15th 3DBODY.TECH Conference & Expo
Lugano, Switzerland · 22-23 October 2024

Book of Abstracts

3DBODY.TECH 2024

15th International Conference and Exhibition on

3D Body Scanning and Processing Technologies

Lugano, Switzerland, 22-23 October 2024

https://3dbody.tech

Editor and Organizer

Hometrica Consulting - Dr. Nicola D'Apuzzo
Switzerland
https://hometrica.ch

hometrica consulting

Table of contents page/*paper*

OPENING SESSION

3DBODY.TECH 2023 - Introduction - Welcome Speech from the Conference Director #00

Nicola D'APUZZO

Hometrica Consulting, Ascona, Switzerland

3DBODY.TECH 2024 - The 15th International Conference and Exhibition on 3D Body Scanning and Processing Technologies took place on 22-23 October 2024, in Lugano, Switzerland.
3DBODY.TECH 2024 was held as hybrid event with conference and exhibition taking place onsite in Lugano, with all contents streamed live online and recorded for later view. In-person onsite and 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 https://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&4D body processing methods and technologies, 3D&4D scan data processing
- 3D body modeling, 3D body visualization, 3D body printing methods and technologies
- 3D digital humans, virtual humans, avatars, metaverse
- Active and passive 3D&4D scanning technologies for the human body (full body, face, legs, 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
- ML (machine learning) and AI (artificial intelligence) for 3D&4D body scanning, processing, modeling
- Full body scanning and measurement systems for the apparel and fashion sector
- 3D virtual fitting, 3D digital fashion, 3D cloth simulation, virtual mirrors
- Applications in medical sciences (plastic surgery, orthotics, prosthetics, forensics, dermatology, 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 metaverse, 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 https://proc.3dbody.tech is dedicated to the proceedings of the series of 3DBODY.TECH conferences and workshops on 3D Body Scanning & Processing Technologies and their contents.
The abstracts, papers and presentation videos (when available) of over 600 publications included in the proceedings of all conferences and workshops are accessible at the website. The full papers are freely available for download as single PDF documents. The recordings/videos of the single presentations and live demonstrations are also freely accessible (when available).
The entire proceedings in digital form (html structure, PDF files, presentation videos, entire sessions recordings) are available for purchase.

TECHNICAL SESSION 1: Medical 3D Body Scanning Systems & Applications

Aura 3D Imaging System - Advanced Reality Capture and Analysis of Photo-Realistic 3D Digital Twins for the Aesthetic Industry #18

Hakki KARAMAN

Hexagon Aura Reality AG, Heerbrugg, Switzerland

Abstract not available.

Real-time Photogrammetry 3D Scan of Body Parts for Smartphones #05

Olivier SAURER

Astrivis Technologies AG, Zurich, Switzerland

Easily scan different body parts, get an accurate 3D representation, and unlock endless possibilities - from automatic segmentation and key landmark detection to instant measurement extraction - all directly on a smartphone.

3D Body Scanning, Skeletal Models and Computer Vision:
The INBODY - Instant Body Scan System from BeyondShape #68

Stanislao GRAZIOSO

BeyondShape Srl, Naples, Italy

Abstract not available.

Three-Dimensional Body Shape Measurement from Single Photographs #45

Harvey MITCHELL

School of Engineering, University of Newcastle, Newcastle, Australia

There is an extensive number of applications of human body shape measurement, for medical, apparel and other purposes, and there is a variety of means of undertaking this task, with a range of complexities, accuracies, and costs. This paper discusses one method, known as shape-from-shading, which emphasises simplicity and low cost for determining body shape. Measurement is based on a single photograph of the body area of interest, provided that the area is illuminated by a suitable point light source, typically provided by a camera's flash. The method requires neither specialised equipment nor special operator skills, so the procedure is cheap, portable, easy to use, not inconvenient for the patient, but still able to provide the three-dimensional information about a patient's body which is appropriate for various purposes.

The process is not simply a matter of presenting a photograph's grey-scales in three-dimensions, but it involves computing a numerical three-dimensional object shape, so that graphical views can be created, but, more importantly, measurements can be taken from the surface model which the method produces. The theory is not trivial, which creates severe practical limitations in many measurement cases, but many problems can often be avoided in many human body surface topography studies, because human skin surface is often evenly coloured, not especially shiny, and generally free from major colour changes. As well, the body shapes of interest can largely be assumed to be smooth, not too convoluted, and free from discontinuities and steep gradients, and this suits the photographic measurement method. It is foreseeable that the technique could be used for a variety of purposes such as providing breast volumes for apparel fitting, aiding scoliosis surveillance, but primarily by helping to create body moulds for radiation positioning and for prosthetic devices.

This paper provides a non-technical outline of the features of the technique, to present this method of measurement and its characteristics, with examples of successful measurement.

High-Fidelity 3D Body Reconstructions from Pictures #67

Ibrar MALIK

Crisalix SA, Lausanne, Switzerland

Accurate 3D reconstruction is crucial for precise simulations and measurements in aesthetic medicine. These solutions need to be easy to use and quick to deploy, while also giving the best possible surface reconstruction accuracy. In this talk we will give an overview of our product and showcase examples and data for face, torso, and full-body reconstructions using only phone pictures, with applications in a variety of fields and products beyond aesthetics.

TECHNICAL SESSION 2: 3D/4D Body Scanning for Apparel I

Re-Innovate the Custom Apparel Retail Experience with 3D Tech #19

Rick YU
TG3D Studio Inc., Taipei, Taiwan

How 3D body scanning and interactive configurators are transforming the custom apparel retail experience. Learn how these innovations not only capture precise measurements but also empower younger consumers to design their own outfits, driving business growth and customer confidence.

Embedding Body Scanning in Bespoke Product Development Pipelines #35

Simeon GILL, Kasey HATCH, Zeeshan AZAM, Muhammad CHEEMA,
Clare RICHARDSON, Kristina BRUBACHER, Ruqey ALHASSAWI,
Renhao WANG, P.U NAVODHYA, Steven G. HAYES
The University of Manchester, Manchester, UK

Body scanning offers opportunities to collect large amounts of measurement data more quickly and often with a better understanding of accuracy than manual methods. This data can be used to develop bespoke products, however, this requires consideration of how the data is captured and processed to be applied into the product development pipeline. This research outlines how the Apparel Design Engineering (ADE) group developed and explored approaches to utilise body scanning directly in bespoke product development.
The pipeline includes scan data collection, processing, measurement extraction (including error analysis and reliability), data preparation, parametric pattern development and the creation of bespoke products. We focused on developing products for a series of 5 dress forms, and explored measurement variability and accuracy to understand how our data may compare to manual approaches. In body scanning we utilised repeat scans to address the issues of allowable error during data collection.
Our research determined that scanner and manual measurements are generally comparable when taken at the same location. We further established that body scanning data can be utilised to create bespoke products with successful outcomes that recognise the individual's body. We have established that body scanning can successfully drive bespoke patterns and facilitates the engineering of garment fit. These approaches can be realised with commercial body scanning applications and open source software. However, considerations must be taken regarding data management throughout the process and we propose some key considerations for the data management pipeline to realise body scanning to bespoke.

Revolutionizing Fashion with Industry-Specific AI and New Breakthrough 3D Technology #06

Stephen SZE
Alvanon Inc., Hong Kong

While the buzz on generative AI continues to dominate media headlines, industry-specific AI is shaping fashion's future through digital bodies. Technologies that allow apparel companies to produce the right goods, at the right time, in the right quantities are vital to a sustainable fashion industry.
Two decades ago, Alvanon embarked on a mission to assist online shoppers and brands find the perfect fit. Today, that vision is on the brink of becoming a reality. Join CTO Stephen Sze as he unveils a revolutionary new technology from Alvanon designed to bring digital bodies to the public - matching consumer bodies to fashion industry sizing standards for the first time and addressing the industry's critical need for consistent execution of sizing and fit. With the new MyAlva, Alvanon is not just adapting to the new normal but leading the charge towards a more sustainable and efficient future for the apparel industry.
Key points:
- 3D Fit Standards - Delve into the significance of 3D fit standards and their role in creating authentic, production-ready digital garments. Understand the impact on production cycles and the potential for operational optimization.
- Better Fit, Shorter Timelines, Less Waste - Highlight the correlation between achieving a better fit, shortened production timelines, reduced waste, and consequently, fewer returns, leading to a more robust and sustainable business model.
- Matching Consumer Bodies to Industry Standards - Unveil Alvanon's new technology designed to

bring digital bodies to the public, creating a seamless match between consumer bodies and industry sizing standards for the first time.
- Data-Driven Decision-Making - Emphasize the power of data in creating fit standards tailored to a brand's unique customer base. Illustrate how this data-driven approach can lead to more effective sizing mixes, reduced waste, and increased profitability.
-Real-World Applications - Showcase real-world applications of MyAlva and BodyAI, and its ability to transform how consumers shop and how brands produce apparel.
Audience takeaways:
- Insight into the synergy between AI, technology and sustainability in the fashion industry.
- Understanding the impact of 3D fit standards on business efficiency and waste reduction as an opportunity to optimize production cycles.
- A sneak peek into MyAlva and BodyAI's cutting-edge technology and its potential to revolutionize consumer experience.
- Strategies for leveraging data to enhance fit standards and sizing predictions.

