure concept, and several gadgets are being developed to serve the clientele in the manufacturing field. Although this technology has an implication on privacy, the adoption is rising fast across the world as people embrace technology.

2. Principles of 3D Technology

Fundamentally, 3D scanning relies on physical principles classified into four categories. The laser triangular 3D scanning technology usually allows the projection of a laser on the surface of the object to measure the deformation of the laser ray (Buchón-Moragues, Bravo, Ferri, Redondo, & Sánchez-Pérez, 2016). Second, there is a structured light 3D scanning that measures the deformation of the light pattern on a surface to scan the surface of an object (Shamata & Thompson, 2018). Photometry is another principle that reconstructs 3D objects from the 2D with the help of

computation and geometry algorithms. Lastly, contact-based 3D scanning depends on the on collecting by a sample of several points on the surface using a probe (Edge 3D Technologies, 2019). All the principles and applications work in tandem before a final 3D image is formed. 3D technology is the process of determining an object's shape and volume in three-dimensional space. The technology relies on such principles as triangulation, sensors, scanners, and a screen where the image is portrayed. Triangulation enables 3D technology to determine the dimensions and geometry of a real-world object. The distance and angles between images and projected laser create the base of a triangle. The sensor uses fixed optics, a light source, and at least one digital imager to acquire 3D data. The sensor just collects and transmits the data for processing (LMI Technologies, 2013). The scanner makes the 3D measurements and visualization to recreate a high resolution and accurate 3D image.

3. Trends in E-tailor

Clothing that can adequately fit has been a concern for both the consumer and customer-oriented manufacturers. The recent past has seen many tailors use the tape measure to take measurements, but even so, they ended up missing essential information of the curves of the body. Three-dimensional body scanning has become the solution for the fashion industry that is prone to changes in designs and preferences. The movie industry started using this technology over fifteen years ago when the actors were exected to look as real as possible (D'Apuzzo, 2007). Digital manual measurement, activity-based technology, white light patterns, and laser scanning have shortened the time that a consumer could spend at a tailor or even a shop to acquire body features in 3D. Customization has seen the emergence of several options developed in the European market to guarantee customer satisfaction achievement in the clothing industry. Several technology companies are coming up with portable scanners that can be used in the small scale production of garments. Infrastructure such as European Sizing Information Infrastructure (ESII), Customised Clothing Infrastructure and Virtual Shopping Infrastructure are the new ways to capture customer features in the 3D tailoring business (Hans-Christian, Thalmann, & Kartsounis, 2014). The Integration of 3D body measurement, advanced CAD, and e-commerce technologies are being pursued by many European countries to ensure real-time clothing simulation and visualization. The smart card collection of information, used to track customer preferences, is another notable e-tailor trend.

Besides, the mainstream products in the 3D technology and especially in the clothing and apparel industry are expansive as the market continues to expand. Market Watch (2019) reports that there has been significant adoption of 3D scanning in Augmented Reality and Virtual Reality. The technology has been famous in the technology and the media industry, but now the fashion industry is catching up fast than ever. The desire by the customer to get a perfect fit from the suppliers has prompted inventions to ensure that this vision is achieved immediately or shortly after (Behr, 2018). The apparel industry is struggling to achieve a standard size for small, medium, and large, but this can only be achieved through improved 3D gargets in the fashion industry. A comprehensive set of measurements is the only option to customize garments that correctly fit the customer. 3D body scanning is allowing customers to scan their bodies using a smartphone equipped with an app to solve the online cloth industry problems such as product fit and return.

A 3D body scanner takes measurements digitally, and a digital twin image is created on the screen of a computer. Vuruskan and Bulgun (2010) appreciate that consumers of a younger age are more comfortable in using body scanners and trusting to order based on the information collected by the gadgets. Several images are taken from different angles to ensure all the body features are captured before aligning to create one image from the several captions taken by the 3D body scanner. 3D body scanners are categorized into laser scanning, which uses laser rays to capture the structure of the human body from head to toe. White light scanners, on the other hand, infringe a series of light into the body of the client. The integrated camera capturing the images then shows a series of deformations that are used to determine the size of the clothing to be made for the consumer in seconds.

