16th 3DBODY.TECH Conference & Expo
Lugano, Switzerland · 21-22 October 2025

Book of Abstracts

3DBODY.TECH 2025

16th International Conference and Expo on

3D/4D Body Scanning, Data and Processing Technologies

Lugano, Switzerland, 21-22 October 2025

https://3dbody.tech

Editor and Organizer

Hometrica Consulting - Dr. Nicola D'Apuzzo
Switzerland
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OPENING SESSION

3DBODY.TECH 2025 - Introduction - Welcome Speech from the Conference Director #00

Nicola D'APUZZO
Hometrica Consulting, Ascona, Switzerland

3DBODY.TECH 2025 - The 16th International Conference and Expo on 3D/4D Body Scanning, Body Data and Body Processing Technologies, took place on 21-22 October 2025, in Lugano, Switzerland.
3DBODY.TECH 2025 was held as a full in-person event with conference and expo taking place onsite in Lugano, with all speakers presenting onsite and with all contents streamed live online and recorded for later view. The large majority of attendees participated onsite, online participation was available for remote attendees.
3DBODY.TECH 2025 was organized by Hometrica Consulting - Dr. Nicola D'Apuzzo, Switzerland.
3DBODY.TECH Conference &: Expo, the premier multidisciplinary international conference and expo on 3D/4D human body scanning, body data and body processing technologies, provides a platform of eminent professionals, entrepreneurs, academicians and researchers across the globe to present, learn and discuss the latest in 3D/4D human body scanning, data 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 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 data use and processing, 3D & 4D body processing methods and technologies
- 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 (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 and AI 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 FX, games, entertainment, metaverse, virtual life
- 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 & Expos on 3D/4D Human Body Scanning, Body Data and Body Processing Technologies and their contents.
The abstracts, papers and presentation videos (when available) of about 1K publications/presentations 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/or live demonstrations are 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/4D Body Scanning Systems & Applications I

Presentation from Crisalix #36

Speaker/author n.a.
Hexag Crisalix SA, Lausanne, Switzerland

Abstract not available.

3D Body Scanning, Biomechanical Modeling and Artificial Intelligence:
The INBODY - Instant Body Scan Medical Device from BeyondShape #51

Stanislao GRAZIOSO

BeyondShape Srl, Naples, Italy

Abstract not available.

Towards Motion Correction in Robotized Medical Procedures
Using Real-Time 3D Body Measurement #10

Matej CAMPELJ, Matija JEZERSEK

Faculty of Mechanical Engineering, University of Ljubljana, Ljubljana, Slovenia

Robotized medical procedures rely on high spatial accuracy and repeatability, yet patient motion during treatment remains a critical challenge that can compromise safety and effectiveness. In particular, procedures such as laser skin rejuvenation require continuous adaptation of the robot trajectory to unintentional movements of the patient. To address this, we propose a real-time motion correction framework that combines dense optical flow with 3D point cloud data acquired by a time-of-flight camera.

The approach, termed Fusion Flow, transforms pixel-level motion fields into real-world displacements in all three spatial directions and integrates them into the global trajectory of the treatment area.

We evaluated seven optical flow algorithms (DeepFlow, DenseRLOF, DualTVL1, Farneback, PCAFlow, SimpleFlow, and SparseToDense) using a controlled experimental setup with sub-millimeter reference motion. Among them, the Farneback method achieved the best balance of speed and accuracy, operating at 140 FPS with an average trajectory error of only 8 mm over a 2250 mm path.

These results demonstrate that real-time fusion of optical flow and 3D depth data provides clinically relevant precision for motion correction, paving the way for safer and more effective robotized medical procedures.

Learning Neural Parametric 3D Breast Shape Models for
Metrical Surface Reconstruction from Monocular RGB Videos #54

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Vanessa BREBANT 3, Bernhard EGGER 1, Christoph PALM 2

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2 Regensburg Medical Image Computing (ReMIC), OTH Regensburg, Germany;
3 Department for Plastic, Hand and Reconstructive Surgery, Univ. Hospital Regensburg, Germany

We present a neural parametric 3D breast shape model and, based on this model, introduce a low-cost and accessible 3D surface reconstruction pipeline capable of recovering accurate breast geometry from a monocular RGB video. In contrast to widely used, commercially available yet prohibitively expensive 3D breast scanning solutions and existing low-cost alternatives, our method requires neither specialized hardware nor proprietary software and can be used with any device that is able to record RGB videos.