Integrating Bespoke Avatars into Digital Fitting Methods to Improve Fit #46

Penelope NORMAN, Jonathan BURGESS, Kyra GIBSON
Arts University Bournemouth (AUB), Poole, UK

With the increasing reliance on digital technology globally, the adoption of industry 4.0 within the fashion industry has accelerated. The full 3D digital production process is at the forefront of fashion innovation, however legacy issues such as traditional size charts persist.
Inclusivity of diverse body shapes is a major issue for the fashion industry. By adopting a new approach, this research introduces a new process that has the potential to improve customer satisfaction and reduce waste.
This study evaluates the traditional size chart by comparing the industry standard to 3D body scan data from participants, focusing on the use of avatars and body scanning to improve the fit process and challenge the existing sizing system implemented throughout the fashion industry. This provides the foundation for a pilot study of a novel virtual fitting room which explores digital process as an alternative to the traditional size charts.
The result of this research is a prototype for the avatar library 'fitting room', that contains the 'real women' avatars from body scans. 3D avatars can be beneficial in both improving fit and reducing waste within the fashion industry. Further development of the avatar fit library will be available for industry to utilise in the fit process from design through to sampling and production stages. This prototype demonstrates a means to disseminate this research in an innovative and engaging way.

Making Fashion Inclusive to Every Body: Body Scan to Digital Product Creation #69

Craig CRAWFORD 1,2
1 Differently Enabled, London, UK;
2 Crawford IT, London, UK

Founded in 2020 after his near death COVID19 experience, Craig Crawford’s Differently Enabled is making fashion inclusive for those living with disability, atypical body morphology, or restricted movement.
Leveraging his 30 year fashion industry career in design and digital innovation, Craig and his global team of industry veterans have been exploring body scan-to-pattern processes to enable clients to co-create bespoke fashion that fits the wearer accommodating their varying needs.
"Fashion is important. When you look good you feel good. With confidence you do your best," Craig explains.
"However 1 in 5 people are excluded from the fashion industry with its sizing and grading borrowed from rules applied from military uniforms based on symmetry.
Our R&D work already demonstrates that today’s fashion tech is biased, and together we are fixing that."
Craig will present the brand's journey to date, with examples from his work with brand champions with varying body types and garment needs. He will conclude his talk with a call to action for any attendees who would like to participate in Differently Enabled's research journey.

TECHNICAL SESSION 3: 3D/4D Body Scanning for Health, Fitness & Sport

Integrating Muscle and Body Fat Measures into a 3D Body Scan Fitness Assessment #10

Richard ALLEN, David BRUNER
Size Stream LLC, Cary NC, USA

The development of a fitness indicator that considers the relative proportion of body muscle mass to fat mass is useful as an assessment of fitness. Muscle mass is a key determinant of several positive health outcomes, including enhanced metabolic function, improved insulin sensitivity, and reduced risk of chronic diseases such as cardiovascular disease and type 2 diabetes. Additionally, maintaining muscle mass supports functional capacity, bone density, and mental well-being. Conversely, excessive body fat, particularly visceral fat that contributes to a larger waist circumference, is associated with numerous negative health implications. High body fat content is linked to an increased risk of metabolic syndrome, certain cancers, respiratory issues, and a heightened overall mortality rate. Excess stomach circumference exacerbates these risks by promoting inflammation and insulin resistance, further contributing to conditions like heart disease and diabetes. The ease of using mobile device-based 3D body scanning technology enhances the accessibility and accuracy of this fitness assessment technique, allowing users to conveniently both track and visualize their fitness progress.
Fitness improvement commonly involves increasing muscle mass while reducing excess body fat. This dual approach not only enhances physical appearance but also can significantly improve overall health levels. Visual examples of body types measured using this fitness indicator intuitively correlate with recognized levels of fitness, from poor to excellent. Individuals with higher muscle mass and lower body fat are often perceived as more fit and healthy, while those with high body fat and low muscle mass are typically seen as less fit. By integrating these visual and measurable aspects, a combined fitness indicator provides a clear, intuitive, and more comprehensive method for assessing and improving individuals health and fitness status than measuring muscle mass or fat alone.
Moreover, such a fitness indicator serves as a natural and motivational metric for individuals on personal fitness improvement journeys. By offering tangible and visible progress markers, it encourages sustained engagement and commitment to fitness goals, fostering a healthier lifestyle and better long-term health outcomes. This innovative approach empowers individuals to take proactive steps towards achieving their health and fitness objectives.

3D Bodyscan in Professional Sports: Practical Use Cases in Prevention, Bodytracking and Rehabilitation #50

Florian KRICKL, Tariq Aziz MOHAMED MIYAKHAN
VITRONIC Machine Vision GmbH, Wiesbaden, Germany

Abstract not available.

Uphill Cycling: Investigating the Effects of Saddle Incline on Comfort, Frontal Area, and Power Output #53

Alexander VAN GASTEL, Kobe HERMANS, Jochen VLEUGELS, Stijn VERWULGEN
University of Antwerp, Antwerp, Belgium

This study investigates the impact of saddle inclination on cycling comfort, frontal area, and power output during uphill cycling, a key challenge in events like the Tour de France. While bike-fitting and bicycle geometry advances have enhanced the cycling experience, little research has focused on bike-fitting for uphill cycling and optimizing saddle tilt for uphill performance. Recently, the adoption of saddle incline by top cyclists such as Tadej Pogacar and 2016 amendments to the Union Cycliste Internationale's (UCI) regulations have increased interest in the benefits of saddle incline. Previous studies have suggested the following benefits from saddle incline: 1) increased comfort, 2) improved metabolic power efficiency, 3) positively modified muscle activation, 4) decreased perceived exertion, and 5) reduced oxygen consumption. All of those could improve performance on challenging climbs. To further assess the precise biomechanics and potential benefits of saddle incline, this study will examine 1) comfort, 2) projected drag area, and 3) power output. Thirteen cyclists of varying experience levels participated in four sessions with saddle inclinations of 0°, 2°, 4°, and 6° while cycling on a simulator set to a 4° uphill slope. The results of this study indicate that there is no definitive ratio between saddle inclination and slope angle that universally optimizes comfort, aero, and power output for all riders. Notably, the saddle incline-to-slope ratio does influence comfort but is highly individualized. A 4° saddle incline received a mean comfort score of 7.4 ± 1.5, while a 0° saddle incline

scored a lower 6.76 ± 1.74. The projected frontal area, a key measure in aerodynamics, was 1.5% lower when comparing a 4° inclined saddle to a horizontal saddle but was not statistically significant. Power output was greater for a horizontal saddle, with a measured 1,02% increase in power output compared to the lowest score gathered from a 4° saddle incline. However, this result was also not statistically significant.

TECHNICAL SESSION 4: Digital Humans & 3D/4D Body Modeling

Automatic Production of Digital Humans in Real Motion with a 4D Scanner #33

Sandra ALEMANY
Instituto de Biomecánica de Valencia IBV, Valencia, Spain

Abstract not available.

Evaluation of Automated Skeleton Fitting to 4D Human Body Scan Data Using Open-Source SMPL- and OSSO Models #40

Ann-Malin SCHMIDT 1, Ingrid PERAZA 1,2, Yordan KYOSEV 1
1 Chair of Development and Assembly of Textile Products, ITM, TU Dresden, Germany;
2 Ghent University, Belgium

4D scan data capture the body's surface in motion, enabling analysis of body deformation, skin stretching, and clothing fit, but are limited to surface-level information. Previous work used 4D scan data to develop individualized Finite Element (FE) models for digital clothing fitting, but these models lack a bone structure and require labor-intensive manual placement or costly CT scans.
An automated method for fitting a skeleton to 4D scan data has been tested and evaluated on three subjects in two different poses. This method involves converting 4D scan data into SMPL models, followed by the automatic application of a skeleton using the open-source Python module OSSO.
The fitting process of the SMPL model demonstrated high accuracy and repeatability, with mesh differences of less than 5 mm for static A-Pose configurations. Although the SMPL model simplifies body surface details, resulting in a slightly slimmer appearance, it successfully supports accurate skeleton fitting to the original 4D scan data. In dynamic poses from 4D scans, inaccuracies and low repeatability were observed for the SMPL fitting. The OSSO-based method efficiently placed bone poses across all tested poses with only minor penetrations noted in areas such as the fingers, legs, and ribs. Integrating the OSSO skeleton with 4D scan data produced a model that effectively combined accurate body surface representation with a detailed skeleton. Nonetheless, pose discrepancies between the SMPL model and the 4D scan data resulted in some intersections for the skeleton mesh, which could lead to errors in Finite Element (FE) models. Minor adjustments, such as rotating joints, improved the fit of the skeleton. Overall, while the method shows promise, further refinements in SMPL model fitting process, especially for complex poses, are needed to enhance its potential for improving the precision of individualized FE models.

Analysis of the Accuracy of the Moving Avatars in Style3D Using 4D Scanning #43

Robert NAFZ 1,2, Yordan KYOSEV 1, Christian KAISER 2, Christian PIRCH
1 Technische Universitaet Dresden, Dresden, Germany;
2 Albstadt-Sigmaringen University, Albstadt, Germany

3D and 4D scanning technologies have revolutionized digital representation forms, particularly in the clothing industry. While traditional 3D scanning already provides detailed static models, 4D scanning extends these capabilities with the dimension of time, capturing dynamic movements and changes.
This study examines the precision and effectiveness of moving avatars created using advanced 4D scanning technology compared to the avatars and movements available to users in the Style3D simulation software. The primary objective is to evaluate how accurately these standard avatars depict real-world movements. By utilizing 4D scanning, which captures three-dimensional spatial data over time, we gain a dynamic perspective on human motion and offer unprecedented detail.
The research focuses on the comparative analysis of three key poses extracted from avatars in Style3D and a 4D scan. This involves examining changes in the mesh within these poses, assessing variations in measurements, and conducting a visual analysis of the avatars' meshes to accurately depict body shape. The study aims to highlight differences and propose methods to enhance the realism and application of avatars, particularly in the fashion industry.

