12th 3DBODY.TECH Conference & Expo
Lugano, Switzerland · 19-20 October 2021
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Book of Abstracts

3DBODY.TECH 2021

12th International Conference and Exhibition on 3D Body Scanning and Processing Technologies

Lugano, Switzerland, 19-20 October 2021

www.3dbody.tech

Editor and Organizer

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3DBODY.TECH 2021 - Introduction #00

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3DBODY.TECH 2021 - The 12th International Conference and Exhibition on 3D Body Scanning and Processing Technologies took place on 19-20 October 2021, in Lugano, Switzerland.

3DBODY.TECH 2021 was held as hybrid onsite+online event with conference and exhibition taking place simultaneously onsite at the Lugano convention center and live-streamed on the online conference platform. In-person onsite and/or remote online participation was possible for attendees, speakers, exhibitors.

This event was organized by Hometrica Consulting - Dr. Nicola D'Apuzzo, Switzerland.

3DBODY.TECH Conference & Expo, the premier multidisciplinary international conference and exhibition on 3D human body scanning and processing technologies, provides a platform of eminent professionals, entrepreneurs, academicians and researchers across the globe to present, learn and discuss the latest in 3D human body scanning and processing technologies. The multidisciplinary character of 3DBODY.TECH makes it unique and not comparable to any other meeting related to 3D body technologies.

3DBODY.TECH Conference & Expo website 3dbody.tech gives all information related to this event.

The contents of the presented works at the conference are related, but not limited to, the following technical areas:

- 3D & 4D body and 3D & 4D face scanning methods, systems and technologies
- 3D body processing methods and technologies
- Machine learning and artificial intelligence for 3D body scanning and processing
- 3D body modeling, 3D body visualization, 3D body printing methods and technologies
- Active and passive 3D scanning technologies for the human body (full body, bust, face, feet, etc.)
- 4D scanning, volumetric capture and MOCAP technologies for the human body
- Mobile/portable and hand-held human body scanning and measurement systems, devices, solutions
- Full body scanning and measurement systems for the apparel and fashion sector
- Applications in medical sciences (plastic surgery, orthotics, prosthetics, forensics, etc.)
- Foot scanning and measurement systems for footwear, sport and orthopedics
- Digital anthropometry, anthropometric studies, ergonomics
- Body measurement and sizing campaigns, fitting mannequins
- Biometrics and applications in security
- Applications in sport, health and fitness
- Applications in virtual life, games, FX and entertainment
- Applications in social sciences, and communication

These proceedings gather the papers presented during the conference by renowned experts in the field of 3D body scanning and processing. The technical papers are organized in theme sessions.

The website 3dbody.tech/cap is dedicated to the proceedings of the serie of conferences and workshops on 3D Body Scanning & Processing Technologies and their contents.

The abstracts and papers of over 500 publications included in the proceedings of all conferences and workshops are available at the website and accessible from its different sections. The full papers are available for download as single documents (PDF), the entire proceedings in digital form (html structure and PDF files) are available for purchase. The videos of the single presentations are also included when available.

Technical Session 1: 3D Body Scanning for Health & Sport 1

Evaluating the Accuracy of an Hallucinatory Algorithm to
Predict Body Shape Changes from Dieting and Physical Activity #43

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Background.

Visualizing body shape at some future time point can be useful in a variety of ways including motivational support for health interventions where fat and muscle mass changes are anticipated to create positive body image reinforcement. Although there are a variety of "hallucinatory" algorithms available, most, if not all, are created using cross-sectional population modeling. Previous work in our group has shown that we can accurately predict changes in total body fat and lean mass using a baseline model applied to baseline and follow-up three-dimensional optical 3DO scans using principal components (PC) of the scan mesh points as predictor variables. In this study, we explore the spatial accuracy of hallucinated and actual scans after diet and physical activity interventions.

Methods.

Participants were recruited for a "shape model" from the Shape Up! Adult Study stratified by sex, BMI, age, and five ethnicities. All participants received 3DO scan using the Proscanner (Fit3D Inc., San Mateo, CA, USA) and total body dual energy X-ray absorptiometry (TBDXA) scans (Hologic Inc., Marlborough, MA, USA). The 3DO scans were co-registered to a standard 110,000-point mesh (Meshcapade GmbH, Tubingen, Germany) and meshes for all participants were transformed to a PC space to orthogonalize and reduce the dimensions of the data. Target features such as DXA and demographic variables (i.e., height, weight, fat mass, lean mass) were applied to the PC weights to create the manifold regression matrix. Once the coefficients have been found for these features, individual scans can be substituted into the equation to solve for the best estimate of an individual's 3DO scan at different feature values (i.e., fat mass, lean mass, weight, etc.) This shape model was applied to a second population of participants from three intervention studies: Shape Up!, FB4, Louisiana State University Athlete's Studies. Hallucinated 3DO scans were created using the known changes in DXA fat and lean mass and these scans were compared to the actual scans taken after the interventions. Hallucinated scans were subtracted from the actual intervention scan on a point-by-point basis. The point location differences for all participants were represented as a second PC model to represent the modes of variance between the hallucinations and actual scans.

Results.

There were 377 adults (167 male) in our shape model and 106 participants (67 male) in our intervention dataset. The first 15 PC shape model components describe 99% of the variance. Hallucination scans for one participant are shown in Figure 1 representing changes of +/-20kg of fat and +/-20kg of lean. The hallucination variances for one male and female participant in the intervention group are shown in Figure 2 as a color heat map.

Conclusion.

We present a method to visualize the accuracy of hallucinated scans that can be used in a general way to study how the human body changes shape with body composition changes.

Predicting Muscular Strength with 3D Optical in a Diverse Adult Population #38

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Background

Lower limb muscular strength is a well-known predictor of all-cause mortality and physical function in adults. Assessment of lower limb muscle strength using the criterion isokinetic dynamometer method is expensive and often not accessible in clinical or field settings. Accessible alternatives to the dynamometer would allow for broader screening of the risk and consequences of frailty, including falls and fractures. Recently, 3-dimensional optical (3DO) scanners have been investigated as an alternative to manual anthropometry and other body composition measures for health assessment. 3DO whole-body scans have the potential for predicting strength due to their ability to produce over 200 variables of total and regional anthropometric measurements such as limb length and girth. Our previous studies have found only modest 3DO anthropometry and isokinetic knee extension; female: $R2=0.24$, RMSE=31.28, male: $R2=0.34$, RMSE=54.51. Bioelectrical impedance (BIA) is another standard clinical tool for estimating body composition, such as skeletal muscle (SMM), phase angle (PhA), which could be a potential complementary tool to 3DO given its ability to give valid estimates of muscle strength.

Objective

Our objective is to identify the optimum estimate of lower limb strength using a combination of 3DO anthropometry measures and BIA.

Methods

Participants were recruited from two US clinical sites for the ShapeUp! Adults study to represent the variance of the US population and equally stratified by sex, BMI, age, and five race/ethnicities. Isokinetic right leg strength (N/m2) was measured by Biodex System 4 (Biodex Medical Systems Inc) or HUMAC NORM (Computer Sports Medicine Inc) dynamometer. Whole-body 3DO scans with repositioning on a ProScanner (Fit3D, Inc) and a tetrapolar multi-frequency BIA assessment (InBody S10) were taken. Demographic, 3DO, and BIA predictor variables were selected by step forward regression, using the lowest predicted sum of squared residuals and a correlation value of 0.001 for inclusion into the model.

Results

For this analysis, 458 participants were available (204 male). Four models were created to predict strength; each included demographic information and separated by sex. The demographics-only model performed poorly: (1a) Female: adj-R2=0.22, RMSE=29.59; (1b) Male: adj-R2=0.30, RMSE=47.96. The strongest predictor variable was height for both male and female. The 3DO model performed slightly better than previously reported: (2a) Female: adj-R2=0.29, RMSE=27.27; (2b) Male: adj-R2=0.31, RMSE=47.82. The strongest predictor variable was thigh girth for females and waist girth for males. The BIA model performed slightly better than the 3DO models: (3a) Female: adj-R2=0.37, RMSE=25.74; (3b) Male: adj-R2=0.41, RMSE=44.18. The strongest predictor variable was SMM for females and 50 kHz PhA for males. The combination of 3DO and BIA model performed the highest of all models: (4a) Female: adj-R2=0.57, RMSE=21.27; (4b) Male: adj-R2=0.56, RMSE=387.30. The strongest predictor variable was SMM for females and 50 kHz PhA for males. All male models performed better than female's.

Conclusion

Using 3DO anthropometry alone or BIA alone does not produce a reliable model for strength predictions. The combination of 3DO and BIA better-predicted strength than either measure alone. Strength predictions appear to be more accurate in males than in females, but further investigation is needed.

Anthropometric Evaluation of a 3D Scanning Mobile Application #33

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Introduction:

3D optical imaging systems have increasingly been used in clinical and research settings for evaluation of body size, shape, and composition. These devices tend to be costly, stationary, and often require some level of technical training to operate and provide maintenance for. In recent years, smartphone applications with 3D imaging capabilities have been developed in order to make these scans more accessible. The aim of the current study was to evaluate a smartphone imaging application (MeThreeSixty, SizeStream, Cary, NC) that is portable, readily available to smartphone users, free to download, and can be used by consumers in their home environment.

To evaluate the apps' accuracy in quantifying standard anthropometric dimensions, we acquired MeThreeSixty and SizeStream SS20 (a professional-grade imaging system; SizeStream, Cary, NC) digital outputs (.obj files) from a sample of healthy adults and processed them with universal software (US) developed in our laboratory. The device-agnostic US was developed to standardize and measure anthropometric dimensions (circumferences, lengths, surface areas, and volumes) from 3D body scans, using identical anatomic landmark definitions across devices.