The key building blocks of our pipeline are a state-of-the-art, off-the-shelf Structure-from-motion pipeline, paired with a parametric breast model for robust and metrically correct surface reconstruction. Our model, similarly to the recently proposed implicit Regensburg Breast Shape Model (iRBSM), leverages implicit neural representations to model breast shapes. However, unlike the iRBSM, which employs a single global neural signed distance function (SDF), our approach -- inspired by recent state-of-the-art face models -- decomposes the implicit breast domain into multiple smaller regions, each represented by a local neural SDF anchored at anatomical landmark positions. When incorporated into our surface reconstruction pipeline, the proposed model, dubbed liRBSM (short for localized iRBSM), significantly outperforms the iRBSM in terms of reconstruction quality, yielding more detailed surface reconstruction than its global counterpart. Overall, we find that the introduced pipeline is able to recover high-quality 3D breast geometry within an error margin of less than 2 mm. Our method is fast (requires less than six minutes), fully transparent and open-source, and - together with the model - publicly available.

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

Custom Fit Model Avatars: 3D Body Scanning Workflows for Digital Fashion #23

Kyra GIBSON, Penelope NORMAN, Jonathan BURGESS, Sarah DICK
Arts University Bournemouth, Poole, UK

As the fashion industry increasingly integrates 3D garment design software such as CLO3D, highly accurate digital avatars that replicate in house fit models has become essential. Standardised avatars are widely available but often fail to accurately align with a brand's legacy sizing systems, which are typically based on specific fit models and bespoke measurements. British performance wear brand ThruDark's dedicated consumer base is accustomed to a consistent garment fit, therefore, transitioning to digital sampling with software stock avatars would risk significant inconsistency in sizing and customer experience. Maintaining continuity with the existing fit model is critical, prompting the need for an accurate, efficient avatar creation process that supports ongoing production without disruption. For brands to fully leverage digital workflows and reduce reliance on physical sampling, accurate brand specific avatars are crucial.
This research - conducted in partnership with ThruDark - explores the creation and implementation of bespoke digital avatars. A comparison study includes manual anthropometric and 3D body scanning technologies which are evaluated for the creation of bespoke fit model avatars. A new avatar creation process pilot study allows critical insights into functionality and scalability. Based on this research a commercially viable workflow for generating digital avatars from brand-specific fit model data has been implemented at ThruDark.

Landmarks for Dressing Avatars at Scale #31

Ye FAN 1,2 Seung Heon SHEEN 1, Clarissa MARTINS 1, Dinesh K. PAI 1,2
1 Vital Mechanics Research Inc., Canada;
2 University of British Columbia, Canada

Dressing avatars in realistic clothing is a key requirement in many settings, including digital fashion, feature films, video games, and the metaverse. Achieving a good initial placement is extremely important, both to capture the intended use of the garment and for physics-based simulation. For example, the waistline of a pair of jeans can be placed at different heights depending on the style and preference. Mainstream tools such as Clo3D and VStitcher provide interactive tools for artists to place a garment on an avatar to achieve the desired look and fit for a single avatar. This is a time-consuming process of manual tweaking, especially for complex, multilayered garments. Moreover, this process is not scalable for dressing multiple avatars, as the manual tweaking process must be repeated for each avatar.
A key reason is that the semantics of how a garment is intended to be worn are not captured explicitly by existing tools. We propose the use of {¥bf garment landmarks} to capture the intended semantics. Garment landmarks, like body landmarks, locate meaningful points, such as the top of the waistline. Garment landmarks only need to placed once, during the design, and paired with corresponding body landmarks. Body landmarks are widely used in anthropometry, and may be built into an avatar, or predicted using machine learning models. The garment's placement is then automatically adjusted to achieve placement intent by solving an optimization problem that minimizes the distance between the garment landmarks and the body landmarks, subject to other requirements described below. This simple yet powerful idea allows a garment to be easily placed on multiple avatars according to the desired intent, with minimal manual effort.
We will demonstrate how this new tool has been successfully implemented in our VitalFit virtual fit testing system, and can achieve complex placements of multilayered garments. It handles multiple garment layers, fixes existing mesh tangling, and scales naturally once a good garment placement is available on one avatar.