25 Years Experience of 4D Body Scanning - What Next? #12

Chris LANE
3dMD LLC, Atlanta GA, USA

Abstract not available.

TECHNICAL SESSION 5: 3D/4D Face Scanning & Modeling

Beyond the Surface: 3D and 4D Imaging for Craniofacial Assessment and Treatment #11

Rami R. HALLAC 1,2, Chris LANE 3
1 UT Southwestern Medical Center, Dallas TX, USA;
2 Children's Health, Dallas TX, USA;
3 3dMD LLC, Atlanta GA, USA

Dr. Hallac is an imaging scientist at Children's Health and an associate professor at UT Southwestern Medical Center. Utilizing 3D imaging, modelling and printing, Dr. Hallac has sought to improve pediatric surgery, providing tangible, patient-specific solutions tailored to surgical planning. His expertise in 3D imaging and modelling has enabled objective assessments of deformities and post-operative results.
Furthermore, he has developed machine learning algorithms that have met or exceeded conventional diagnostic standards.
With a focus on patient safety, Dr. Hallac has innovated imaging protocols to minimize radiation during craniofacial assessments. His published contributions highlight his dedication to integrating technology and medicine.

Automatic Facial Reconstruction API by KeenTools #70

Roman BELOV, Artyom ROMANENKO
KeenTools, Yerevan, Armenia

Abstract not available.

AAA Characters & Indie Scanning - Leveraging Scan Data for Realistic Digital Doubles #61

Vuk RAJKOVIC, Miroslav RADMANOVIC, Marko SASIC
2DNAC, Novi Sad, Serbia

Abstract not available.

3D Face Scanning and AI - Latest Projects and Insights on Immersive Productions #72

Kadine JAMES 1,2
1 The Immersive Kind, London, UK;
2 Artificial Rome GmbH, Berlin, Germany

Abstract not available.

TECHNICAL SESSION 6: Mobile 3D Body Scanning & Measurement

Advancements in Body Composition Assessment using Mobile Devices #09

Steven C. HAUSER, Matthew S. GILMER, David BRUNER, Breck SIEGLINGER
Size Stream LLC, Cary NC, USA

Advancements in mobile technology and artificial intelligence have transformed body composition assessment, providing a practical alternative to traditional methods like air displacement plethysmography (ADP), dual energy X-ray absorptiometry (DXA), and expensive optical booth scanners for 3D body measurement. This paper evaluates the competitiveness of Size Stream's mobile 3D body scanning applications against these alternatives and compares their performance with two-point and four-point bioimpedance devices. Based on a substantial dataset of 209 samples across 118 subjects, body composition was assessed using a four-compartment model, incorporating DXA, bioimpedance analysis, body volume measurements, and body weight. Our findings demonstrate that

mobile device 3D scanning achieves impressive accuracy and reliability, closely aligning with full booth results and outperforming conventional bioimpedance scales. The paper details the methodology, data analysis, and comparative metrics, highlighting the potential of mobile devices as viable tools for body composition assessment. This advancement not only enhances accessibility but also ensures precision and accuracy in health and fitness applications.

Measure.Match.Manage - 3D Body Scanning to Size Recommendations Tech Solution #34

Tuoc LUONG

BodiData Inc., Saratoga CA, USA

Bodidata's Measure.Match.Manage size-matching solution can eliminate the need for, and costs associated with free returns, while increasing the loyalty of customers to brands who use our solution.
This solution has been deployed in both Europe and North America with our partners in the Uniform Industry - at notable clients such as Mercedes-Benz.
To do this we created and patented Kora, the only handheld scanner that measures the surface of the underlying body of an individual wearing their normal street clothing. Kora is the only scalable body measurement solution because it does not require people to completely undress to obtain real body measurements.
Bodidata's Kora scanner is dramatically different than competing 2-photo or 3D video measurement technologies that use optical scanners. These optical solutions measure the visible surface of a person and require people to completely remove all their clothing to collect actual body surface measurements. This is not a scalable alternative. Body dimension databases created with optical technology are not actual body measurements. It should be noted that Bodidata also owns these measurement solutions, including the original patent for 2-photo body measurement, which means we can speak honestly about their weaknesses compared to Kora.
Once the wearer has been scanned using the Kora scanner, their optimal sizes for relevant styles will appear in the portal. The details of the fit of each size are broken down clearly to allow the wearer to understand how each size recommendation will fit their unique body in each key area. The size recommendations are based on Bodidata's sophisticated size-matching algorithms that consider the properties of each unique style, including the intended fit of the garment, the wearer's functionality, safety and movement requirements, stretch, drape, grade, construction, and patterning, among other fit elements.
As some prefer a tighter or looser fit, the Partner Portal will also display the details of fit for other sizes and inform the wearer if it is an acceptable alternative fit. The optimal fit or preference selection can be recorded directly in the portal, along with the desired amount of each product. This data can then be sent directly to an ordering platform through an API integration or exported as a CSV.
The end-to-end scenario will be discussed and demonstrated live on stage at 3DBody.Tech.

Esenca Sizing - Advanced Body Measurement Solutions #55

Eduard COJOCEA

Esenca Sizing, Bucharest, Romania

Abstract not available.

Tailoring into the Digital Era: A Novel Approach for Precise, Remote and Objective Body Measurements Mapping #54

Paola GRIGGIO

PGM12, Padova, Italy

Abstract not available.

Digital Body Measurements and AI: Transforming Fashion and Apparel Production and Retail in Africa #38

Julcit Sally BAWA, Oluwole AKANDE

1 Mezer, Lagos, Nigeria; 2 Design Shark International Ltd, Lagos, Nigeria;
3 Univ. of Lagos, Nigeria; 4 Netloft Ltd, Lagos, Nigeria

The fashion and apparel industry in Africa is yet to fully benefit from the recent transformations in the global fashion scene driven by the integration of digital body measurement technologies and artificial

intelligence (AI). This paper explores the potential impact of these innovations on apparel production and retail within the region, highlighting how they will enhance efficiency, accuracy, and customization. Leveraging 3D body scanning and AI-powered data analytics, African garment manufacturers and designers can offer tailored solutions that meet diverse global consumer needs, meet orders, improve fit and reduce waste and production costs. This paper will further examine the case study of how Design Shark International will leverage machine learning and computer vision technology for mobile 3D body scanning with the introduction of Mezer its AI powered digital body measurement solution to address quality standards and scalability challenges in its local fashion industry. It discusses the challenges of adoption, provides strategic recommendations for stakeholders, and addresses how our solution is being applied for the development and adoption of a standardized African clothing size chart. Our results suggest that embracing digital body measurements and AI not only improves competitive advantage but also fosters sustainable growth in Africa's growing fashion industry.
The integration of digital body measurements and artificial intelligence (AI) is revolutionizing the fashion and apparel industry globally. This paper explores a case study of a pioneering company in Africa that leverages machine learning and computer vision technology for mobile 3D body scanning, providing an AI-powered digital body measurement solution. The study examines the technological framework, implementation challenges, and the transformative impact on production efficiency and retail experiences.

TECHNICAL SESSION 7: Medical 3D Body Scanning Systems & Applications II

Precision Analysis of Patient-Specific Bone Mechanics: Orthopedic Care through 3D Image-Based Modeling #37

Zeang ZHAO, Weili SONG, Panding WANG, Daining FANG
Institute of Advanced Structure Technology, Beijing Institute of Technology, Beijing, China

Accurate assessment of the mechanical status of patient bones is crucial for selecting surgical strategies and ensuring postoperative recovery in orthopedic disease treatment. Due to the complexity of bone structures and significant interindividual variability, coupled with limitations in current in vivo bone characterization techniques, effectively analyzing the stress state of patient bones has become a pressing issue in the field of medical engineering integration. The utilization of finite element methods based on medical CT imaging offers a novel perspective by simplifying bone models, thus facilitating individualized biomechanical analysis of bones. This approach not only enhances the precision of analysis but also provides scientific recommendations for postoperative patient recovery, aiding clinicians in more accurately assessing surgical outcomes. In this presentation, I will elaborate on the complete technical process of reconstructing simplified bone models from medical CT images and demonstrate through specific cases how mechanical analysis can be effectively integrated into medical procedures. Through this discussion, the aim is to underscore the crucial role of mechanical analysis in orthopedic disease treatment and provide insights for further research and clinical applications in related fields.

Design for Disability: Prosthetic BK Socket's Manufacturing with New Digital Methodology #08

Daniele BONACINI, Gerardina BULDO
Roadrunnerfoot Engineering s.r.l., Milan, Italy

This study presents the definition and validation of a new process methodology for the creation of sockets for transtibial amputations and has the objective of automating and digitizing the prosthesis production process through digital transformation activities of the orthopedic workshop, additive manufacturing and advanced manufacturing solutions, as well as simulation for Gait analysis.
The work is part of an interdisciplinary project which sees, in addition to the experience of the orthopedic technician, the involvement of the mechanical engineer, the biomedical engineer and the designer.
The elements of digital innovation concern: the acquisition of the digital 3D model of the stump through scanning with the scanner and MRI; physically based modeling and FEM simulation of the stump to obtain the "compressed and stylized" model through new quantitative rules developed by the work team; rapid prototyping of the 3D model of the stump; the autoclave lamination process of prepreg fabrics or the socket printed directly in 3D thanks to the use of innovative printers; the acquisition of 3D models of leg, foot and cover foot or leg for the creation of customized parts; static and dynamic alignment; validation of the prosthesis via Gait analysis; monitoring the patient's health status during

the life of the device supplied with the Gait analysis system.
The innovations made and the new methodology certainly revolutionize an obsolete sector and speedup the creation of prostheses, with aspects of eco-innovation of the product and process and with significant energy savings.
In this context, "inclusive" design aims to allow all disabled people to have equal opportunities for participation in every aspect of social and cultural life, thanks to innovative prostheses that improve the quality of their life. This holistic and innovative approach constitutes a creative and ethical challenge for all designers because human diversity, social inclusion and equality are aspects to be considered in the design process, enhancing human needs and aspirations. To achieve this, end-user involvement is required at every stage of the design process. Furthermore, technological innovation brings benefits for everyone and competitive and economic advantages, since the possibility of remotely producing the orthopedic prosthesis customized for each patient makes the technology accessible to users, guaranteeing high technology at low costs.
The methodology was tested on seven patients with transtibial amputation: the results obtained and the final considerations can be considered satisfactory.
Future research, in this way, can increase the fields of application using the same digital methodologies.