The current study aimed to compare conventional body circumferences at standard locations to those digitally generated from US analysis of the 3D body images created by the MeThreeSixty application and the SizeStream SS20.

The MeThreeSixty app guides participants while it acquires two standing images, a frontal and lateral view. Proprietary software post-processing of the two-dimensional images allows for extraction of front and lateral silhouettes, from which major body landmarks are identified. Machine learning then allows a 3D body template to be distorted in an organized manner and fit to the scanned body shape. The large 3D body scan library available to the developer includes a range of body shapes as a reference for the distorting the template when fitting the scanned body.

Methods:

Participants were 10 healthy adults ([mean+-SD] age 41.8+-22.4yrs; BMI, 27.7+-5.8 kg/m2). Conventional standardized anthropometric measurements were made with a flexible tape at the waist, hips, mid-thighs, and upper arms. Scans were performed with the MeThreeSixty app and the SizeStream SS20 in each participant. Acquired 3D .obj image files were processed using the US.

Results:

Overall, circumferences measured with the app-US approach agreed closely with those acquired with the flexible tape as shown in Table 1 (absolute errors, 0.79-1.96 cm; root-mean square errors, 1.32-3.97 cm). Results were largely equivalent to those from the SizeStream SS20 scanner (Table 2; mean absolute errors, 0.71-5.6 cm; RMSE, 2.00-11.75 cm).

Conclusions:

This initial evaluation of the MeThreeSixty app opens up the possibility of acquiring digital standardized anthropometric measurements that can be used to derive estimates of body fat, other clinically relevant compartments, and health risk predictions at little to no cost. The app's accuracy is comparable to conventional flexible tape-anthropometry administered by a trained technician and similar to data acquired by a professional-grade 3D optical scanner. The app's accessibility makes it useful for monitoring and tracking bodymeasurements in settings outside of specialized facilities. A larger sample to follow up on these pilot evaluations is now being collected.

Health and Telemedicine Applications of 3D Body Scanning with Mobile Devices #59

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Utilization of 3D body scanning for health purposes has been a point of research interest for decades. Access, Cost, Secure Platforms, and Data Privacy have been roadblocks for widespread use. 3D body scanning using mobile devices is coming into the mainstream. Secure data transmission of medical data from the patient to the doctor is now being enabled at the platform level. Data privacy is greatly enhanced by elimination of uploading of photos or videos to the cloud. There are many valuable health metrics that can be provided as extracted from a 3D body scan using a smartphone that are key enablers for telemedicine applications. Altogether, this can reduce the overall cost of health care while improving the quality and level of service. This presentation will be an overview of these critical points of interest and the data components and privacy features that Size Stream is providing for health applications.

Technical Session 2: 3D Body Scanning for Apparel 1

Development of an Easy Mobile Smartphone-Based Image Capturing System for Avatar Production for Garment Manufacturing #52

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Starting with an innovative approach for generating 4D sewing patterns, OpenDress was faced with the task of developing a pipeline that leads from an autonomous user scanning process to the development of a personalized avatar to a production procedure for 4D sewing patterns. We were looking for an approach that makes it possible to reconstruct a 3D scan from a 2D photo (see also: Ballester et. al.(2018), Saito et. al. (2019), Saito et. al. (2020), Zhang et. al. (2020)) apply AI trained movement to the generated avatar and construct the sewing pattern directly on the movement-trained avatar. The goal was to develop a pipeline, i.e. as platform-independent as possible, without special hardware for broad and easy user access. This paper presents partial results of a larger validation study that compared data results from different low-threshold and pseudo-monocular technologies to investigate the development of an ai-driven approach. The study conducted body measurements of more than 200 participants, using the Lidar sensor scan function from mobile devices and photos generated via mobile cameras in comparison to scans from the structure scanner via tablet and measurements by hand. Shape and pose parameters from the systems tested were analyzed in order to create a customized, parametric 3D model (avatar). Here the importance of physical realistic shape-, pose, and measurement parameters of the individual human body was emphasized, in order to further process the 4D sewing patterns.

"PS for You": A Contactless, Remote, Cloud-Based Body Measurement Technology Powered by Artificial Intelligence #31

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Contactless and remote measurement technologies have recently been at the core of the digital shopping experience, not only for their potential to provide better customization but to revolutionize the way customers shop - from minimizing returns due to misfits to reducing environmental impact by producing on-demand. For small-batch retailers, this is key in ensuring minimal waste and streamlining the consumer journey. From the consumer's point of view, fit is also an unaddressed issue. After conducting user interviews on 60+ women, we identified 70% of respondents reported difficulties finding proper fitting apparel by designers. Reports by Mintel and Deloitte also confirm that the issue of fit is paramount in the industry. Here we introduce "PS for you", our AI-powered solution to provide a fast and scalable platform for designers to obtain reliable measurements and for shoppers to find the right fit.

Our solution uses computer vision models paired with a proprietary layer of post-processing algorithms to extract personalized measurements from photos that the user can upload from any device. The solution is deployed on a serverless CPU using Amazon Web Services (AWS) for easier interoperability and faster run times.

To test the effectiveness of this approach, we collected 40 images from 20 volunteers of different body shapes and sizes (including petite, short-stature, and athletic). The system was able to detect measurements for waist, hips, and bust with an average difference of less than 3% with respect to tape-measured data. The median difference remained <1in, a significant improvement which is 3x more reflective of true size than the current universal sizing methods.

Working on this technology allows us to foster a new connection between shoppers interested in customization, sustainability, and comfort and designers who are interested in decreasing returns, eliminating waste, and understanding more about their consumers. Technology will not just help but can create opportunities to build new systems, without heavy manual support that connects and fosters experiences anywhere in the World. By using the right technology and data, responsibly, we're building a product that will open up opportunities in connected markets as well as enhancing existing ones.

Online Shopping Featuring "My Customized Avatar" – Generating Customized Avatars for a Sustainable Shopping Experience in E-Commerce #34

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Niederrhein University of Applied Sciences, Germany

Nowadays E-commerce and E-shopping become more and more popular, supported by the actual pandemic situation on one side but especially driven by technology and society transformation on the other. The product development process in clothing industry is in a state of constant change, implementing more and more digital, and especially virtual tools, within the past years. Beside the product itself and physical as well as optical virtual fabrics and trimmings, especially the avatar plays an important role in this process - from the beginning in design and ending up in E-commerce when presenting the products on matching avatars gains an attractive importance for the consumer.

Companies developing their collections and products for target groups are aiming for fit and brand consistency.

Anyway, within the product development process, there is a totally different understanding when it comes to design of avatars, visual expression on one side and technical and measurement reliable avatars on the other.

Beside the question of individualization of customized avatars, the importance of avatar design at the beginning of the process becomes "cruelly" important again at the end when getting in "touch" with the customer and its individual and subjective feelings.

Though the complete product development process is lifted up to a cloud-based system - at the end of the day a valuable customer has to buy the products to make them "alive", and keep the company running.

ESENCA – A Fit Predictor Built for the 21st Century #62

Dragos TANASA, Eduard COJOCEA

ESENCA, Lisbon, Portugal

In the last two decades, the e-commerce industry has increased significantly making shopping easier and more comfortable for users world-wide. Despite the ease of use and the convenience, this growth came together with some inevitable issues, among which we mention the return rate of the purchased items. This is particularly problematic in the case of on-line shops selling apparel, since the users cannot try out the items to see if they fit. Thus, we present our solution for body measurements that comes to the aid of the customer, who can find out their exact measurements, based on which he will be recommended the right size for each piece of clothing. Using the latest developments in Computer Vision and Machine Learning, we created a robust tool which can reliably measure various parts of the body (lengths, circumferences etc) based on two images (front and side). We get results with less than 0.5 cm measuring error in less than 10 seconds processing time.

Technical Session 3: 3D Face & Head Scanning

3D Face Scanner Comparison: Visual and Anthropometric Accuracy Analysis #41

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Compared to traditional manual measurement methods, 3D face scanning has opened more design possibilities for face protection product development, such as masks and goggles, by acquiring the three-dimensional shape and dimension. Various scanning technologies have been developed with different levels of price, expertise, and functional sophistication. In order to appropriately utilize 3D face scan data for a particular purpose, it is crucial to understand the characteristics of each scanner and validate their accuracy. The purpose of this study was to compare the visual and anthropometric accuracy of 3D face scanners and explore the characteristics and applicability of each scanner. Three-dimensional face data of nine participants were acquired with three scanners: Artec Leo, Structure Sensor, and Bellus3D FaceApp. Before scanning, seven landmarks were marked, and five measurements were taken manually. The visual accuracy of each scanner was evaluated by experts through a survey with real-time comparison between scan and real face. It included assessment for distortion of textured and non-textured scans, as well as the visibility of landmarks. Measurements were obtained using Rhino 7 and Anthroscan ScanWorX software, and the anthropometric accuracy of each scanner was compared based on the manual measurements. The results of this study presented the visual and dimensional accuracy of the face mesh creation of three scanners, providing a comprehensive review of possible uses in consideration of the cost and usability of each scanner.

Respirators, Face Masks, and Diverse Populations: An Analysis of 3D Facial Anthropometrics #60

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Background: Previous research has emphasized the importance of facial anthropometrics (shape and size) when considering ideal respirator fit. It is also known that facial anthropometrics vary by age, sex, and ethnicity; all of which need to be considered in the context of respirator fit. The purpose of our research is to quantify the differences in facial anthropometrics between Caucasian, African American, LatinX/Hispanic and Asian American workers. The LatinX population are of significant interest given their higher rates of COVID-19 illness due in part to higher ratios of this population working in "essential" jobs.