As if that is not all, there is a combination of modeling and image processing, where 2D is extracted by scanners to help generate a 3D image of the client. There is also the virtual try-on solutions that allow the customer to have a virtual representation of how they will look in a particular garment (Fibre2Fashion, 2008). This technology only collects information from the consumer, such as the shoulders, waist, neck, and even hair. When the data is entered in the computer, several images are displayed, and the consumer is allowed to modify them to find one that fits them the best (Fibre2Fashion, 2008). Garment selling stores own the machines, and the client only walks in and enters a booth where they measure their size and send the information to a computer system to search the matching size.

However, it should be noted that 3D body scans face criticism from those who feel that internal privacy is compromised. With the current technology, one cannot be sure of the integrity of the people handling the scans. Adoption in the fashion industry may, therefore, take some time, especially among the conservative population. As Parker, Gill, and Hayes (2019) recommended, that users of 3D scanning equipment have to asses the reliability of the obtained measurement, casting doubt about the universal sizes adopted by the 3D scanning equipment. Of importance were manufacturers of high measurement tolerance such as compression sportswear, where traditional measurement procedures prevail.

4. 3D Applications in the Fashion Industry

4.1 Virtual-try-on

This solution simulates how the garment will look like when won by the consumer. Digital human body models are used to probe when the digital image is formed after scanning, the preferred cloth is sewn into the digital body, and the software can show how the to clothe will behave under several circumstances. Some current solutions simulate the different poses the client is likely to assume before manufacturing.

4.2 Virtual Make Over

The application virtually changes the makeups and other social accessories to a virtual human face. The features such as haircuts and style are captured in 3D, and the customers keep changing them digitally until the match is found. The concerned stores can avoid any damages when customers physically try the different makeups, unlike in the digital set up where no real makeup is used to do face or body trials until an actual purchase is made.

4.3 Anthropometric Mannequins

These dummies are made based on the size surveys done in the recent past. Information gathered to make the model is as near as possible to the actual one. Size surveying has made it possible for the dummies from the digital images. The dummies are then printed through the government for now. Mannequin business is famous across the globe as retailers buy them for fashion exhibitions.

Regarding the costs, the Shining 3D Einscan Pro 2X has a structured light technology and goes for $5.499 with an accuracy of 0.04 mm. Thor3D Calibry has an accuracy of 0.1 mm and goes for $7.99. Then, the Shining 3D Einscan Pro 2X with an accuracy of 0.04 mm is sold for $6.899 (Delamore, Sweeney, & Peng, 2012). The low cost of body scanners allows customers to realize their body size and shape from their homes. Virtual fashion mirrors in advanced clothing stores enable customers to try clothing virtually using augmented reality. Some body-metric machines also allow customers to fit into self-fridges that can affect their bodies before directing them on where they can find their fitting sizes in the clothing stores.

Mainly, several portable scanning devices have been developed in the recent past, like webcam, cameras are used at home for whole-body scanning and obtaining body information. The Kinect camera is touted to become the newest way of self-scanning in front of a TV screen. The customer stands before the screen with depth-sensing cameras. The cameras can map the body to capture the contours, and the information is sent to the retailing store to manufacture a perfect fit as posted by

the client. Low-cost webcam allows customers to go to a website through a smartphone or a computer, which then photographs them to obtain the actual measurement. By changing styles and garments virtually, the app can tell the proper size before the client can order (Delamore, Sweeney, & Peng, 2012). The same information from the specific client can be shared online to friends for peer marketing purposes. This technology allows the formation of a virtual mannequin from which the customer can try the clothes virtually before making the actual purchase. McCann, Malmivaara, Bryson, and Hurford (2009) notes that contrary to the opinions of many participants in the fashion industry, the technology is suitable for the aging population who do not have the luxury to walk into a store and keep trying clothes or shoes to find those which fit.