Estimating Spinal Position in 3D Using a Connected Garment to Assess Bracing Fit for Adolescent Idiopathic Scoliosis #22

Aruny PATHAMMAVONG 1, David R. LABBE 1, Neila MEZGHANI 2, Luc DUONG 1
1 École de Technologie Supérieure, Montréal QC, Canada;
2 Université TÉLUQ, Montréal QC, Canada

Adolescent idiopathic scoliosis (AIS) is characterized by a three-dimensional curvature of the spine that affects a ratio of one boy to eight girls. Frequent monitoring of AIS is crucial due to unpredictable growth spurts. For eligible patients, bracing can be considered to prevent curve progression. This study aims to provide a 3D visualization of the patient’s postural condition and bracing results, in real time. We propose a new custom designed connected garment for tracking and monitoring patient's posture. Since connected garments have proven to be a promising markerless motion capture method, a bodysuit was designed for this experiment. The simulation of the garment and fabric was created with CLO 3D 2024 simulation software. The prototype's main function is to quantify indicators of AIS deformities using stitch-based stretch sensors. The bodysuit transmits signals through a data acquisition system for precise and high-rate transmission. Simultaneously, a customized algorithm generates on a computer a 3D visualization of the posture using Processing 4 (2023). The experimental results are validated using inertial measurement units (IMU). Finally, the outcome of this research is a system for continuous monitoring of AIS, without an impact on daily life as it will have the same attributes as everyday wear.

3D Scanning Smart Glove for Shape and Softness of a Patient's Body in Orthopedic Applications #30

Vera PAMMINGER, Robert KOEPPE, Clemens SCHARTMUELLER, Leon KAINZ, Thomas STOCKINGER, Daniela WIRTHL, Raphael SIEGL, Yana VERESHCHAG
sendance GmbH, Linz, Austria

The sendance-glove measuring system metaphorically turns the hands of healthcare professionals into a 3D scanner for the shape and softness of a patient's body. It is a scanning glove with combined pressure and position sensors embedded in a silicone matrix, which makes it possible to transform tactile information into digital data directly usable for designing mobility aids and orthopedic devices, such as ankle-foot orthoses and custom orthopedic shoes. To the best of our knowledge, capturing the implicit knowledge embedded in an expert's fingertips via a scanning glove is a completely new approach to digitize healthcare. The sendance-glove system allows designing orthopedic devices without artisan processes like plaster casting or tape measuring. The position sensors, which work with a measurement principle based on electromagnetic induction, identify the fingertips' positions with <1 mm precision. The pressure sensors developed by sendance GmbH are small (6mm diameter, 0.3 mm thickness), built from a flex-PCB and a thin film of piezoresistive material. Integrated in the glove, they are calibrated over a pressure range of 10 - 250 kPa to achieve high precision and repeatability. The core functionality of the glove scanning system is realized when data from the pressure and position sensors are correlated. With data pairs of both pressure and position captured at the same time,

functionalities such as shape surface detection, distance measurement and tissue hardness estimation can be achieved.

Overcoming Challenges in 3D Scanner Validation for Orthotics and Prosthetics #64

Paul LORE

Qwadra, Vancouver BC, Canada

Comparing 3D scanners is challenging due to inconsistent metrics that often fail to reflect their practical utility in clinical settings.
This presentation addresses these issues and outlines methods for validation, including circumferential measurements, comparisons to a high-accuracy 'gold' scan, and quick metrics using a custom object. We also evaluate scanner performance on various clinical devices to ensure both accuracy and precision in orthotics and prosthetics applications.

TECHNICAL SESSION 8: 3D/4D Body Scanning for Apparel II

A Comparative Study on the Influence of Body Shape on the Fit and Functionality of Stretch Knit Garments #25

P.U NAVODHYA 1, R.K.J DE SILVA 1, Simeon GILL 2

1 Dept. of Textile and Apparel Engineering, Univ. of Moratuwa, Sri Lanka;
2 Dept. of Materials, The Univ. of Manchester, UK

Stretch knit garments have gained popularity for their adaptability, comfort, and ability to accommodate diverse body shapes. However, ensuring an optimal fit remains a challenge, particularly given the variability in the wearer's body shapes, specifically in women's upper body garments. This research explores the correlation between body shape and the fit and function of stretch knit garments.
Garment fit is a multifaceted concept that encompasses both design aesthetics and alignment with the wearer's body contours, which is especially crucial for stretch fabrics. Achieving the right fit requires optimisation between body shapes, measurements, and ease allowance. The garment design should complement the natural curves and contours of the body, ensuring wearer comfort and aesthetic appeal. This study examined the impact of body shape on the fit and functionality of stretch knit garments, utilising three Alvanon dress forms (UK sizes 10, 12, and 14) utilizing Cole (2015) pattern drafting method tailored for stretch knit garments. Body measurements were obtained using a size stream 3D body scanner, informing pattern development. Fit was accessed visually using digital Alavforms and Browzwear VStitcher.
The findings underscored the critical role of considering the wearer's body shape in garment design and pattern development. Neglecting this aspect can lead to critical fit issues, indicating a gap in current pattern drafting methods. Moreover, this study highlights the necessity of engineered fit solutions tailored to diverse body shapes, rather than relying on generalised approaches. By establishing the intricate interplay between body shape and garment fit and function, this research contributes to the development of more inclusive and accurately fitting stretch knit garments, enhancing wearer satisfaction, comfort, and functionality at the same time employing advanced digital tools.

Comparative Analysis of Various 3D Scanners for Body-Garment Relationship Measurement #42

Chakravarthy PALANISAMY 1, Noopur ANAND 2, Manoj TIWARI 1,
Nafrin ASHKAR 1, Dhiya S. VARGHESE 1

1 National Institute of Fashion Technology, Kannur, India;
2 National Institute of Fashion Technology, New Delhi, India

This study aims to explore different 3D scanning technologies to scan both body and garment to check the fit in the ready-to-wear apparel industry. Even though 3D scanning technology is widely used to scan the body, scanning of garments remains underexplored.
The main objective of this research is to analyse different 3D scanners for body-garment analysis. This includes examining the scanned date for accuracy, reliability and body-garment scan alignment processes.
The study explores various scanning techniques like white light, infrared and photogrammetry for capturing body and gament details. Additionally, it examines various scanning techniques like scanning mode, resolution and other parameters to optimise the scanning process.

This study accesses the precision of the scanned model by validating the manual measurement taken using an anthropometer. Additionally, heat maps are created using 3D visualization software and compared.
In conclusion, this study aims to provide valuable insights into the selection and optimization of 3D scanning technologies to improve apparel fit. By addressing challenges and limitations associated with traditional measurement methods, the study seeks to enhance the accuracy and reliability of garment production processes. Leveraging innovative 3D scanning approaches, the research aims to improve customer satisfaction and drive technological advancements in producing optimally fitting garments.

Methodology for Analysis of the Deformations of a Wetsuit Using 4D Scanning and FEM Simulation #16

Nikolay PEEV 1, Yordan KYOSEV 2

1 EduQuest Ltd., Sofia, Bulgaria;
2 Chair of Development and Assembly of Textile Products, ITM, TU Dresden, Germany

As a recently established field, 4D body scanning offers significant potential for application in the clothing development. It enables various forms of analysis of the movement of a body, without having to physically interact with it or destroy it. The objective of this study is to identify the most optimal sequence of stages for preparing a sample for analysis and following scanning and FEM analysis. A body-clothing interaction between a neoprene surfing wetsuit and a person was taken as an example scenario to apply the steps on. The chosen example outlined various weak spots in the methodology at every stage of the process. The following issues were identified and subsequently addressed: failure of the homologous mesh generation process following 4D scanning, suit detection failure during scanning, suit digitalization, and complications associated with the simulation modelling process. Two separate material testing techniques are applied, ensuring that accurate material properties are obtained for the simulation phase. Each stage is discussed, outlining all assumptions and limitations taken into consideration. The results present a proposal of the most efficient analysis algorithm, including all issue workarounds. The methodology presents a method for improvement of higher performance wetsuits, by establishing precise simulation models and using high speed (4D) body scanning techniques.