Methods: The 3D facial images for this research were recently obtained by Human Solutions North America using the Artec Eva handheld 3D body scanner on n=2022 United States participant volunteers. The researchers will be digitizing the facial scans to determine key facial dimensions for respirator and mask fit. Inter- and intra-rater reliability tests will be conducted among the five research personnel that manually digitize the facial points associated with the key facial dimensions. Demographics of the workers were also collected and included gender, ethnicity, age, occupation status, income, and various health and lifestyle factors.

Results and Conclusions: An analysis of the demographic data for the 3D facial scan participants indicated that the mean participant age is 34.6 years (SD=11.5), primary ethnicity was Caucasian (61.2%), and females represented 53% of the total sample. Digitizing of the n=2022 facial images is scheduled to take place between September 2021 and January 2022. Utilization of 3D facial data and digital extraction of anthropometrics is expected to provide a greater amount of measurement and fit information when compared to 'traditional' measurement techniques used in previous research involving smaller sample sizes. The significance of this research is the quantification of facial anthropometric differences across racial and ethnic backgrounds. It is expected that this research will contribute to improved respirator fit and better face mask sizing to protect workers and the general population that may be exposed to respiratory hazards such as wildfire smoke, agricultural dusts, and aerosolized viruses.

Exemplar 3D Faces and N95 Pleated Mask Measurement by Sex and Race #40

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The National Institute for Occupational Safety and Health (NIOSH) requires N95 masks to provide adequate fit to at least 95% of the US population through a fit test panel, with defined face dimensions. However, researchers for many years have reported discrepancies with N95 mask fit for women and minorities. More recently with the COVID-19 pandemic, these issues were critically raised again locally when a hospital mask fitter explained to the PI issues of mask fit with women and minorities, and the challenges of finding available masks on the market that protect appropriately. A pilot study was conducted with 3D face scans from the Civilian American and European Surface Anthropometry Resource (CAESAR) dataset to uncover how exemplar faces identified through an unsupervised machine learning algorithm measured and compared to an existing N95 pleated mask (Crosstex Isolator Plus). The algorithm was based on a Variational Autoencoder (VAE) with a Point-Net inspired encoder and decoder architecture trained on Human point-cloud data obtained from the CEASAR dataset. The pilot demonstrated that the algorithm worked well to identify exemplars for sizing buckets based on sex and race and proved that ML could help replace tedious anthropometric measuring practices to develop sizing systems. From the anthropometric measures collected from the exemplars, 37.5% fitted lengthwise and widthwise into the mask, where 16.7% of the exemplars fitted in the length only, and 20.8% in the width only. Twenty-five percent did not fit at all into the mask. The results of this work highlight how critical it is for N95 mask manufacturers to look at the sizing and fit of masks differently. Multiple sizes are needed within a mask style and sex/race must be considered through relevant 3D anthropometric face/head data that represents users appropriately when developing equitable sizing systems for Personal Protective Equipment (PPE).

Technical Session 4: 3D Body Scanning Systems 1

To MOVE4D, or not to Move, that is the Question #48

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This presentation describes the key technical features of MOVE4D system and provides details about the type of outcomes that can be obtained using it. We also provide a few examples of the new features that will be included in the software in the next months as well some examples of the research and consultancy work that our research group is conducting using MOVE4D to farm data and apply deep learning and machine learning techniques.

MOVE4D is a modular photogrammetry-based 3D/4D capture and analysis system developed at IBV. The system can be configured to scan body parts or full bodies with texture. A typical full body configuration can provide a spatial resolution of 1mm.

MOVE4D modules capture shape and texture simultaneously. Each module captures shape with a pair of IR cameras and texture with an RGB camera. The fact of capturing shape and texture simultaneously, makes it possible to capture at high frequencies: up to 178 fps at medium resolution and up to 90 fps at high resolution. At maximum frame rates, the equipment is able to capture 55 seconds at mid resolution and 25 seconds at high resolution. Lighting elements can be added to the structure to obtain a more uniform texture and color.

The scanning volume in the basic 12-module configuration is 2x2x3m (length, width, height) and it can be extended in length by adding and repositioning the modules; for instance, with 16 modules you can get a scanning volume of 3x2x3m. The system is conceived to have plenty of space and a safe distance from the modules to the scanning volume to let the subjects perform high speed sports motions comfortably. The modules are deliberately placed in two rows to create a free lane to let you capture go-through movements. Despite that the Laboratory has a large footprint we can build the MOVE4D modules with higher angles of view to fit smaller spaces, bringing the columns closer to the scanning space. Sensors can either be mounted in columns or in walls. MOVE4D uses a wand calibration method. We chose this method because it makes it very easy and fast to get an accurate and robust calibration.

Another characteristic of MOVE4D that is critical for conducting research activities is that it can be synchronised with other measuring equipment. It is ready for three possibilities: trigger input, synchro input and synchro output. This enables data gathering, for instance, to develop new technologies based on deep learning from MOVE4D content paired to other biometric signals. But possibilities are endless and this laboratory can open new research lines that we cannot imagine today.

Regarding the data outcomes, the unique feature of this laboratory is that MOVE4D software incorporates anthropometric and biomechanical data processing. What you obtain is a sequence of homologous meshes. A homologous mesh is a textured watertight mesh of 50 thousand vertices that is fitted to the captured point cloud using AI and proprietary template fitting software. This mesh has point-to-point correspondence along the sequence of frames and across different subjects. It is actually having 50 thousand landmarks on the body surface captured. A subset of these landmarks includes key anatomical references and lines. These organised datasets are therefore ready to be used in your research and development work. These 3D content can be exported in OBJ format. Moreover, at each frame, you can also obtain an estimate of 23 joint positions and a Linear Blend Skinning rig per frame that can be exported in FBX format. From A-Pose you can also obtain more than 100 standard static body measurements. Currently, this type of anthropometric and biomechanical processing is conceived to capture humans in tight garments and with fists closed according to standards. In addition to these, we can also provide the typical outcomes that can be provided by any 3D or 4D scanner, like dense point cloud capture or a non-organised mesh with holes.

3D Body Scanning, Size Surveys and Avatar Generation as Door Openers for 3D Apparel Product Development #53

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Due to major technological advancements and enormous cost pressure, virtual 3D product development has evolved in recent years from an innovation technology to a basic application in the apparel sector as well as in many other industries. This development was further accelerated by the Corona crisis and the associated restrictions on fit testing of physical sample parts on real models. In the meantime, all companies and their global counterparts are looking into the use of these technologies in the areas of technical product development and sample testing.

Components of this apparel development chain are digital, virtually sewn pattern, material parameters to simulate the properties of the textile and, last but not least, a suitable avatar, i.e. a digital twin of the actual customer on which the product can be fitted. The integration of the customer into the virtual development process takes place on the basis of 3D body scan data, which must be recorded as part of measurement surveys and prepared accordingly for implementation as an avatar. More and more companies are interested in using avatars throughout the entire chain of apparel production, right up to the product offering in ecommerce. This results in new requirements for the scanning process on the one hand and a new awareness of the value of human data on the other hand. So body scanning technology can be considered as one of the key technologies to integrate the customer into the virtual world of digital product development.

Since the end of the 1990s, the first 3D body scanners were developed with the idea of mass customization, that attracted a great deal of attention in all sectors of industry. The basis for the individualization of products is the precise knowledge of individual body shape and measurements, to which a product is then adapted accordingly. At that time, therefore, high-precision full-body scanners were developed that could record the body in 3D with millimeter precision using eye-safe laser technology. Such scanner solutions are now used in almost all measurement surveys worldwide, as they can capture the human being in various postures and provide a large number of ISO-compliant body dimensions.

One requirement resulting from this, however, is a comparatively large footprint combined with a relatively static setup. Conversely, the requirement to go with the body scanners to where the people to be measured are located has been steadily increasing, so the necessity for mobile scanning solutions has become more important. Due to the spread of the internet and the increasing use as a sales channel, new generations of "scanner solutions" have emerged in recent years, which can be made available to the end consumer in the form of web services or via an app on a cell phone. Scanning technology now comes to the user - and not the other way around.

However, the random collection of as many 3D data as possible from customers via apps or by mobile phone alone is not yet a sufficient basis for generating realistic 3D avatars that exhibit the individual body shape characteristics of the specific target group. Only if statistically valid data from representative measurement surveys are available with a corresponding degree of accuracy, apps and alternative measurement approaches are able to make make predictions for 3D avatars at all, despite the more imprecise input data.

Representative size survey data are also the basis for creating standard avatars that reliably represent a broad target group and its socio-demographic characteristics and fulfill a different objective than individual avatars.

Avaluation has been conducting representative measurement surveys worldwide for many years, and on this basis creates both, individual and standard avatars, for use in 3D product development. Extensive avatar experience has been built up in the course of numerous customer projects and insights will be presented.

Mobile Scanning Improvements from Size Stream #58

Warren WRIGHT

Size Stream LLC, Cary NC, USA

As the adoption of 3D body scanning is increasingly being centered on mobile scanning, Size Stream has continued to evolve our technology to deliver both an attractive scanning experience and high-quality measurements. From our initial mobile scanning solution to today, there have been many improvements. This presentation will be a quantitative analysis of the measurement quality of our latest mobile scanning solutions.

Integrated Head, Face, Ear, Hand, Foot and Body 4D Enrollment Strategies #01

Chris LANE

3dMD Ltd., London / Atlanta GA, UK / USA

Abstract not available.