5. Ultra-high Precision (Handheld, Fixed) Body Scanner

Presently, there are many machines developed in the garment industry to ease body scanning, which was previously reserved for wealth. In ensuring that all the market segments are captured for the fashion industry, technology manufacturing industries have made better machines. These new scanners have replaced tape measures which took time and were not reliable for the fitness of the clothes. Companies are now migrating from stationary scanners to improve accessibility and adoption of the technique by remote consumers. The body scanners are improving efficiency, reliability, and validity in the garment industry, and the portable ones are making the situation even better (Xia, Guo, Li, & Istook, 2018). Such famous organizations as Occipital have developed better devices that can be integrated with smartphones. Structure Sensor is one of the products that are gaining popularity as it captures body shape in real-time at the click of a button. The scanner has higher fidelity and excellent resolution. With the increasing number of smartphone owners, the scanning industry is moving towards the direction of consumers owning their scanners, which they can use from the comfort of the room.

Similarly, Delloite Development LLC (2018) emphasizes that 3D scanning is improving reliability from customers in the supply chain. The field that requires high precision in the measurement of their garments like swimming, medical, and lingerie industry is the biggest benefactor of the portable 3D body scanners. The scanners are going through improvements in quality, including enhancements in the accuracy and speed of converting the images to near-reality for the consumer. Even after production, 3D scanners take precise measurements to ensure that the product has according to customer specification and precision requirements are met. In the medical world, fitting for liposuction, lumber, and varicose veins positioning requires a high level of precision and operation from an expert (Oliveira, 2009). Swimsuits are not supposed to inhibit the movement of the swimmer, and to meet this level of high precision; the manufacturers have to use 3D scanners to capture different parts of the body that may experience this kind of compressions during movement. The lingerie industry also requires that the consumers feel as comfortable as possible hence the solution can only be achieved by the use of 3D scanning. Handheld scanners manufactured by Artec 3D and FARO are providing solutions in various market segments. For example, Artec Eva, which is used to 3D scan the fitting doormats for various cars in the automobile industry (Artec 3D, 2019).

Moreover, high precision machines are preferred where small error margins are costly to the consumer and image of the company. Mikołajczyk, Kasielska-Trojan, and Antoszewski (2019) highlighted the importance of anthropometric measurements in aesthetic breast surgery. Manual measurements have been found to have minor errors but with fatal repercussions. The 3D scanner has been adopted in the medical industry to avoid such mistakes. State of the art surgery can only rely on measurements done by 3D scanners. Whether it is reconstructive surgery, reductive, or oncological o aesthetic surgery (Mikołajczyk, Kasielska-Trojan, & Antoszewski, 2019). The female breast is hard to asses due to size contour and asymmetry, but the use of 3D scanning can do all this. The use of 3D technology eliminates the idea of drawing lines and interfering with the privacy of the patient in question. Ultra-high precision scanners are essential and popular among medical practitioners.

However, it is essential not to attract an extra cost to the user. One of the contributing factors is that those used in the medical industry require a professional to handle them. The industry that has to purchase the 3D scanners of ultra-high precision have to incur an extra cost of training their staff on how to handle the machines. For the accuracy requirements, the devices have increased installation costs and high operational demands (Abdel-BaryEbrahim, 2015). Another disadvantage is that the ultra-precision scanners in the sensitive markets are heavy equipment that requires the client to be enclosed inside, sometimes causing discomfort to the users. For this kind of scanners, the clients have to go to a physical shop as they operate offline.

6. General Precision

For general precision, low-cost webcam/ cameras and other home scanning services are gaining popularity. Under harsh conditions such as humid weather or water splash, laser scanners are ineffective for use (Yang, Zou, Li, Ji, & Chen, 2011). The article further indicates that the process of converting images to reality, especially from 2D to 3D body shape, is costly to the company. As early as 2011, Selfridges and Bloomingdale had introduced scanning booths in their clothing line stores. However, online shoppers now require devices that they can use to capture the body at a cheaper rate and send the metrics to the online shop to find a perfect fit for them. In a notable show of transition, 3D body scanning companies such as Styku, Me-Alit, and mPort have rolled out scanning devices at various stores in countries such as Australia. General precision equipment is relatively low when compared with ultra-high precision devices like the ones used in sports of the medical industry. Apeagyei (2010), in her research, noted that the adoption of 3D body scanning technology is increasing as people prefer more fitting clothes in the savvy world of today. As more and convenient machines continue being developed, the technology is expected to become cheaper by the day. The most popular adopted are types of equipment of general precision that are readily available, and their level of accuracy is relatively better when customizing clothing, and their cost is relatively low. Scanners such as the Vitronic allow the client to walk into the nearest store and take the body metrics, and within seconds, the consumer gets made-to-measure cloth in the store (Vitronic, 2019). It is highly adopted in the medium and small clothing industries but not for the individuals.