Methodology for Design of Well Fitting Load-Bearing Belts #36

Nataliya SADRETDINOVA 1,2, Larysa IVANOVA 1,3, Jana SIEGMUND 1, Yordan KYOSEV 1

1 Technische Universitaet Dresden, ITM, Dresden, Germany;
2 Kyiv State University of Technologies and Design, Ukraine;
3 Kyiv National University of Construction and Architecture, Ukraine

Rapid advances in scanning technology have revolutionized the ability to accurately reproduce the contours of scanned objects, facilitating the design process for various product categories. In the apparel industry, these systems are particularly effective in creating custom-fit garments tailored to individual customers. However, for mass production, it is necessary to generalize and interpret the scan data to establish standard size categories that represent typical consumer groups. At the same time, some products manufactured within this framework can only achieve their functionality if they smoothly fit to the human body. An illustrative example would be a carrying system whose main function is to distribute weight between the shoulders and hips. The effectiveness of this load distribution is directly influenced by the contact area between the belt and the body: the larger the contact area, the lower the perceived load. This principle can be applied to various load-bearing products such as backpacks, functional harnesses such as tactical harnesses and mounting harnesses as well as baby carriers.
The goal of our research is to develop and test a methodology for the design of function-specific mass-produced items that closely conform to the surface of the lower body, using functionally specific harness systems with tool bearing belts or assembly belts as a case study. For this purpose, parametric human models in standard sizes (e.g. German women's sizes 38 to 54) with three hip width variants - narrow, normal and wide - were used, which were previously developed for 3D product design projects. These models served as a prerequisite to investigate the typical geometry of the lower body surface. The area of interest was limited to the area between waist and hip circumference, as recommended for optimal belt positioning on the body. The 3D construction of the functional belt is carried out directly on the parametric human model in the Design Concept 3D software, Lectra. The 2D pattern parts are automatically unfolded from the 3D design. These flattened patterns were analyzed and standardized, taking into account the body geometry of the different sizes, the material properties

and the subsequent manufacturing processes. The anthropometric fit of these designs was verified through simulations in 3D garment design software. This approach ensures that the resulting products not only meet the requirements of mass production, but also provide the necessary functionality and comfort for the end user.

Size-Me: Fast, Cost-Effective, Accurate Garment Size Recommendation Tool for B2B and B2C Apparel Businesses #66

Lara MAZZONI

Bodi.me Ltd., London, UK

Abstract not available.

TECHNICAL SESSION 9: 3D Foot, Ankle & Leg Scanning

Fast and Accurate 3D Foot Reconstruction from a Single Image #13

Joaquin SANCHIZ, Eduardo PARRILLA, Jordi URIEL, Alfredo BALLESTER, Sandra ALEMANY

Instituto de Biomecánica de Valencia IBV, Valencia, Spain

Obtaining accurate 3D reconstructions of the human foot from 2D images holds significant importance in various fields, including anthropometry, footwear design, and medical diagnostics. In this study, we propose a novel neural network-based approach for reconstructing a 3D mesh of the foot from a single image. Our method integrates multiple sources of information, including binary segmentation masks and 2D keypoint estimation. By leveraging Principal Component Analysis (PCA) to represent foot morphology in a low-dimensional space, we infer the parameters needed for 3D mesh reconstruction, including rotation and translation parameters for alignment with the input image. Our approach builds upon recent advancements in deep learning for 3D reconstruction from images and demonstrates promising results in accurately capturing foot morphology. The model has been trained with two datasets: one consisting of 1M synthetic samples and another with 500K augmented real samples. Validation on a test subset of over 674 samples resulted in a PA-MPJPE (Procrustes-Aligned Mean Per Joint Position Error) of 0.9 mm. Furthermore, the real-time capability of our method makes it suitable for applications in augmented reality, such as virtual try-on and improvements in user experience and precision of phone-based foot scanning solutions.

Unlocking Online Shoe Fitting: Data-Driven Foot Measurements and Size Recommendation #59

Andres PRADA GONZALEZ

Footprint Technologies GmbH, Berlin, Germany

Finding the correct shoe size remains a significant challenge. Having multiple sizing standards around the globe causes uncertainty in selecting the correct size. The inability to physically try on shoes further exacerbates this issue in online shopping. At Footprint Technologies, we enable online shoe fittings using our accurate and precise shoe size recommendation system. It relies on two key components: the foot measurement and matching algorithms. The first one determines the foot dimension based on images and, the second one predicts the best-fitting size for a particular shoe model by analyzing the user's foot measurements and additional data such as gender, age, height, and weight. Finding the ideal fitting parameters for each shoe model is complex, so we developed a try-on process to collect and analyze data to optimize these parameters.

This process involves two stages. First, we gather data by selecting 3 to 8 shoe models for testers to evaluate. Testers try shoes in different sizes and provide feedback on comfort and their size preference for the particular model.

Additionally, we collect 2D images via our web app and 3D foot meshes using a laser scanner. In the second stage, we post-process this data to analyze and identify the best parameters for achieving an optimal fit. By following these steps, we found the best fit for 131 users out of 138 Footprint users running on a client’s webshop. However, this process has some limitations in scaling it to many different shoes and can incur biased analysis on a limited number of testers.

medi vision - The Digital Assistant for Taking Measurements of Medical Compression Garments #63

Thomas SEBALD
medi GmbH & Co. KG, Bayreuth, Germany

medi vision combines a tablet with a 3D camera and the specifically developed so>ware. It supports the process from taking measurements to ordering – in medical supply stores or mobile at patients' homes and in clinics.
With the medi vision app, you can take measurements easily and digitally to effectively configure mediven compression garments for round and flat knit. The scan generates an exact 3D model with all relevant measurements almost contact-free. The measurement data is automatically incorporated into the ordering process in the medi e-shop.
The trained specialist scans the patient's limb with a 3D camera. The tool then generates an exact 3D model with all the relevant measurements. This is done digitally, ergonomically, conveniently and almost contact-free.
Depending on the space available or individual customer requirements, there is now a choice of two scan variants:
Full-Circle Scan
- The established scan option
- More than 500,000 scans performed worldwide
- Efficient scanning in just one pass
- Space requirements: appr. 2 x 2 metres
Multi-View Scan
- The flexible scan in 3 sections
- Space-saving (appr. 1.5 x 2 metre)
- Customer can hold on if required
- Breaks possible between the individual sections

TECHNICAL SESSION 10: 3D Body Data & 3D Body Processing

Capturing Time: Advanced Anthropometric Data Collection and Processing in Longitudinal Studies #49

Matthew BENNETT
Humanetics Digital Europe GmbH, Kaiserslautern, Germany

Abstract not available.

Metrics for Including Posture and Body-Shape Variation in Scan Databases for Apparel Practice #17

Carol MCDONALD 1, Emma SCOTT 2, Fatma BAYTAR 3,
Susan ASHDOWN 3, Gerald RUDERMAN 4
1 Gneiss Concept, USA;
2 Fashion Should Empower Research Group, Canada;
3 Cornell University, USA;
4 Zdoit, USA

The foundations of good fit in patternmaking are identified as grain/wale, line, ease, balance and set. The interaction of these factors with themselves and the human body establishes the body-to-garment relationship understood to be ‘fit’. Posture is a critical component of this relationship. Posture also impacts the balance and set of the garment, both in stationary and active poses. The skeletal joints distinguishing posture provide the understanding of the garment suspension points and direct the distribution of ease and flow of the garment from these points.
During large-scale study of scanned human body data, it is common practice to normalize subject posture and focus on subject shape. This practice has proven effective for ergonomic use cases, but problematic for apparel-related practice where the body must be understood in relationship to interaction with garment materials and design. Often, posture and shape are intrinsically related, and separation invalidates apparel use-case results. Varying degrees of head thrust, shoulder rotation, pelvic tilt, kyphosis, lordosis, and varus or valgus knee alignment all change the body-to-garment relationship. A previous posture study has identified placement, alignment, rotation, curvature, and symmetry (PARCS) as descriptors for body region relationships related to posture and pose.

In this paper, we use PARCS descriptors to consider metrics for describing the aspects of posture related to the body-to-garment relationship. These descriptors could be used to reassess vast accumulated 3D body data sets for posture-inclusive shape studies better suited to apparel practice. Recognizing where posture exists outside a baseline 'normalized' range is essential for providing good apparel fit for the population. Studies to support where skeletal posture and body shape are intrinsically intertwined will further such efforts.

Learning to Predict Anthropometric Landmarks via Feature Refinement #47

Yibo JIAO 1, Chang SHU 2, Dinesh K. PAI 1

1 University of British Columbia, Vancouver BC, Canada;
2 National Research Council Canada, Canada

Precise localization of anthropometric landmarks is essential in many applications - including computer graphics, computer vision, biomechanics, and morphometric studies. Current methods in machine learning can produce dense correspondence with good global properties, but are poor at localizing specific landmarks. Landmarks are the most important correspondences for many applications and the only independently verifiable criteria. Here we propose a new method for localizing landmarks using learned features that significantly outperforms the state of the art.
Our method learns refined features that characterize the intrinsic and extrinsic geometry around the landmark, thereby making it easy to recognize and localize. We propose a novel loss function for training using two functions to evaluate the likelihood of a vertex being a target landmark: the landmark potential (P), which characterizes the likelihood of a vertex being a landmark and is computed by the network from a given mesh, and the similarity function (D), which measures the distance from a landmark, extrinsically or/and intrinsically, and provides supervision information for training. The network is trained to optimize the correlation between the two functions so that vertices that have high similarity with the target landmark also have high potential, and vice versa. In addition, we introduce nuclear-norm minimization to compute an optimal span of refined features for landmarks among training models. The resulting system is easy to implement and learns efficiently from a small number of meshes with identified landmarks.
Our implantation is available at https://github.com/yibojiao211/Learning_to_Predict_Landmarks.