Technical Session 5: 3D Hand & Foot Scanning

Estimating Footwear Fit by Using 3D Foot Scans of Shoe Shoppers #51

Ales JURCA 1,2, Saso DZEROSKI 3,2

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Shoes are available in multiple sizes and widths to accommodate the anatomic variation of human feet. Several footwear sizing systems are being used to indicate the size and width of footwear: UK, US, EU, and mondopoint. Shoe sizes are supposed to help retail customers buy well-fitting shoes. Ideally, all shoes labeled with the same size and width should provide the same fit. However, physical measurements and x-ray images of shoes of the same size have shown inconsistent internal lengths and widths. The aim of this study was to estimate the fit of women’s running shoes, utilizing foot scans and purchase data of shoe shoppers.

A dataset of over 90,000 3D foot scans and matched running shoes labeled US size 9 medium width was used in this study. Each shoe shopper purchased one of 841 running models of 14 most popular running brands. The optimal foot length and width for each model was calculated using hundreds or even thousands of foot scans of customers that bought that model in US size 9 medium width.

Results show a large dispersion of optimal foot lengths and widths for running models that are all labeled with the same size and width. Only 60% of the models in this study fitted as a true US 9 medium. A large dispersion of optimal foot length was observed for shoe styles within most footwear brands.

Foot Measurements Using Mobile Devices and Typical Pitfalls #30

Konstantin SEMIANOV, Anton LEBEDEV

Neatsy Inc., Santa Clara CA, USA

The human foot is a complex dynamic 3D object. However, the footwear industry tends to over-simplify it by providing size charts based on foot length only. This presentation will discuss various approaches of how to meaningfully measure human feet with mobile devices. Overall accuracy and user experience will be considered across a range of different options: ARKit/ARCore, structured light cameras, LiDAR, and SLAM with a reference object. Finally, the matching between an individual's feet measurements and a footwear model will be discussed.

Visual Analysis within 3D Hand Scanning to Ensure the Reliability and Precision of Anthropometric Data Collection #42

Emily SEIFERT, Linsey GRIFFIN

University of Minnesota, St. Paul MN, USA

Three-dimensional hand scanning relies on participants to hold a position for a certain amount of time. Any involuntary movements or posture changes can lead to distortions in the three-dimensional scans. When color-capture is possible, clear visible landmarks are needed to create reliable digital landmarks and to take accurate digital measurements. Visual analysis of three-dimensional scanning to assess scan quality for anthropometric data collection is not often considered. However, the quality of the scan can greatly affect the reliability and precision of the anthropometric measurements. This study examined a visual analysis of the three-dimensional hand models provided from two (2) full-color hand-held three-dimensional scanners (the Occipital Structure Sensor and Artec Leo) in the post-processing stage to determine the three-dimensional visual reliability and three-dimensional visual precision for twelve (12) participants. The Post-Processing Visual Analysis Likert Scale, developed by Juhnke, Pokorny, and Griffin (2021), was used to provide clear definitions for each location to quantify the scans' overall quality within the visual assessment. This study found that the Occipital Structure Sensor and Artec Leo are comparable within the visual reliability and visual precision analyses at all locations, except for the Visibility of Landmark location. The visual reliability and precision analyses were crucial to understanding where the quality of the scans taken by both scanners might affect the outcomes from the anthropometric data collection. This study provides a method of visual analysis of the three-dimensional models provided by three-dimensional scanners to determine the three-dimensional visual reliability and three-dimensional visual precision for better anthropometric data collection outcomes.

A Novel Approach for Determining Glove Area Factors Based on the 3D Scanning Technology #27

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2 College of Fashion and Design, Donghua University, Shanghai, China

The clothing area factor (fcl), which is the ratio of the clothing surface area to the body surface area, is an important parameter in the analysis of heat transfer between clothing and thermal environments and measurement of clothing thermal properties. Traditionally, fcl was measured by a photographing method, which potentially underestimates it due to the loss of information converting three-dimensional (3D) objects into two-dimensional images. Recent advancement in 3D scanning techniques has made it possible to quantify the 3D geometry of the nude and clothed human body and the developed air gap of the clothing microclimates. However, so far, there exists no essential data related to the glove area factor (fgl). Actually, the hand has a significantly large surface area to volume ratio, making it especially susceptible to heat loss, specifically under different environmental conditions. Without accurate fcl, it is impossible to determine the thermal properties provided by the glove properly. Consequently, better protection and enhanced work performance, health, and safety of human beings are hindered.

This study aimed to determine the area factor of gloves used by a wide range of occupations by a 3D body scanning approach. A hand-held 3D laser scanner (HandySCAN 3D Black, Creaform, Quebec, Canada) was used to obtain the 3D geometry of the nude and gloved hand manikin. The hand manikin applied has a 50th percentile western male hand size. Total 53 gloves (right hand) were investigated, including firefighters' protective gloves, light-duty work gloves, anti-vibration gloves, cold weather protective gloves, and chemical protective gloves. Geomagic Studio 12 software (Geomagic, USA)

was used to smooth, overlap, and align the nude and gloved hand model. After alignment, the surface area of the nude and gloved hand manikin was identified, and the corresponding fgl was calculated.

It was found that fgl ranged from 1.02 to 1.67 and varied significantly by glove types. The fgl averaged 1.39, 1.07, 1.28, 1.60, and 1.28 for firefighters' protective gloves, light-duty work gloves, anti-vibration gloves, cold weather protective gloves, and chemical protective gloves, respectively, indicating a significant occupational difference. Typically, The calculated fgl for firefighters and cold weather protective clothing is greater than the corresponding fgl suggested by ASTM F 1291-16 standard. These results obtained contribute to the accurate measurement of thermal properties of gloves and the development of comfort models, which ultimately contribute to the engineering of high-performance gloves. Future studies include applying the developed approach to investigate and study glove design, material application, and performance analysis for next-generation glove development.

Technical Session 6: 3D Body Scanning Systems 2

HumanDataset – World's Most Popular 3D Human Datasets #56

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Abstract not available.

Guidelines and Standards for Calibrated Millimeter Accurate Measurements in 3D Body Scans #15

Ken VARNER

botspot AG, Berlin, Germany

By applying standard precision measurement techniques from the surveying industry, we demonstrate a process for calibrating the measurement accuracy in the millimeter range on a photogrammetry-based 3D model of humans. The two key elements behind a successful and truthful calibration baseline are:

1) Trust your measurement (which is we apply measurement standards from the surveying industry)

2) Control your space (the design aspects of the scanner space that optimize the calibration techniques)

This calibration method was applied to a commercial 3D body scanner and then verified using externally and independently calibrated scale bars. After calibrating the body scanner, a statistical comparison of measurements on mesh-based 3D models from humans pre- and post-calibration was performed.

Based on these results, a new calibration hardware optimized for photogrammetry-based body scans was developed to ease the open question of calibrated measurement accuracy on-site at the end customer's facilities.

IO Industries Volucam Cameras – for Multi-Camera Video Recording Solutions #18

Andrew SEARLE

IO Industries Inc., London ON, Canada

Summary: IO Industries Volucam video cameras are designed for integration into volumetric video capture systems, 4D body scanners, and other synchronized multi-camera recording systems. This presentation will review the innovative Volucam video camera family and explain its capabilities in comparison to other solutions IO Industries and other camera system designers have provided the market thus far.

The Volucam is the first camera of its kind, combining capabilities and features normally found in industrial machine vision style cameras with internal RAW recording to a high-capacity solid-state drive (SSD). Precise synchronization features ensure microsecond-level accuracy between many cameras (as many can be connected to an Ethernet network), making the Volucam series ideal for synchronized multi-camera video recording applications. Easy-to-use operator software allows control and management of many cameras from a single interface, and a high-speed 10GigE connection ensures recordings are downloaded quickly, so the data may then be promptly processed by 3rd party tools such as 3D reconstruction software for volumetric video content creation.

IO Industries specializes in high-performance video cameras, focusing on providing robust equipment that ensures high-bandwidth video data can be collected reliably. IO Industries delivers solutions to

researchers, corporations and creative studios working to push the limits of their image and video processing tools, providing confidence that a video capture system with IO Industries cameras will provide the data needed for them to deliver their best results.

Technical Session 7: 3D Body Scanning for Health & Sport 2

3D Optical Body Composition Accuracy across Subgroups of BMI and Race/Ethnicity #36

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Background

Three-dimensional optical (3DO) body scanning is emerging as an alternative for health assessments. Body composition models predicted from 3DO body shape have been shown to correlate strongly with criterion methods like dual-energy X-ray absorptiometry (DXA) in highly diverse sample sets. Further examination of 3DO in subgroups is needed to increase generalizability and establish wider clinical applicability. Therefore, the objective of this study was to evaluate the accuracy of these 3DO body composition models by subgroups of sex, body mass index (BMI), and Race/ethnicity.

Methods

Participants were recruited from the Shape Up! Adults, FB4, and Louisiana State University Athlete's Studies. BMI categories included underweight, normal, overweight, and obese. Race/ethnic groups included White, Black, Hispanic, Asian, and Native Hawaiian and other Pacific Islanders (NHOPI). Each participant received whole-body 3DO and DXA scans on a Fit3D Proscanner (Fit3D Inc., San Mateo, CA, USA) and Hologic Horizon/A or Discovery/A system (Hologic Inc., Marlborough, MA, USA), respectively. 3DO scans were templated with a 110,000-vertex mesh for standardization and reposed through Meshcapade (Meshcapade GmbH, Tubingen, Germany). Principal component (PC) analysis was performed on the 3DO scans to reduce the dimensionality of the data to explain the shape variance in the sample with minimal PCs. These PCs were used to create fat and lean models for whole-body, arms, legs, and torso as well as visceral adipose tissue (VAT) using stepwise forward linear regression with 5-fold cross-validation. 3DO body composition estimates were subtracted from DXA measures to obtain the difference. Students t-test of the differences in each subgroup were considered significant if the P-value was <0.05. Percent (%) mean differences were categorized low (< 5%), moderate (5–10%), and large (>10%). For this analysis, we present whole-body results and VAT.