That notwithstanding, general precision equipment has several drawbacks despite their ease of availability. It is impossible to measure any area that is beyond the line of sight for the scanner. It, therefore, requires to be taken from different angles to capture the desired areas of the body. This requires the consumer to pose for different curves to be captured for the scanner, and some, especially the old, may feel uncomfortable. The initial cost of the excellent scanning machine is high considering the sheer installation and training costs companies have to incur. As a result, the general precision scanners cannot be used independently by the consumer. As such, the client has to go to a store that owns the equipment to take the 3D body metrics. Hence, users cannot carry out the process independently. Janet et al. (2015) noted that among some age groups like children, poor scans are obtained because of the constant body movements or failure of the hardware to get shape outputs. As such, for quality images to be captured by the scanners, an experienced person handles the scanner. Other factors that hinder the acquisition of functional quality scans can be attributed to the body posture of an individual, failure to locate the girth and body movement of one's arms, inappropriate clothing, and body movements that affect the scanning track.

7. Low Precision and Simulation Mode

Another group of 3D scanner used in the fashion industry is those with low precision and simulation mode. The advantage of these scanners is that they are readily available and can be used among a wide range of customers (Straub & Kerlin, 2014). The 3D body scanners still capture accurate information for the hips, arms, and legs, and it is adopted among a considerable number of customers in the fashion industry. The scanners are easy for clients of being able to use them with anyone around who can help to scan their body. The information gathered can meet the basic needs

of a tailor for fit cloth, making for the client for regular daily clothing. Its popularity also indicates that the 3D body scanners in this category are affordable and can be owned by individuals at home, unlike ultra-high precision and high precision, which are owned by particular stores. The introduction of the depth cameras has revolutionized the industry as they are cheap and readily available without compromising on quality. Wang, Wang, Xing, Yang, and Liu (2019) highlighted several whole-body scanners that are using domestically and in small retail stores. The inexpensive in-house scanners produce low-quality scans as compared to high-end scanners. With the development of technology, some devices are modified to take 3D images, even if that was not their primary function. The quality is, of course, compromised, but the result is better than the manual use of the tape measure. The quality of the software and hardware is not fully developed at this stage, and the information collected has no guarantee. Furthermore, the method used does not have uniformity of size as there is a deviation from one country to another about large, small, or medium.

8. The Future Trends

The success of a 3D body scan will depend on the acceptance from the clients and ease of use of the process. Many customers are willing to use the application, but the privacy concerns from a section of the clients are what will slow the whole process down. For clients to adopt this technology, the total cost of the gadgets, the fit and finish of the product, as well as the awareness on usage of the technology are determining factors. Manufacturers have to make these scanners readily available either for individual use or in small scale retailing stores. It is worth noting that some of the three-dimensional scanning machines are not integrated with the system, such as the virtual try-on solutions making it hard for the clients to choose a design by themselves. With the emergence of smartphone technology, more consumers can readily access the technology if the manufacturers come up with an app that is installed on a smartphone. As organizations eye, the global market, Information technology companies will find it inevitable to work together and find common ground where some of the technology is shared.

The smartphone industry will partner with fashion houses to develop 3D apps with easy to use interfaces to allow clothing stores to hold databases from customers who frequently shop with them. Televised scanners are already in the market to make use of the TV, which captures body contours and sends the information to the preferred store for verification on the availability of a fitting dress. A sizing system is underway to allow companies to standardize size based on the database to suit a segment of customers in the clothing and apparel industry. The 3Dscanning technology has made it possible to collect information on individual measurements and body shape database, and retailers are getting a better understanding of the body shapes of their regular customers. Countries have employed 3 D body scanners to conduct anthropometric information at the national level to develop such standards as SizeUK, SizeUSA, and SizeKorea.