Leveraging AI to Examine Diversity in Body Dimensions Through Contrasting 3D Scans with Standardized Forms #14

Ruqey ALHASSAWI, Simeon GILL, Steven HAYES, Kristina BRUBACHER

The University of Manchester, Manchester, UK

This study addresses the challenge of providing well-fitting clothing sizes by using 3D body scanning and machine learning algorithms for improved size prediction. Data from 677 female participants' revealed notable variations in body measurements, emphasizing the need for more anthropometric analysis to better understand existing sizing standards. The research compared basic Support Vector Machine (SVM) models, using key measurements such as bust, waist, and hips, with an enhanced PCA-SVM model incorporating additional body dimensions. The basic SVM achieved higher accuracy (89.66%) than the PCA-SVM (68.97%), suggesting that fewer key measurements provide better predictions. These findings highlight the potential of 3D scanning and SVM models in developing sizing systems that accommodate diverse body types.

IEEE Industry Connections and Standards Group for 3D Body Processing (3DBP) #03

Carol MCDONALD 1,2

1 Gneiss Concept, USA;
2 IEEE-SA, Piscataway NJ, USA

Abstract not available.

TECHNICAL SESSION 11: Digital Anthropometry, Ergonomics & Human Factors

Personalized Fitting of Respiratory Mask Using Deep Learning and 3D Facial Modeling #23

Eya MLIKA 1, Bahe HACHEM 2, Yamen AL HABASHI 2, Loic DEGUELDRE 2, Luc DUONG 1

1 École de Technologie Supérieure, Montréal QC, Canada;
2 Numalogics, Montréal QC, Canada

Respiratory masks are highly used in healthcare and industrial environments to protect individuals from airborne contaminants and infectious pathogens. However, conventional respiratory masks are often one-sized, therefore it becomes challenging to fit diverse facial morphologies. If loosely fit, the mask may not adequately safeguard or be over-tight to achieve protection, which could cause discomfort or even generate pressure wounds over extended wear.
This project aims to propose an artificial intelligence approach for the design and customization of respiratory masks, emphasizing customized products to better fit into the variety of human face morphology. The proposed approach begins with the creation of facial geometries using 3D facial data obtained by using the ARKit framework. ARKit allows to acquire a structured and complete mesh of the subject's face despites incomplete and noisy data. Each facial scan captures 5,023 3D points, providing a detailed map of individual facial features. The resulting dataset, including 60 different facial scans, forms the basis of our machine learning algorithm. This algorithm is designed to improve the customization and fit of respiratory masks, enhancing wearer safety and comfort. From this facial modelling, a deep learning model designed to predict the deformations of a mask when fitted to the face was deployed. The model enables the identification of potential areas of pressure and mask misfits, predicting problems before they become critical. A predictive model was further introduced to simulate the interaction between the facial structure and the mask as closely as possible. Combining scanning technologies and predictive modelling will alleviate the detection of gaps and pressure points, enabling preventive measures to be taken to rectify these defects. Due to an in-depth understanding of these interactions, the newly developed model proposes modifications to the mask design to better match the unique contours of each face, thus improving the mask's seal and comfort.
This research might contribute to improve fitting and address important health protection issues and accelerate safety regulation compliance, thereby lessening health risks related to the long-term use of poorly fitted masks. Adequate fitting might have an important impact on the design of personalized protective equipment.

Service System of Human Factors Experience - Hearables #52

Will GUO 1, Miguel SILVA 2

1 Goertek Inc., Qingdao, China;
2 Goertek Inc., Atlanta GA, USA

Abstract not available.

Volume Measurements of the External Nose for Anthropometric Purposes: A Comparison between Stereophotogrammetry and Laser Scanner #26

Riccardo SOLAZZO 1, Annalisa CAPPELLA 2,3, Claudia BRUNETTI 3, Daniele GIBELLI 1, Claudia DOLCI 1, Chiarella SFORZA 1

1 LAFAS, Laboratorio di Anatomia Funzionale dell'Apparato Stomatognatico, Dipartimento di Scienze Biomediche per la Salute, Università degli Studi di Milano, Milan, Italy;
2 U.O. Laboratorio di Morfologia Umana Applicata, IRCCS Policlinico San Donato, San Donato Milanese, Italy;
3 Dipartimento di Scienze Biomediche per la Salute, Università degli Studi di Milano, Milan, Italy

Three-dimensional (3D) optical imaging technologies for the anthropometric study of superficial soft tissues are widely used nowadays, particularly stereophotogrammetry and laser scanning. Different instruments have been validated for the assessment of linear measurements, angles, and surfaces, proving to be interchangeable. However, despite the growing interest in the volumetric calculation of craniofacial structures, no studies have evaluated the agreement in calculating the volume of 3D models of external facial structures obtained with instruments based on diverse technologies.
This preliminary study compared the volumetric measurements of external nasal casts scanned with optical systems based on stereophotogrammetry and laser scanning to verify their interchangeability in volume assessment. Specifically, 23 nasal casts were scanned with the Vectra M3 (Canfield Scientific Inc, Parsippany, NJ) and the Dental Wings 3Series (Dental Wings Inc, Montreal, Canada). The volume

was calculated for the right and left nasal side on each 3D model using the Vectra Analysis Module (VAM, version 7.4.6). The protocol entails the digitization of specific anthropometric landmarks (median: nasion, pronasale, subnasale; paired: subalare, alar curvature, endocanthion) that are also used to select the surface of the nasal side for which the volume has to be calculated. The selected surface is then projected onto a virtual plane passing through the median landmarks to obtain a closed structure for which the volume is automatically calculated by the software. The protocol was applied to all nasal casts, resulting in a total of 92 volumetric measurements. The intra- and inter-operator reliability was evaluated using the Intraclass Correlation Coefficient (ICC). The agreement between the volumetric measurements calculated on the 3D nasal casts acquired with the two devices was verified by Lin's Concordance Correlation Coefficient (CCC) and Passing-Bablok regression.
The ICCs for intra- and inter-operator repeatability proved to be "excellent" (ICCIntra = 0.98; ICCInter = 0.94). The results of Lin's CCC and Passing-Bablok regression confirmed the interchangeability of the two systems in the volumetric calculation. The Lin's CCC value was g = 0.99 with the lower border of 95% CI equals to 0.98, interpretable as "substantial agreement". The Passing-Bablok regression equation was: y = 1.00x - 0.04 where the 95% CI for the slope (95% CI: 0.96 - 1.06) and the intercept (95% CI: - 0.65 - 0.44) respectively included 1 and 0, allowing to state that no significant differences between the volumes of nose scanned with the two instruments exist.
In conclusion, nasal volumes can be reliably and interchangeably evaluated in 3D models acquired with different optical surface devices, as previously described for linear measurements, angles, and areas.
This opens the possibility to interchangeably use different instruments for the volumetric characterization of the external nose. Further studies should evaluate volumes of external facial structures in living subjects and focus on verifying the agreement between different protocols of data collection and analysis.

Waist Hip Somatotype and Classification for Young Chinese Women #32

Linghua RAN, Xin ZHANG, Huimin HU, Chaoyi ZHAO, He ZHAO

AQSIQ Key Laboratory of Human Factors and Ergonomics,
CNIS, China National Institute of Standardization, Beijing, China

To analyze the influencing factors of the fit of pants structure design, the waist and hip body shape characteristics and categories of specific populations were studied. 2000 young Chinese women aged 18-26 were selected as the research subjects, and 18 waist and hip characteristic variables were obtained. Using principal component factor analysis, four morphological factors affecting the waist and hip body shape characteristics were obtained: circumference factor, height factor, ratio factor, and girth difference factor. Based on morphological factors, four variables were selected: waist circumference, waist to hip height, Waist transverse diameter, and D-value between hip circumference and waist circumference. A two-step clustering method was used to classify waist and hip body types, dividing young women into four categories. The first type is short round body, the second type is high flat body, the third type is short flat body, and the fourth type is high round body. The proportions of each type of body in the experimental sample are 11.3%, 23.3%, 35.2%, and 30.3%, respectively.

Possibility for Application of 3D Scanning to Evaluate the Opening Behavior of Side Airbags in Interaction with the Human Body Model and Car Seat #44

Tabea HOFEMEISTER 1, Yordan KYOSEV 2

1 Volkswagen AG, Wolfsburg, Germany;
2 Technische Universität Dresden, Dresden, Germany

To ensure the protection of an occupant in the event of a side impact, the side airbags play an important aspect of protection. The airbags interact directly with the occupant's body to prevent injuries in den area of the hip-thorax zone. Due to the small impact zone of an side impact, the side airbags need to be open approximately in less than 5 ms and be in position in about less than 20 ms. As a standard checking the performance of a side airbag during the development 2D high-speed cameras are used.
The investigation of this study is based on the evaluation of the possibility of using an alternative 3D technique for the application of testing the side airbag deployment. This already known 3D measurement technique was developed in a cooperation between Fraunhofer IOF, Fraunhofer SCAI and Volkswagen AG.

TECHNICAL SESSION 12: 3D/4D Body Scanning for Apparel III

Investigation of Microwave Imaging Scanning Compared to Conventional 3D Laser Scanning for Capturing Body Dimensions Through Clothing #51

Miriam SENNE 1, Elena Alida BRAKE 2, Felix KUNZELMANN 3,
Ann-Malin SCHMIDT 3, Christoph BAUR 1, Katerina ROSE 2, Yordan KYOSEV 3
1 Rohde & Schwarz GmbH& Co. KG, Munich, Germany;
2 Reutlingen Research Institute, Reutlingen University, Germany;
3 Chair of Development and Assembly of Textile Products, ITM, TU Dresden, Germany

Capturing accurate body dimensions is crucial for the apparel industry, particularly in the creation of customized garments and ensuring an optimal fit. The current standard methods include using measuring tapes on key body areas or employing 3D scanners. Both techniques require the individual to wear tightly fitted clothing or no clothing at all to ensure accurate measurements. These inconveniences may be alleviated with so-called Microwave Imaging (MI), a lesser known imaging technology typically employed in security scanning. MI offers an alternative approach as it is capable of capturing body dimensions accurately and rapidly even under clothing. In this inital work, MI is thoroughly investigated and compared both visually and quantitatively to established measurement techniques. For a quantitative assessment, approximate methods for determining human body dimensions based on MI are presented and compared to aforementioned conventional measurements methods. All scanning procedures were conducted on a static mannequin, being tested in two distinct configurations: unclothed and wearing a jacket. The experimental setup is designed to evaluate the effectiveness of capturing body dimensions in general, and in particular through clothing, with a specific focus on exploring the potential applications of MI data in the context of body measurement. To this end, MI demonstrates to be a fast, comfortable and feasible method for measuring body circumferences, rendering it a viable option for use in the clothing industry. The technology shows promise, especially in its ability to capture body dimensions even through thick clothing.