Results

In total, 723 participants aged 18-89 years were included in this study (381 females). Female and male total fat mass achieved a coefficient of determination (R2) of 0.95 and 0.94 and a root mean square error (RMSE) of 2.74 kg and 3.01 kg, respectively. Total fat mass ranged from 6.3 kg to 72.7 kg for females and 5 kg to 67.3 kg for males. Significant total fat mass differences were found in underweight females, Asian females, Black females, NHOPI females, and NHOPI males (% mean differences = 6.8%, 2.9%, -2.6%, -4.8%, and -9.3%, respectively; all P-values < 0.03). A significant VAT difference was also found in underweight males (%mean difference = -1.2%, P-value = 0.01).

Conclusion

3DO assessment appears to be comparable to DXA measures not only on the population level but also in most ethnic and weight subgroups except for underweight females and NHOPI males, possibly due to their low representation in our study sample. Using this overall model will provide accurate results in respects to DXA, but these two subgroups may need specific calibration.

Accessible Five Compartment Body Composition via 3-Dimensional Imaging and Bioelectrical Impedance #39

Jonathan P. BENNETT, Devon CATALDI, Brandon K. QUON, Yong En LIU, Nisa N. KELLY, Tom KELLY, Steven B. HEYMSFIELD, Andrea K. GARBER, Ethan J. WEISS, John A. SHEPHERD

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Background

Five-compartment modeling of body composition (bone mineral, fat, water, protein, extraosseous mineral masses) is considered to be the criterion in vivo model for body composition assessment. Use of multiple techniques to assess composition minimizes measurement errors of each separate contributor and allows for a more accurate estimation of body composition in populations where hydration, bone density, or musculature may vary significantly. However, the 5-compartment (5C) model requires multiple technologies including dual-energy X-ray absorptiometry (DXA) for bone mass, air-displacement plethysmography (ADP) for body volume, deuterium dilution (D2O) for total body water measurement and extraosseous mineral estimation and scale weight. The combination is time-consuming, taking 4 hours for the acquisition alone, and costly, limiting its broad use. The purpose of this study was to compare the standard 5C model to an accessible version using 3-dimensional optical (3DO) imaging, bioelectrical impedance analysis (BIA) and scale weight, a model named 3DO-5C.

Methods

Student athletes enrolled in the Da Kine Study at the University of Hawaii, Manoa participated. The target was to recruitment of 80 athletes (40 female) from a variety of collegiate sports. Each measure for the 5-compartment model was performed including scale weight for body mass (BM), D2O for total body water (TBW) and soft tissue mineral (Ms) estimation, DXA for bone mineral mass (Mo), and ADP for body volume (BV). Wang's form of the 5-compartment model was used to estimate body fat mass (FM) as FM = 2.748 * BV – 0.715 * TBW + 1.129 * Mo + 1.222 * Ms – 2.051 * BM. BIA was calibrated to TBW and 3-dimensional optical was calibrated to BV. Demographics were modeled to estimate Mo using data from the Shape Up! Adults study dataset. The simplified multicompartment model (3DO-5C) was modeled and validated using a 5-fold cross validation.

Results

Analysis included 72 participants (34 female; mean age 23.3 +- 4.9 years) with all measures available. 3DO estimates of body volume was highly accurate to ADP (R2=0.99, ADP = 0.998 * 3DO + 1.676). BIA estimated TBW was also highly associated to deuterium dilution (R2=0.98, D2O = 0.986 * BIA - 0.646). DXA Mo was estimated using height, weight, and gender (R2=0.71). An additional correction term was used in the Wang equation to account for covariance of the technique, 3DO-5C = Wang-5C = Wang-3DO + Cov, where Cov = gender, BIA TBW, 3DO volume. With the above substitutions, 3DO-5C model was highly associated with the criterion model (r2 = 0.92, RMSE = 2.0 kg).

Conclusion

3DO-5C provides an accessible, cost-effective and accurate measure of 5-compartment body composition. The use of this practical and easy to use model to measure body composition and hydration has the potential for clinical monitoring of acute changes in sport and clinical practice.

Creating Accurate Representations of DXA Scans from 3D Optical Body Surface Scans Using Deep Learning #35

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4 Hologic, Inc., Santa Clara CA, USA;
5 Pennington Biomedical Research Center, Baton Rouge LA, USA

Background

Dual energy X-ray absorptiometry (DXA) has long been the gold standard method of quantifying the fat, lean, and bone composition of the body. Accessibility to DXA is a concern and not everyone is afforded the opportunity to receive a DXA scan. Three-dimensional (3D) body scanning technology offers an accessible method for accurately capturing the 3D surface of an individual. Previous works have demonstrated strong correlations between 3D body scans and metabolic risk factors as well as DXA comparable body composition. In essence, body shape, as measured by 3D body scanning technology,

is highly correlated to and is a product of the underlying boney structures and soft tissue. In this work we derive mappings from 3D body scans to DXA scans to produce a model that can predict DXA equivalent images from a 3D body scan. We call this method Pseudo-DXA and generated images are compatible with DXA analysis software which can be used for arbitrary exploration of subregional body composition.

Methods

Participants recruited for the Shape Up! Study received whole body DXA scans (Hologic Inc., Marlborough, MA, USA) and 3D body scan on a Proscanner (Fit3D Inc., San Mateo, CA, USA). Principal component analysis (PCA) was used to generate four separate PCA models: three appearance models from the separate fat, lean tissue, and bone thicknesses, and one model to describe the variance in the 3D optical scan meshes. The end result was four sets of orthogonal and dimensionally efficient descriptions of the variance of fat, lean, bone, and 3D body shape. Linear regression was used to map the 3D optical model to each DXA PC model. Predicted DXA PC variables were then converted back to real space to create best estimate DXA images. Predicted DXA images were evaluated against the actual acquired DXA image in a hold-out set of images.

Results

In total, 300 participants (150 male and 150 female) were available for this study. Twenty-seven 3DO PCs were used to 99% of the variance of the DXA fat images. Likewise, 31 3DO PCs were used to explain 99% of the variance in the DXA bone and lean images. Pseudo-DXA was able to predict DXA fat composition from a 3D body scan with a pixel root mean squared error (RMSE) of 15 mg on a female participant, see Figure.

Conclusion

We demonstrate a proof-of-concept method for predicting accurate, DXA equivalent, bone and soft tissue distributions from a 3D body scan. Pseudo-DXA may provide a more accessible method for evaluating arbitrary body regions for body composition important for many fields of study. Pseudo-DXA image can also be combined with the 3D body scans for visualization of soft tissue and joint centers which may improve safety and comfort when designing garments and protective wear.

A Deep CNN Model for Inferring 3D Human Body Shapes Using Front and Side Images #32

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Immersive Virtual Reality (IVR) studies indicate that there is some level of the brain that does not distinguish between reality and virtual reality. In this context, a self avatar embodied from first person perspective brings a significant and lasting change to the user. IVR is therefore widely used in research and for psychological and physiological health rehabilitation. We use IVR in a wide range of areas in pain and mobility, emotional health, diversity equity and inclusion, to rehabilitate domestic violence offenders and to promote healthier lifestyles among obese people. A remaining challenge is to accurately and efficiently create avatars with body shapes and appearance that closely match those of the real user's bodies. This is owing to the huge differences in human body forms, the reduction of the complex human shape by body scanning technology and the complexity of acquiring accurate body measurements.

The primary objective of this work was to construct a cost-effective and accurate model to infer the 3D shape from a front and side image of a person taken with a smartphone. To achieve this, we used a fully morphable human body model to change the body shape using a set of body shape modifying parameters. We create a dataset of thousands of computer generated front and side images varying the shape modifiers of the morphable model. We then train a convolutional neural network (CNN) using that dataset.

Our approach efficiently infers 3D human body shapes from a person's front and side image generating an accurate representation of a person. We made preliminary tests using a set of 10 body scans with known measurements, creating computer generated front and side images of the scans and using these images as input to the CNN and to compare the resulting body shape with the original 3D body scan.

Our results demonstrate the effectiveness of the designed approach. Our proposed model enables us to create a fully movable avatar that can be embodied in IVR from a front and side smartphone photo in a fully automated way. The same inferred shape modifiers can also be used on the clothing of the avatar to enable us to dress the avatar. Although a larger comparative study needs to be performed before the use of this approach can be routinely recommended, we believe that the convenience and ease-of-use of this model will contribute to increase the reach of VR tools with look-alike avatars also in clinical settings.