As technology become sophisticated and readily available at the company and household level, 3D scanning technology is becoming cheaper and accessible among many consumers. The level of consumer satisfaction is realized by companies that are ready to adopt the available 3D solutions in the current market. Companies realize high profits despite the competition by delivering products according to customer specifications with the help of readily available 3D scanners.

Towards this end, 3D scanning is has gained popularity in the fashion industry as a fast and accurate way of collecting measurement data from customers and converting them into operation in real-time. The fashion market enjoys personalized service even in the advent of online shopping behaviors as the user experience has both continuity and credibility of the information. Human-computer interaction is well understood with language description and schematic diagrams. There is a gap where users need to learn how measurements are done before they can operate the 3D applications. The garment enterprises can provide more professional and perfect body shapes in their database, and the service should be accessed offline with unique features of their products. Other than the 3D digitization of the customer body, the fashion enterprises should create analog methods with manuals on how the body measurements are taken.

Users can use direct purposes such as the measurement wizard combined with pictures and guides used to complete the measures from the consumer end. Direct purposes give a guide to the client on how to complete the measurement step by step by reading the provided manual. Indirect methods allow human customer service to interact with the consumer. The user can measure a piece of clothing and ask questions from the customer service available. The techniques are indirect because there is intervention from a human customer service who answers such questions like were to scale and where to be satisfied and to measure the relevant data by tiling the garment.

References

[1] Abdel-BaryEbrahim, M. (2015). 3D laser scanners' techniques overview. International Journal of Science and Research (IJSR), 4(10), 323–331.

[2] Apeagyei, P. R. (2010). Application of 3D body scanning technology to human measurement for clothing Fit. International Journal of Digital Content Technology and Its Applications, 4(7), 58–68. doi: 10.4156/jdcta.vol4.issue7.6

[3] Artec 3D. (2019). Reverse engineering 3d scanning applications | Artec 3D Scanners. Retrieved from https://www.artec3d.com/cases/reverse-engineering

[4] Behr, O. (2018). Fashion 4.0 - Digital innovation in the fashion industry. Journal of Technology and Innovation Management, 2(1), 1–9.

[5] Buchón-Moragues, F., Bravo, J., Ferri, M., Redondo, J., & Sánchez-Pérez, J. (2016). Application of Structured Light System Technique for Authentication of Wooden Panel Paintings. Sensors, 16(6), 881. Doi: 10.3390/s16060881

[6] Delamore, P., Sweeney, D., & Peng, F. (2012). Digital Innovation in Fashion -How to 'Capture' the User Experience in 3D Body Scanning. International Journal of Industrial Engineering and Management, 3(4), 233-240.

[7] D'Apuzzo, N. (2007). 3D body scanning technology for fashion and apparel industry. In J. Beraldin, F. Remondin, & M. R. Shortis (Eds.), Proc. of SPIE-IS & T Electronic Imaging, SPIE (Vol. 6491). San Jose (CA): Videometrics IX.

[8] Delloite Development LLC. (2018). A series exploring Industry 4.0 technologies and their potential impact for enabling digital supply networks in manufacturing. Retrieved from https://www2.deloitte.com/content/dam/Deloitte/us/Documents/process-and-operations/us-cons-using-3d-scanning-to-drive-supply-chain-innovation.pdf

[9] Edge 3D Technologies. (2019). 3d scanning: Methods, Applications and Advantages. Retrieved from https://www.edge3d.io/what-3d-scanning-types-applications-advantages-and-methods-laser-lidar-contact-based-photogrammetry-triangulation-structured-pulse-light/

[10] Fibre2Fashion. (2008). Apparel Industry, Scanning Technology, 3D Body Scanning. Retrieved from https://www.fibre2fashion.com/industry-article/2980/a-glimpse-of-3-d-body-scanning-technology-in-the-apparel-industry

[11] Hans-Christian, R., Thalmann, M., & Kartsounis, G. (2014). E-TAILOR: Integration of 3D Scanners, CAD and Virtual-Try-on Technology for online Retailing of Made-to-Measure Garments. Research Gate, 1-14.