Automated 3D Virtual Try-On from Production Data - Reduce Apparel E-Commerce Returns with High Fidelity Size and Fit Guidance #65

Faycal M'HAMDI
Alter Ego Technologies AG, Zurich, Switzerland

Abstract not available.

Next-Level 3D Scanning: Precision, Efficiency, and Cost-Effective Avatars #71

Giulio AUGELLO, Vincenzo ARMANDI, Silvano CARRADORI, Gustavo MARFIA
Alma Mater Studiorum - University of Bologna, Bologna, Italy

In recent years, the fashion and e-commerce industries have experienced a growing demand for technologies that capture accurate real-world data, such as 3D models, to enhance user shopping experiences and improve sales optimization. Although numerous solutions exist, many face limitations in accessibility and application.
Our invention introduces a cutting-edge 3D scanning system capable of creating highly detailed avatars with precise measurements, significantly faster and at a fraction of the cost of the comparable current market offerings.
Leveraging an automatic body measurement extraction algorithm, the system analyzes acquired data to accurately identify key body measurements, capturing a comprehensive and detailed representation of the individual.
The designed scanning booth provides a controlled environment, ensuring high-quality results efficiently and reliably.
An integrated management platform allows users to view, edit, and apply their avatars in various contexts, ensuring a complete and interactive user experience. Concluding with a combination of speed, price-effectiveness and avatar quality our invention may stands out as a disruptive force in the 3D scanning market, offering a superior and more accessible solution for businesses and consumers alike.

Comparison of the Accuracy of a Turntable-3D-Scanner and a 4D-Scanner in the Context of Clothing Development #48

Anselm NAAKE 1, Dzmitry KOMAR 2, Yordan KYOSEV 1, Irene Saura NAVEDO 1

1 Chair of Development and Assembly of Textile Products, ITM, TU Dresden, Germany;
2 SCANECA GmbH, Berlin, Germany

There are different 3D scanner designs and underlying technological principles for performing 3D scans. More sophisticated systems generally use more cameras/sensors and are able to are able to create very controlled conditions for the scan. Less sophisticated systems use less cameras/sensors and the scans are performed under the environmental conditions which result from the location of the scanner. More sophisticated systems can usually carry out the scan in a few fractions of a second, less sophisticated systems have scan times of around half a minute. The resulting higher cost, space requirement and general technological effort of more sophisticated systems is generally offset by a gain in greater accuracy and reliability. However, the extent to which this gain exists and what effect it has on the usability of the scan has not been examined in detail. For this reason, a parallel series measurement was carried out with a turntable 3D scanner and a 4D scanner and the results were compared. The results are presented in this paper.

The End-To-End 3D Virtual Try-On Solution for The Fashion World #56

Eduard COJOCEA

Vesto3D, Bucharest, Romania

Vesto3D is a pioneer in developing cutting-edge technology for 3D virtual try-on experiences, enabling users to visualize how garments fit on a 3D avatar representing their body dimensions.
To experience our solution, users follow three simple steps. First, they measure their body with Esenca Sizing to generate their digital twin. Second, the garments are digitalized from sewing patterns, creating 3D assets that are ready to be draped onto the avatar. Finally, the 3D garments are virtually sewn together and draped onto the avatar in real-time.
During the garment digitalization process, users can customize the sewing patterns by defining how the panels are stitched together and altering the shape of the panels. Once the garments are applied to the 3D avatar, our physics engine simulates realistic interactions with forces such as gravity, friction, wind, elasticity, and others, as well as handling collisions between the garments, the avatar, and the environment. This ensures that the garments behave as they would in the real world. Users can also update garment properties (such as elasticity, bending, and mass) to simulate a variety of real and conceptual fabrics.
Vesto3D provides a dynamic environment where users can try on different garment sizes and swatches, helping them make more informed decisions when purchasing clothing. A built-in tension map highlights areas where garments may be too tight or too loose, offering detailed fit feedback. Users can further personalize their avatar by adjusting skin tone and pose, as well as visualizing it in different environmental settings.
By combining fashion, technology, and physics, Vesto3D offers an immersive and customizable virtual try-on experience, designed to enhance fit accuracy and elevate the user experience in both retail and design applications. not available.

TECHNICAL SESSION 13: 3D/4D Body Scanning for Apparel IV

Investigating the Possibilities of 4D Scanning Technology to Analyze the Dynamic Fit and Comfort of Karate Uniforms "Karate-Gi" #41

Sofiene MOKHTAR 1, Felix KUNZELMANN 2, Yordan KYOSEV 2

1 Textile Materials and Processes Research Unit (MPTex), National Engineering School of Monastir ENIM, University of Monastir, Monastir, Tunisia;
2 ITM, TU Dresden, Germany

The objective of this research work is to investigate the possibilities of 4D body scanning technology to analyze both the karate practitioners (Karateka) body shape and measurements during specific movements as well as the dynamic behavior and fit of their uniforms (Karate-Gi). That's in the aim to design more suitable/comfortable Karate-Gi for various cases and situations, meeting karateka's specific needs and requirements and improving their performance. We present in this paper the scanning process and protocol, the generated and exported data as well as some first results and conclusions. Indeed, we started by using the 4D scanner "MOVE4D by IBV" to capture a karateka test

person both in static poses as well as while performing a simple/short karate basic technique, in three situations: Minimally Clothed; Partially Clothed and Fully Clothed. Then, we processed raw scans to export various data from MOVE4D's processing software such as the karateka 3D homologous meshes, the rigged animated 3D karateka body models and a set of both static and dynamic measurements. All of these data were processed by using dedicated softwares such as MeshLab and CloudCompare to analyze dynamic shape and measurements of the karateka body in motion, the dynamic deformation of the karate-Gi's elements (pant and vest) as well as their physical fit both in static and dynamic poses.
Finally, we are also working on using the obtained rigged animated 3D karateka avatars to virtually simulate the dynamic fit and deformation of the studied karate-Gi, with 3D garment's virtual design and simulation softwares like VStitcher and Clo3D.

3D Body Scanning to Transform Sleeve Patternmaking in the Fashion Industry #07

Sumayah WAZIR, Simeon GILL, Kristina BRUBACHER
The University of Manchester, Manchester, UK

In apparel design, sleeve patternmaking plays a pivotal role in determining both the comfort and aesthetic of a garment, especially for set-in sleeves. These sleeves not only contribute to the overall fit but also influence the wearer's range of motion and ease of movement. However, the process of creating a well-fitted sleeve pattern is complex, as it requires an in-depth understanding of the relationship between body measurements and pattern design. This understanding can be significantly enhanced by using 3D body scanning technology and parametric software, which offer precise and accurate measurements that reflect the wearer's unique shape.
This research focuses on enhancing the design of women's set-in sleeve patterns by incorporating 3D body scanning technology into the drafting process. By using advanced parametric tools, such as Seamly 2D Parametric software, this study assesses how precise, real-time body data can revolutionize the accuracy of sleeve patterns. The focus of the study is on size 12 Alvanon UK women's forms, which serve as a standardized model for evaluating eight established sleeve drafting methods. These methods, while unique in their approaches, share a common goal: to create a sleeve that fits well and meets the design's aesthetic requirements. Each method is sequential and detail-oriented, involving direct measurements (from the body or bodice pattern), proportional calculations, and fixed integers to define the shape and size of the sleeve.
At the core of the research lies a comprehensive comparative analysis. This study meticulously evaluates each method's calculation of critical dimensions such as sleeve crown height, bicep width, and armhole circumference. The visual comparisons produced by Seamly 2D highlight distinct variations in sleeve shape, reflecting differences in ease, styling, and how each method approaches fit. Despite all methods being applied to the same size 12 Alvanon body form, each yields a uniquely shaped sleeve. The analysis vividly highlights these differences, pointing out the primary factors of variation across the methods, such as ease and crown height.
The study also involved evaluating sleeve pattern drafting methods through virtual fit analysis in CLO 3D, employing a standard UK size 12 Alvanon avatar without modifications to the original drafts. This comparison aimed to understand each method's strengths and limitations, offering a foundation for proposing new engineered sleeve pattern construction approaches. By analysing the theoretical underpinnings and practical outcomes of these sleeve-drafting methods, as well as conducting virtual assessments, the research identified several shortcomings in traditional techniques, such as their lack of adaptability to diverse body shapes. These deficiencies underscored the need for an innovative approach that integrates modern technology to refine the process. By leveraging tools like 3D body scanning and virtual fitting, the research seeks to develop innovative solutions for diagnosing and addressing sleeve fitting issues, contributing to the advancement of sleeve design techniques and promoting a synthesis of traditional drafting methods with modern digital tools to enhance garment fit and aesthetics.
The integration of 3D body scanning technology signals a key advancement in custom-fit apparel, offering accurate body measurements and precise contours that help produce sleeves with enhanced fit and comfort. Aligning 3D scans with sleeve patterns enables designers to visually assess and make real-time adjustments to the fit, permitting nuanced modifications potentially overlooked in traditional methods. This precise data ensures sleeves that not only conform to the wearer's shape but also complement the body's natural movements, achieving harmony between aesthetics and functionality.
As part of this research, a new method was developed that not only incorporates the strengths of traditional drafting techniques but also enhances them by integrating detailed, accurate data from 3D body scans. This method accounts for the wearer's bones, joints, and muscles, creating sleeves that

allow for natural movement and enhanced comfort. The 3D scans provide precise measurements that capture the true contours of the arm, ensuring a custom fit not only to the size but to the wearer's unique body shape. Furthermore, an analysis of armhole sizes and the correlation between shoulder height and underarm height was conducted to understand the variation in armhole depth across a diverse population of females. Using Python for statistical analysis, this correlation analysis revealed the relationship between shoulder and underarm height, providing insights into different body shapes and informing the pattern-making process. The analysis indicated potential variability in armhole depth, which was incorporated into the new method to create patterns that adapt to various body shapes. This data-driven approach improves the functionality and aesthetics of garments, allowing for better-fitting, more comfortable sleeve patterns that meet the needs of a wider population.