Technical Session 8: 3D Body Scanning for Apparel 2

How the Utilisation of 3D Body Scanners Enhance the Construction of Traditional Sawwan Garments #49

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The garment industry relies upon direct measurements of the human form to ensure that items of clothing fit as well as possible. Over time, conventional measurements taken using manual methods have been replaced and enhanced by the output of 3D digital body scanners. This study identifies the specific measurements produced by 3D body scanning and compares these with the measurements produced using conventional methods. This data is then used to improve the creation of a pattern for the traditional Sawwan garment that part of the cultural identity of a region of Saudi Arabia. Traditional clothing such as this provides insight into the heritage of a region and adopting new technology in its manufacture sustains access to traditional garments. This study considers how the utilisation of 3D body scanners rather than conventional, manual measuring methods can enhance the construction of Sawwan garments for individuals. Importantly, the greater depth of data afforded by 3D body scanners than manual methods when measuring the human form creates opportunities for garments to be tailored digitally. Consequently, there is a need for the measurement profile to define the required measurements relating to the basic block construction. For the purpose of this research, a widely-utilised garment draft is compared to a new novel method using CAD pattern software (Lectra Modaris Expert) which utilises the measurements afforded by a 3D body scanner. As such, there is a need for highly accurate and consistent measurements in order for a garment to offer a good fit. In addition, it is anticipated that this study will prompt future researchers to investigate the potential for modern technology to help produce traditional garments and enhance our grasp of pattern theory. It is apparent from the findings of the current study that 3D body scanners offer a greater number of highly accurate measurements than would be possible when relying on conventional methods and this can help to improve how Sawwan garments are produced. The findings help to enhance our appreciation of the contribution that 3D body scanners can make to patternmaking practice and its evolution. It helps to further the development of technology-assisted pattern drafting and expands the variety of garments accessible to consumers in Saudi Arabia, including traditional garments often made by hand.

The Efficiency of Programs to Determine the Appropriate Size of the Pre-Ordered Product #11

Miad ALJAYZANI, Steven G. HAYES, Simeon GILL
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The fit of a garment is known as one of the main concerns of customers when selecting clothing. Various solutions have been developed to help address the issue of returning online purchases due to inappropriate clothing issue such as the 3D body scanners that have become widely available along with Computer Aided Design (CAD) technologies which play a significant role in manufacturing processes as well as enabling individuals to identify garments that are likely to offer a better fit. This paper provides insight into the use of virtual technologies intended to offer consumers better fitting bespoke garments including the associated benefits and limitations by assessing post-purchase satisfaction and fulfillment. Furthermore, the study aims to develop an innovative technology-based process offering greater customer engagement with the bespoke garment experience. No previous attempt has been made to assess how customer satisfaction with online purchases, once the items have been received, relates to the suitability of - and satisfaction with - the clothing obtained. This novel insight will be answered by undertaking online questioners. The responses received will enable the research objective to be achieved by comparing the fit based on a virtual try-on with the real-world try-on using 3D scanning technology and appropriate computer aided design software, thereby assessing customer satisfaction with the entire process from start to finish. the current study provides fresh insight into how well garments fit after utilising digital technologies for both purchase and creation

Diversity Sizing – How Different or Similar are European Women and Men? #54

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The diversity discussion gets more and more important in our society and also the industry and body related product development are affected by this trend. For the apparel sector the diversity approach comes along with certain questions considering the feasibility of combining different genders in sizing.

The following analysis focusses on differences and similarities of European female and male body dimensions and evaluates the question if both traditionally used single target customer groups can be combined to a gender-neutral target market and therefore consider the increasing importance of gender diversity. Average body measurements give an overview of how different average gender specific measurements are. Further analysis of measurement correlations visualize how female and male measurement distributions are differing or overlapping each other. The analysis of proportions and the generation of avatars gives an overview of what needs to be regarded within a possible diverse sizing approach and shows how gender diversity can be combined and implemented into apparel specific product development.

Average girth measurements already differ with regards to one gender within the European market. Adding an additional gender layer to the analysis leads to even more difference. Whereas average girth measurements and girth related body proportions can be covered by a feasible size range and fit tolerances, the differences in length dimensions represent the most challenging differences between both genders. The more overlapping the body proportions are, the easier the combination of both target groups is. The results show that a combination of both genders is possible, but it also leads to some length and fit related compromises in product quality.

Reclassification of South African Hourglass and Pear-Shaped Women for Apparel Sizing and Fit #05

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Existing product lines in the fashion industry do not satisfy the unique body shapes of South African hourglass and pear-shaped women. The supply of correct fitting clothing for the South African hourglass and pear-shaped figures are challenging for the manufacturer, retailer and the consumer. Defining a typical pear shape from western ideology uses the drop values of bust and hip measurement being larger than the bust by at least 8 cm. Hourglass body is described as one with hip and bust measurements similar or very closely related. These descriptions does not isolate cases with large breasts, but still smaller than the hips by more than 30 cm. Efforts by industry players to become more body shape inclusive have not borne as much result as would have been anticipated. Only a limited measure of success has been achieved using waist-to-hip or bust-to-hip drop values, yet descriptions are not exclusive for either pear or hourglass body. Further, bust is frequently measured inaccurately. A woman's bust girth will vary from push-up to sports bra and is hardly considered when developing sizing systems. An additional problem with the adopted standard sizes is that a customer may fit a size 12 with one clothing retailer and yet the same size will not fit if the same customer buys it from a different retail store. Evidently, there is no universally accepted standardised sizing system for the unique African body shapes.

The aim of the study is to identify, describe and reclassify different forms of hourglass and pear-shaped women's body shapes in South Africa using 3D technology. The study will determine the different shapes and formats of pear-shaped women in South Africa and integrate the measurement data collected into proprietary measurement extraction software. Results from the proprietary measurement extraction software will be used to create virtual avatars to test fit in order to produce virtual 3D prototypes. All this will feed into the development of a size classification model for different forms of hourglass and pear-shaped women.

Secondary data will be used, supplemented with primary data where necessary in order to meet the saturation points for the type of study.

One Avatar, Two Level of Detail, One Result? – Analyzing the Effect of Low and High Detailed Avatars on Fitting Simulations #46

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3D garment simulation is in the market for many years. In the beginning, most users found it hard to transfer their traditional analogue processes into the digital world. Yet, the technical enhancements of the simulation software fastened the readiness of the companies to implement systems in their product development cycle. Through the use of 3D garment simulation systems, resources can be saved and development times shortened. In addition, garment simulation can already be used to check the fit in a digital environment. By being able to check design and fit early in the process, more time can be invested in their development. A complete simulation is important for a quality fit. In addition to the pattern, this also includes the material parameters and a digital fitting tape. For reliable fitting tests an avatar has to fulfil various requirements. This also includes the level of detail (LOD) of the avatar to perform valid quality assessments. It is assumed that the LOD has a major impact on fitting results. Yet, creating high level avatars require time and comprehensive knowledge of 3D workflows.

Technical Session 9: 3D Body Processing

Creating Lifelike Digital Humans for Everyone #07

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Abstract not available.

3D Body Processing Interoperability, State of the Art and Outstanding Issues #09

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The 3D Body Processing Industry Connections (3DBP IC) Working Group, an adjunct group of IEEE P3141, Standard for 3D Body Processing (3DBP) is a group that brings together diverse entities devoted to making recommendations for 3D body processing interoperability. In the past three years, 3D has continued making inroads in product development, but the Covid-19 pandemic has accelerated the utilization of on-line retail, increased the number of phone apps for scanning, and increased usage of 3D Apparel CAD software. 5G technology and improved camera optics have also become pervasive, enabling faster file transfers and better image quality. Individual body model storage has grown as the volume of scans has greatly increased. Privacy laws and regulations to protect personal identifiable information are becoming of greater importance.

The next question becomes "what makes sense for Retail?" Retail Use Case ranges from Ready to Wear (RTW) to Body Shape Categories (body shapes) to fully Bespoke Apparel, Footwear and Eyewear. These conditions may require different types of body scans. Body avatars may vary from complete body scan avatars to population data avatars, or modifiable body-shape models.

Interoperability of data is still an issue for 3D environments not only for the 3D body scans but for the "near body environment" as well as materials and wearables. Body scans may include a soft tissue layer to better model the interaction between garments and the digital or virtual body. Interest in 3D to solve the fit and size problems, as well as reduce returns, in retail has grown.

To understand what is next for Retail, the goal of common taxonomies for 3D environments becomes particularly important. How are the terms around 3D, Digital, Virtual, Fit, Twins, avatars defined for the Retail industry when the applications can range from AR to bespoke garments? Terms need to mean the same for consumers and the retailers so that points of view of consumers and retailers are in alignment.

New areas of the 3D Body Processing Environment are the definitions of the Digital (Virtual) Twin or Digital (Virtual) Clone and how these pertain to Retail in relation to the Internet of Things (IoT). In Retail, the Digital Twin real time data can include the addition of consumer purchases to the consumer's body avatar for better understanding of fit preferences.

An example of Interoperability research was the EU project "BodyPass", with the aim to introduce an API-ecosystem for cross-sectorial exchange of 3D personal data, useful in order to analyze and extract shape information from large samples of 3D data, while giving special attention to personal data

privacy protection. Thus, highlighting that the direction of processing and exchange of 3D data must protect personal data, and on other side protect the derived data which could have commercial value such as associated clothes models, custom annotations, measurement models.

The remaining outstanding issues include alignment and interoperability of file formats and quality levels of scans required and a common taxonomy for the Retail environment. The start of art should assist with the outstanding issues.

Landmarking for 3D Body Scanning, Moving Manual Practices Into a Digital Realm #10

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Landmarking has traditionally been a manual practice where the positions for measurement are marked onto a physical body by marking anthropometric points onto body. It is rooted in defining common points to allow, for instance, replicable measurements across a population. Such common points are heavily linked to skeletal and surface body features. With improvements in body scanning and contactless measurements methods, including automation, there is a need to better correlate virtual & physical practice. This further capitalises on the known accuracy of booth scanning applications and considers acceptable degrees of error from mobile apps This paper reports on research seeking to determine the differences in manual, manual virtual and virtual automatic landmark definitions and how they might be defined and applied. It is possible to establish categories of landmark and to classify different landmarks according to key features and to identify critical base points of reference that can be used for product-driven landmarks. This paper considers how "landmark and measurement" (LM) practice could evolve suitably for both virtual and physical environments while remaining relevant through posture change and across disciplines.