[12] Janet et al. (2015). Acceptability, precision and accuracy of 3D photonic scanning for measurement of body shape in a multi-ethnic sample of children aged 5-11 years: The SLIC Study. PLoS ONE, 10(4): e0124193. Doi:10.1371/journal.pone.0124193.

[13] Koepke et al. (2017). Comparison of 3D laser-based photonic scans and manual

anthropometric measurements of body size and shape in a validation study of 123 young Swiss men. PeerJ, 5, e2980. Doi: 10.7717/peerj.2980

[14] LMI Technologies. (2013). A simple guide to understanding 3d scanning technologies. LMI Technologies Inc

[15] Market Watch. (2019). 3D scanning market trends 2019 global industry share, size, growth, demand, top players, opportunities and forecast to 2024. Retrieved from https://www.marketwatch.com/press-release/3d-scanning-market-trends-2019-global-industry-share-size-growth-demand-top-players-opportunities-and-forecast-to-2024-2019-11-26

[16] McCann, J., Malmivaara, M., Bryson, D., &Hurford, R. D. (2009). Smart clothes and wearable technology. (1st edn). Woodhead Publishing Limited.

[17] Mikołajczyk, M., Kasielska-Trojan, A., & Antoszewski, B. (2019). A new tool for breast anthropometric measurements: presentation and validation for women and men. Aesthetic Plastic Surgery, 43(5), 1160–1170. doi: 10.1007/s00266-019-01467-6

[18] Oliveira, S. (2009). Measurement of compression in different last generation swimsuits using three-dimensional body scanner (Undergraduate Thesis; pp. 1–53). Retrieved from https://repositorio-aberto.up.pt/bitstream/10216/21608/2/39483.pdf

[19] Parker, C. J., Gill, S., & Hayes, S. G. (2017). 3d body scanning has suitable reliability: an anthropometric investigation for garment construction. 8th International Conference and Exhibition on 3D Body Scanning and Processing Technologies, 298–305. Montreal QC, Canada.

[20] Shamata, A., & Thompson, T. (2018). Using structured light three-dimensional surface scanning on living individuals: Key considerations and best practice for forensic medicine. Journal of Forensic and Legal Medicine, 55, 58–64. Doi: 10.1016/j.jflm.2018.02.017

[21] Straub, J., & Kerlin, S. (2014). Development of a large, low-cost, instant 3D Scanner. Technologies, 2(2), 76–95. Doi: 10.3390/technologies2020076

[22] Vancat, F. E., & Flynn, A. (2012). Custom nation. Dallas: BenBella Books Inc.

[23] Vitronic. (2019). High Precision, Fast and Colored 3D Measurement of the Human Body with the Vitus 3D Body Scanners. Retrieved from: https://www.vitronic.com/industrial-and-logistics-automation/sectors/3d-body-scanner/3d-scan-for-customized-clothing.html

[24] Vuruskan, A., & Bulgun, E. (2010). Analysis of 3D body scanning for body measurement extraction considering the cultural context. Presented at the International Conference on 3D Body Scanning Technologies, Lugano, Switzerland. Retrieved from https://pdfs.semanticscholar.org/d884/a3885ec9e9a013f2c3a1ce9c1916f8bdebcb.pdf

[25] Wang, Z., Wang, J., Xing, Y., Yang, Y., & Liu, K. (2019). Estimating human body dimensions using RBF artificial neural networks technology and its application in activewear pattern making. Applied Sciences, 9(6), 1140. doi: 10.3390/app9061140

[26] Xia, S., Guo, S., Li, J., & Istook, C. (2018). Comparison of different body measurement techniques: 3D stationary scanner, 3D handheld scanner, and tape measurement. The Journal of the Textile Institute, 110(8), 1103–1113. Doi:10.1080/00405000.2018.1541437

[27] Yang, Y., Zou, F., Li, Z., Ji, X., & Chen, M. (2011). Development of a prototype pattern based on the 3D surface flattening method for MTM garment production. Textiles in Eastern Europe, 88(5), 107-111.