Development of a Web Application for 3D Body-Garment Fit Analysis #39

Chakravarthy PALANISAMY 1, Noopur ANAND 2, Manoj TIWARI 1, Jyothika SUBOTH 1

1 National Institute of Fashion Technology, Kannur, India;
2 National Institute of Fashion Technology, New Delhi, India

The fashion industry has long struggled to achieve the ideal fit for clothing because of the wide range of body types and customer preferences for fit. With the creation of a web application that allows for the objective assessment and quantification of the body-garment interaction using 3D scanned models, this research project presents a novel methodology.
The application leverages 3D scanned models to provide cross-sectional visualization and measurements at key areas. This application addresses the limitation of 3D scans being used to capture only the outer surface of the clothing, making it difficult to quantify the distance between the inner fabric surface and the body. This research project aims to address this issue of fit analysis through objective evaluation and quantification of the body-garment relationship using 3D scans.
The application's features include landmark-based distance computations, visual references, and ease value calculation reports, addressing the difficulty faced by fit technicians in comparing the body and the garment. This data-driven approach empowers fit technicians to make informed decisions, leading to improved garment fit, reduced returns, and enhanced customer satisfaction.
The research methodology employs an experimental design, focusing on the development of a web application with iterative refinement of its algorithms and functionalities through testing. The research findings and the development of this comprehensive 3D body-garment measurement web application contribute to the advancement of fit analysis in the apparel industry.

Mimoda Technologies: Empowering African Designers with Global Industry Opportunities Through 3D Innovation #62

Obinna ECHENDU

Mimoda Technologies Ltd., Lekki, Nigeria

The African fashion industry holds tremendous potential, but local designers face several challenges in scaling their operations and competing globally.
A significant bottleneck is the reliance on outdated and inaccurate manual body measurement techniques, which limit efficiency, scalability, and customization capabilities. Mimoda Technologies seeks to address this gap by introducing contactless 3D body measurement technology to the continent's designers.
This innovative technology allows for precise and inclusive measurements that cater to Africa’s diverse body types, while also providing solutions that enable designers to meet international standards. By automating the traditionally manual process of measurement, 3D technology empowers designers to focus on creativity, reduce garment returns, and enhance customer satisfaction.
The presentation will delve into the key challenges the industry faces, particularly the inefficiencies in production and the fragmented supply chains that hamper designers' ability to scale. It will also demonstrate how Mimoda Technologies' 3D system not only overcomes these challenges but also opens new global market opportunities by allowing designers to produce well-fitting, custom-made garments at scale.
With the global fashion market projected to grow to $5 trillion by 2030, and Africa standing at the crossroads of cultural creativity and technological advancement, Mimoda is uniquely positioned to lead this transformation. The presentation will emphasize the $31 billion opportunity for the African fashion industry and how Mimoda’s solutions can help designers tap into this potential, making the continent a key player in the global fashion arena.

CLOSING SESSION

Closing Speech from the Conference Director and Announcements for 3DBODY.TECH 2025

Nicola D'APUZZO
Hometrica Consulting, Ascona, Switzerland

The live program of 3DBODY.TECH 2024 is finished, however the online conference platform will stay open and will be fully functioning for 90 days, until January 2025. All the recorded sessions and all the single presentations and live demonstrations will be accessible within the online conference platform. The messaging and networking system will also still be functioning.
The 3DBODY.TECH 2024 proceedings are available in digital form. The proceedings have a ISBN and all full papers have DOIs. The proceedings have a simple HTML structure which give access to all abstracts and papers (if available) as PDF files, all the recordings of the single presentations and live demonstrations, and all the recordings with entire sessions, including discussion. The proceedings can be downloaded directly from the online conference platform. The proceedings are available for purchase from 22 Oct. 2024.
The 3DBODY.TECH proceedings website, https://proc.3dbody.tech, gives free access to over 600 publications from 2010 to 2024. Presentation videos of the single presentations and live demonstrations, from 2020, are also freely accessible with the website.
The recordings (single presentations, exhibitors' live demonstrations) of 3DBODY.TECH 2024 will be published on the website in Q3.2025. All the recordings (including entire sessions with discussion) are available already now in the proceedings of 3DBODY.TECH 2024.
3DBODY.TECH 2025, the 16th International Conference and Exhibition on 3D Body Scanning and Processing Technologies, will be held in Lugano Switzerland on 21-22 October 2025.
3DBODY.TECH 2025 will be held as an in-person event, with all the presentations held onsite, but with the possibility to attend online through an online conference platform.
Details and information will be available on 3DBODY.TECH website at https://3dbody.tech/.

Huimin HU	TS 11	32
Larysa IVANOVA	TS 8	36
Kadine JAMES	TS 5	72
Yibo JIAO	TS 10	47
Leon KAINZ	TS 7	30
Hakki KARAMAN	TS 1	18
Robert KOEPPE	TS 7	30
Dzmitry KOMAR	TS 11	48
Florian KRICKL	TS 3	50
Felix KUNZELMANN	TS 11,13	41,51
Yordan KYOSEV	TS 4,8,11,13	16,36,40,41,44,48,51
David R. LABBE	TS 7	22
Chris LANE	TS 4,5	11,12
Paul LORE	TS 7	64
Tuoc LUONG	TS 6	34
Ibrar MALIK	TS 1	67
Gustavo MARFIA	TS 11	71
Lara MAZZONI	TS 8	66
Carol MCDONALD	TS 10	03,17
Neila MEZGHANI	TS 7	22
Faycal M'HAMDI	TS 11	65
Harvey MITCHELL	TS 1	45
Eya MLIKA	TS 11	23
Tariq Aziz MOHAMED MIYAKHAN	TS 3	50
Sofiene MOKHTAR	TS 13	41
Anselm NAAKE	TS 11	48
Irene Saura NAVEDO	TS 11	48
P.U NAVODHYA	TS 2,8	25,35
Penelope NORMAN	TS 2	46
Dinesh K. PAI	TS 10	47
Chakravarthy PALANISAMY	TS 8,13	39,42
Vera PAMMINGER	TS 7	30
Eduardo PARRILLA	TS 9	13
Aruny PATHAMMAVONG	TS 7	22
Andres PRADA GONZALEZ	TS 9	59
Nikolay PEEV	TS 8	16
Ingrid PERAZA	TS 4	40
Miroslav RADMANOVIC	TS 5	61
Vuk RAJKOVIC	TS 5	61
Linghua RAN	TS 11	32
Clare RICHARDSON	TS 2	35
Artyom ROMANENKO	TS 5	70
Katerina ROSE	TS 11	51
Gerald RUDERMAN	TS 10	17
Nataliya SADRETDINOVA	TS 8	36
Joaquin SANCHIZ	TS 9	13
Marko SASIC	TS 5	61
Olivier SAURER	TS 1	05
Clemens SCHARTMUELLER	TS 7	30
Ann-Malin SCHMIDT	TS 4,11	40,51
Emma SCOTT	TS 10	17

Thomas SEBALD	TS 9	63
Miriam SENNE	TS 11	51
Chiarella SFORZA	TS 11	26
Chang SHU	TS 10	47
Raphael SIEGL	TS 7	30
Breck SIEGLINGER	TS 6	09
Jana SIEGMUND	TS 8	36
Miguel SILVA	TS 11	52
Riccardo SOLAZZO	TS 11	26
Weili SONG	TS 7	37
Thomas STOCKINGER	TS 7	30
Jyothika SUBOTH	TS 13	39
Manoj TIWARI	TS 8,13	39,42
Stephen SZE	TS 2	06
Jordi URIEL	TS 9	13
Alexander VAN GASTEL	TS 3	53
Dhiya S. VARGHESE	TS 8	42
Yana VERESHCHAG	TS 7	30
Stijn VERWULGEN	TS 3	53
Jochen VLEUGELS	TS 3	53
Panding WANG	TS 7	37
Renhao WANG	TS 2	35
Sumayah WAZIR	TS 13	07
Daniela WIRTHL	TS 7	30
Rick YU	TS 2	19
Xin ZHANG	TS 11	32
Chaoyi ZHAO	TS 11	32
He ZHAO	TS 11	32
Zeang ZHAO	TS 7	37

Published by
Hometrica Consulting - Dr. Nicola D'Apuzzo
Contrada Maggiore 2, CH-6612 Ascona, Switzerland
Tel: +41 91 7915524
Email: info@hometrica.ch
Web: https://hometrica.ch
3DBODY.TECH website: https://3dbody.tech