Consideration is given to advantages of body scanning and the necessary adjustments in terms of practice and approach which will benefit virtual measurement. Changes in practice between the physical and virtual include defining the origin plane to be the plantar plane, specifying the handedness of the coordinate systems, identifying coordinate transformation matrices for converting between CAD applications, and the order of listing the landmarks. We generalise the notion of landmarks to encompass anatomical folds such as the inframammary and gluteal folds. The virtual environment allows the user of scan data to understand the relationship of the locations of the landmarks. By having the landmarks in a coordinate system, it is possible to determine the body shape and translate the relationship into clothing patterns that promise advances in current practice. The data moves beyond the 1D and 2D to truly the 3D. Landmark tables have three methods for obtaining landmarks: manual, manual virtual and automated virtual. Automated virtual methods are defined by utilising algorithms to automatically find the landmarks and measurements on a body scan based on ISO or other international standard definitions. The manual virtual method is defined by the user manually identifying the most likely location for the landmark and the pose of the body in the scan, requiring transitional steps defining which provide suitable guidance. Landmarks can be determined using sectional planes, analysing the characteristics (e.g., convex hull) of the scan surface or analysis of sectional curves' shapes and proportions used to identify transitions. The manual virtual example utilized Rhino7 / Grasshopper software.

Post-Evaluation of 3D Body Scans from Worldwide Surveys #55

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3D body scanners have already been used successfully for many years in the context of measurement surveys worldwide. In addition to accuracy and speed, the availability of the 3D data of the individuals also plays a major role beyond the measurements, as it allows any form of post evaluation of the data at any time.

Today, products are increasingly tailored to the needs and requirements of specific target groups. For this reason, special measurements that go beyond the standardized body dimensions from worldwide standards are also required more frequently in order to create an optimal product fit and comfort. For the post-evaluation of scan data, Avalution has built a complete integrated process chain that provides tools for all stages of the evaluation process.

A prerequisite for the management of large scan data pools is a database-supported infrastructure that allows the fast and targeted selection of relevant data. Not only are the body scans of a person in different postures and all socio-demographic characteristics of the individual scans stored here, but also all body measurements that have already been finalized. In addition, quality assessments of the scans are available, which, for example, provide a good basis for selecting and compiling scans for post evaluations.

If specific additional measurements are to be evaluated, these must be clearly described using measurement specifications and reference points on the body. These are then integrated into a computer-assisted evaluation scenario, which is run through by evaluation specialists, in which the required reference points on the individual scan are marked and evaluated in the most suitable posture for each scan. A higher-level quality assurance system checks whether all evaluators are working consistently.

When the reference points on the scans are available, the new body data can be programmed on this basis in an automatic algorithm for measurement, which creates all additional dimensions for the scans. The new body dimensions can then be measured automatically for all available scans and also for all subsequent measurement surveys.

After that, avatars or specific 3D typologies can also be created, where the post-evaluated body data can be used as target features to verify the fit and comfort of the newly developed products, both digitally and physically, in the form of e.g. 3D printed or milled 3D bodies.

In the final step, the evaluated additional dimensions can then be made available in the international body data portal iSize from Avalution for individual evaluations in combination with already existing standard measurements.

Technical Session 10: 3D Body Scanning Systems 3

The Downstream World of Precision 4D Capture – Exploiting all that Rich Data #02

Chris LANE
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Abstract not available.

Calibry: 3D Scanning in Sports and Games #04

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Abstract not available.

From Digital to Digital: The Importance of Post Scanning Treatment for End Users #64

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Abstract not available.

High Accuracy Consumer-Grade 3D Scanner and 3D Camera #21

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Revopoint 3D Technologies Inc., Los Angeles CA / Shenzhen, USA / China

Abstract not available.

Technical Session 11: 3D Body Scanning in Medicine 1

Custom Prosthetic Cover Development Methodology #17

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A prosthetic covers function is to protect other components of the prosthesis and to increase its service life, while also fulfilling its aesthetic function. Its primary purpose is to prevent damage to the functional parts of the prosthesis and to prevent the penetration of various impurities into these parts of the prosthesis. Its aesthetic function is no less important for the user because it increases his mental comfort, socialization and allows the user to adjust his prosthesis in a unique way.

For amputees, the aesthetic aspect of their lost limb is often important. Dissatisfaction with their appearance leads to loss of self-esteem and depression, which can cause dissatisfaction in people's quality of life and can even lead to the complete rejection or non-use of the prosthesis. To improve these requirements, a proposal was made to develop a custom lower limb prosthetic cover.

Currently, there are companies that provide designer covers made using AM (additive manufacturing) or plastic moulding. The disadvantage, however, is their high price. For this reason, a methodology for the individual lower limb prosthesis cover design is proposed. The main aim of this new design is to be financially inexpensive and suitable for mass production.

In the first step, a database of foreleg 3D scans, with adequate circumferential and length measurements has been created. The database consists of 17 scanned subjects, 11 female and 6 males from the age range of 18 to 70 years. Total of 34 forelegs (left and right) scans have been acquired. The emphasis during scanning was on the target placement and positioning of the foreleg. The second step was the cover size categories development. In this step, the design of sizes for serial production, sorting, and arrangement of measured values into groups was made. The classification was performed based on the measured values. The last step was the custom cover design process. This process consisted of CAD software design based on the data acquired from the 3D scanner and measurement gauges.

The result of this study is a methodology for the correct selection from the appropriate prosthetic cover size category. Based on the foreleg database creation, the cover sizes have been divided into 3 categories (small, medium, large). All models have been designed for simple AM production. In the future, correct material and AM technology selection will be performed.

Critical Pre and Post Processes for Quick and Accurate Extraction of Foot Measurements for Custom Prostheses and Orthoses #20

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ProtoTech Solutions and Services Pvt. Ltd., India

Getting accurate measurements extracted from a foot scan quickly and reliably is always challenging. While our tendency is to focus on optimizing the measurement extraction processes and algorithms, we at 3D Measure Up (www.3dmeasureup.com) have found some pre-processes and post-processes which go a long way in helping with the goal. In this paper we discuss 3D scan preprocessing viz. Alignment and positioning, mesh cleaning, unit extraction etc. and post processing such as sanity checks and validations, nomenclature etc. and evaluate their impact on measurement extraction speed and accuracy.

Leveraging Digital Technology and AI Application in Eyebrow Design and Cosmetic Treatments #57

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Achieving the ideal results through eyebrow cosmetic treatments such as microblading or eyebrow transplant can be challenging. The challenges in these procedures are selecting the ideal form to suit the clients' face and satisfy their needs, implementing the chosen form on the clients' face, and stating the eyebrows' symmetry.

This paper highlights how the combination of current technologies such as 3D scanning, artificial intelligence, and 3D printing can help achieve the ideal results through eyebrow treatments. Moreover, in this paper, the newly designed software AIbrow is introduced.

The process starts with scanning the face acquired from an RGB-D camera. The software AIbrow finds the facial points and the corresponding points on the face 3D model using artificial intelligence (AI). After aligning the scanned face with the 2D image from the camera, different eyebrows-designed models can be shown on the face, and related measurements and symmetry assessment can be performed. The chosen eyebrows 3D model is produced automatically for 3D printing using computer vision and AI. the 3D printed product can be stencils or stamps that can indicate the margin of the eyebrows in the case of eyebrow transplant and the eyebrows hair strokes in the case of microblading. For the accurate implementation of the eyebrow model on the face, the proper positioning of stencils and stamps can be assessed by the software using the described technology. This approach allows the smart performing of eyebrow treatments leading to symmetric and suitable eyebrows form.

Few-Shot High-Fidelity 3D Reconstruction of Human Bodies #63

Jaime GARCIA

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We provide a fully automated solution for the 3D reconstruction of human heads, including hair and shoulders, from a sparse collection of photos (as few as 3). Our approach yields anatomically accurate reconstructions, improving over commonly used methods based on 3D morphable models, while retaining a comparable robustness. The key technology enabling our method is a deep learning system that combines a 3D prior (shape space) pretrained from over 10K real scans, with a state-of-the art 3D reconstruction architecture based on differentiable rendering. This technology offers a promising avenue to model and reconstruct full bodies in 3D with unprecedented accuracy and flexibility, being able to capture complex shapes, e.g garments, clothing, or diverse bodies.

Technical Session 12: 4D Body Scanning for Apparel

Possibilities for Simulating Clothing in Motion on Person-Specific Avatars #08

Doudou ZHANG, Sybille KRZYWINSKI, Yordan KYOSEV

TU Dresden, Institute of Textile Machinery and High Performance Material Technology, Germany

Efficient modeling of realistic clothing deformation remains a challenge. Our work presents an approach for numerical evaluation of simulated clothing in consideration of simulation errors. Our method considers the fabric properties and compares real clothing and virtual clothing. Our method generates a believable comparison between both in motion. We make it possible to do quantitative evaluation based on motion capture, not only visual evaluation based on picture and video.

User-Oriented Product Development with Advanced Scan Solutions #12

Huangmei LIN, Ellen WENDT, Doudou ZHANG, Jessica BOLL,
Jana SIEGMUND, Sybille KRZYWINSKI, Yordan KYOSEV

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Recent developments in scanning technology have enabled researchers to scan persons at up to 180 frames per second with an accuracy of less than 1mm during movement. This allows a highly precise analysis of the interaction between body and textile as well as deformations of the fabric during movements. With the Move4D scanner, dynamic movement can be recorded and analysed very quickly. Thus, the authors are capable of making a significant contribution to the improvement of functional (e.g. sports and medical) and protective clothing by a digital process chain. The result of this research can be used for the applications on the product development of the tight-fitting and loose-fitting garments. Advantages of the digital linked process chain based on scanner are as follows: i) The design cycle of clothing is shortened by early simulation. The influence of the material behaviour on the product design can be analysed at an early stage; ii) Modification between the 3D development and the 2D patterns is convenient and intuitive; iii) Sophisticated digital data management helps to increase the efficiency of the entire process chain.

Investigating Fit in Motion with a 4D Photogrammetry Scanner System #13

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Fit in motion is of vital importance for sports- and workwear. Ashdown et al. (2011) point out that valid fitting tests need to be performed in typical sports or work related movements. Only when the garment fits well in specific positions it can protect the user without restriction of the range of motion. Therefore, a comprehensive knowledge about dynamic anthropometry is needed. Bye (2006) and Bougourd (2014) believe in this as an important research field within clothing technology. In the past sizing surveys issuing the change of body dimensions due to movement could only be performed with traditional anthropometric devices. This was time consuming and therefore often uncomfortable for the participants. Through 3D scanning technology sound implementation of big analysis in dynamic anthropometry are possible. Consequently, several research projects were conducted investigating everyday, work and sport related static poses. Significant body surface and measurement changes due to movement were found.

3D scanning is not only a reliable method to capture body measurements but is utilized for garment fit investigations as well. So far, research was performed in regard of static poses. The further development from 3D to 4D changed the conditions. The interaction between garment und body in motion can be investigated with 4D scanning technology comprehensively.

In a basic research project, photogrammetry scanner "little Alice" was utilized for fit in motion assessment. "Little Alice" consists of 38 digital SLR cameras. Like every digital camera, it is possible to perform serial recording. This enables scanning in motion or 4D scanning. Three frames per second are recorded and moderate movements can be captured. In this study 25 male test subjects aged between 22-65 years (37.86 +-12) with an average body height of 181.49 cm (+-6) and chest girths 96-120 cm (German sizes 48-60) participated. They were all either athletes or physical workers. Supporting companies provided work- and sportswear clothing systems (jackets and pants). Three movements were scanned with up to seven frames. Test subjects were scanned in static poses and dynamic sequences, both in underwear and in work- or sportswear. The reference scans were performed in Vitus Smart XXL system. In addition, each scan or sequence was captured twice.

4D scanning technology can be utilized to investigate fit in motion, assessment matrices were developed, air gaps and penetration areas were identified to compare different products. 4D scans are an excellent basis for comprehensive analysis of body-garment interaction. The limitation of the study is the focus on male subjects. More studies should be performed regarding female subjects, different movements and different garments.

Analysis of Dimensional Changes in the Lower Limbs During Movement for Sizing and Fit Development #14

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The aim of this research is to improve sizing and fit of compression sports leggings for an athletic female population. Using 3D and 4D body scan technology, it is possible to understand how the body's dimensions change during movement, which can provide information to enhance the fit of compression garments, that are commonly worn for physical activity. The Hohenstein Institut collaborated with this research and conducted body scanning using their Vitus Smart Laser scanner and Little Alice 4D scanner. Six German amateur football players were recruited and scanned in two static postures and two corresponding dynamic postures. Dimensional changes around key measurements for pattern creation were analysed and compared. It was hypothesised that lower body dimensions would change substantially from the standard scan posture to the functional postures, and results would present a difference between the static functional postures and the dynamic posture.

4D Scanning of Clothed Humans – Preliminary Results #25

Tino KUEHN, Yordan KYOSEV

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Modern hardware makes high speed 3D scanning (4D scanning) of moving clothed humans possible and opens new possibilities for optimization of the pattern in order to provide improved clothing comfort.

At the same time the high speed scanning process generates a large amount of data which analysis over times series is not more as efficient as it is for single 3D frames. This contribution reports first steps in the area of evaluation of high speed scanned data sets of humans with not tight clothing. The newest export of the IBV scanner MOVE4D in the form of triangulated meshes of the complete scan (human and textiles) is critically analyzed. It was recognized that it provides an efficient initial mesh for additional analysis from one side and some effects like small folds and areas, where the cloth is sticking to the body cannot be recognized anymore. After that the method of the approximate distances between different raw data cloud points are analyzed for a raising arms motion of a clothed human. The optical analysis demonstrates good correlation with the reality and suitability of the method for fast analysis of the clothing behavior based on 4D scanned frames.

Technical Session 13: 3D Body Scanning in Medicine 2

Multispectral 3D Whole-Body Imaging of Dressed and Undressed Bodies in Combination with Post-Mortem X-Ray Computed Tomography #24

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Introduction

In the last few years, postmortem 3D body documentation, especially through the use of photogrammetry, has gained importance in the field of forensic medicine. For this purpose, conventional digital cameras are used to capture information within the visible part of the electromagnetic spectrum (i.e., visible light). Moreover, the use of multispectral photography allows the detection and documentation of traces and injuries, for instance, in the ultraviolet (UV) or near-infrared (NIR) range, which are otherwise invisible to the human eye. Although multispectral photography offers a wide range of applications for legal investigations, multispectral photogrammetry is not yet well known or widely used within the field of forensic medicine. Therefore, within this study and the framework of the VirtoScan project, a method for multispectral whole-body photogrammetry was developed and evaluated.

Materials and Methods

A multicamera setup based on four modified digital single-lens reflex cameras, different light sources, and additional lens filters was mounted on a mobile wooden frame. The setup was used in combination with a medical X-ray computed tomography (CT) scanner. Automatic table movement from the CT scanner was used to capture consecutive image sets of the body from head to toe. In addition to standard photogrammetry within the visible range, multispectral photogrammetry was performed under UV and NIR light sources at 365 nm, 400 nm, 860 nm and 960 nm on undressed human bodies and under blue light and NIR light sources at 450 nm and 860 nm on dressed mannequins. After the multispectral photogrammetry procedure was finished, a whole-body CT scan was conducted to capture the internal information of the human body.

Results

Multiview 3D reconstructions based on multispectral image data from four forensic cases and four different sets of dressed mannequins were carried out successfully. The overall quality and level of detail of the polygon models from the undressed bodies varied with regard to the spectral range of the image data. Dressed bodies captured under blue and visible light exhibited reduced quality and reduced level of detail on the polygon models within areas of dark-colored clothing. Whole-body photogrammetry for undressed bodies took approximately 5 min under UV illumination and approximately 3 min under visible light or NIR illumination. Whole-body photogrammetry for dressed bodies took approximately 12 min under blue-light illumination and approximately 4 min under visible light or NIR illumination.

Discussion and Conclusion

The multispectral camera setup allows the capture of whole body datasets in an extended spectral range within a few minutes. With the help of photogrammetry software, textured 3D models for different spectral ranges can be reconstructed. Multispectral 3D whole-body imaging in line with postmortem CT examinations allows the combination of multispectral information from external body documentation with radiological findings from internal body documentation. Multispectral 3D documentation extends the postmortem forensic documentation of the deceased, as it detects (and documents) latent

evidence on the body and textiles and can assist in detecting subcutaneous injuries and bruises on the body.

3D Sequential Spacal and Thermal Measurements #47

Lifong ZOU, Farida FORTUNE, L. NIBALI, N. GKRANIAS, N. MARDAS, N. DONOS

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Medical thermography has become ever more accessible for the healthcare provision, due to the combination of easier operation and the lower cost of thermal cameras from the newer production. This has encouraged more applications of thermal imaging in hospitals and medical research laboratories. This study describes a non-invasive three dimensional spacal and thermal imaging system (3dMD) that was certified by the national measurement institute – NPL, and the analytical methodology for volume and temperature measurements over the same region of interest (ROI), and yet this ROI was transited through a sequential pre-registered images, in order to guarantee the measurement of changes were taken from the same location with the same boundary over a sequential subtracted imges. A clinical case was given as an example to demonstrate the effectiveness of this proposed methodology.

Technical Session 14: Mobile Body Scanning Systems

Consumer-Facing Smartphone 3D Body & Foot Scanning Based on Medical-Precision Platform #19

Jeff CHEN

NetVirta Inc., Boston MA, USA

Apparel and footwear e-commerce has a high return rate of 35%, and 70% of these returns are due to the "wrong size". This leads to an estimated $66 billion of loss in profit globally. Over the last decade, various big-data-based algorithms have been utilized to combat this problem. Due to the unique nature of the human body/foot morphology, the apparel and footwear industry highly desires a more accurate approach. Recently, several major apparel & footwear brands have adopted a smartphone-based 3D body/foot scanning platform to combat high return rates problem more effectively.

This presentation provides an update with in-depth details of such a smartphone 3D scanning platform and size-recommendation engine. We also demonstrate how this platform can help apparel and footwear brands and retailers reduce returns, increase conversions, and scale-up mass-customized offerings.

Accurate Capture of Body Shape and Size Using TrueToForm, a 3D Body Scanning Mobile Application #22

Margaret TAM, Janice TAM

TrueToForm – Tam Technologes, Chicago IL, USA

This presentation will introduce TrueToForm, a new smartphone-based body scanning and data management platform for apparel design and fitting. The TrueToForm mobile application uses proprietary algorithms and depth-sensing technology to capture body shape and size in 3D, along with full body measurement extraction. This talk will provide an overview of the platform as well as an analysis of the body capture capabilities of this technology.

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