Adopting 3D Body Scanning in Customized Apparel Design: Cultural, Technical, and Perceptual Barriers of Fashion Designers, Pattern Maker and Final Users Technology #42

Daria CASCIANI 1, Alessandra CARELLA 2, Marta CASEROTTI 2, Enrico RUBALTELLI 2
1 Politecnico di Milano, Department of Design, Milan, Italy;
2 Universita degli studi di Padova, Department of Developmental and Social Psychology, Padova, Italy

This study investigates the technical, operational, and socio-cultural aspects of 3D body scanning, exploring consumer perceptions and fashion operators experiences in integrating scanning into digital fashion workflows. A mixed-method approach was adopted: approximately 23 participants completed

surveys before and after scanning sessions using the We Wear by Prisma Tech cabin, assessing emotional responses, trust, and usability. In parallel, 8 fashion operators among designers and pattern makers participated in semi-structured interviews to examine digital measurement extraction, avatar generation, digital-to-analog conversion, and parametric pattern-making. Consumers reported that the 3D body scanning experience was generally positive, describing it as fast, intuitive, and non-invasive, with increased confidence in its ease of use after the session, although some concerns remained about body image discomfort and the perceived loss of artisanal touch. Fashion operators valued body scanning for enhancing fit, reducing waste, and enabling visualization and pre-prototyping, yet noted challenges including measurement inconsistencies and misalignment with manual ones, mesh quality issues in converting digital avatars, limited software interoperability, emphasizing the need for leaner digital processes and clearer training. A revised workflow framework is proposed to bridge gaps between analog and digital practices across fashion design workflows.

TECHNICAL SESSION 3: Body Data, Digital Anthropometry & Sizing Surveys

Fit for the Future: Why Europe Needs New Body Data Now #46

Tim GUENZEL, Rainer TRIEB
Humanetics Digital Europe GmbH, Kaiserslautern, Germany

Abstract not available.

Anthropometric Scale Models #20

Boris BAUER, Thomas FISCHER, Alexander MIROSNICENKO, Sibylle SCHMIED
German Institutes of Textile and Fiber Research (DIFT), Denkendorf, Germany

In this study, we analyze scan data from women and men collected in sizing campaigns. Our goal is to find regularities between the sizes, proportions, and shapes of the human body, and we pursue the thesis that body size and weight systematically influence human physiology and biomechanics. In order to make the results usable for applications in occupational physiology, ergonomics, clothing industry, medicine, and sports physiology, we summarize the data in anthropometric scale models that describe the distribution of body measures for women and men of different lengths and weights. The results show that the volume and width-to-length ratio of various body segments systematically change with body length and weight, which must be considered when designing bandages and orthoses. In addition, we are conducting a numerical experiment to investigate the influence of body size on temperature regulation. This reveals that people of different sizes have different requirements in terms of ambient temperature, which must be considered in areas such as air conditioning or clothing design.

Analyzing Body Asymmetry Using 3D Scans and Machine Learning: Insights from Demographic Patterns and Dominant Hand Bias #30

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Accurate body measurements underpin anthropometry, ergonomics, and apparel design, yet practitioners often assume bilateral symmetry and measure only one side. The rationale for this convention is limited. Therefore, this exploratory study aimed at quantifying body asymmetries at various body locations for improving the accuracy of measurement protocols, garment patterns, and ultimately product fit. The researchers analyzed 22 paired measurements derived from three-dimensional body scans of 245 adults. Statistical tests included independent samples t-tests, Pearson correlations, and chi-square tests. The researchers further applied a Support Vector Machine model to examine relationships between asymmetry, demographics, and hand dominance. The results reveal where asymmetries are negligible versus practically meaningful, highlight relationships among body dimensions, and identify demographic and dominance factors associated with asymmetry. Based on these findings, the researchers propose actionable recommendations for refining anthropometric procedures and patternmaking standards, encouraging when bilateral measurements are warranted and when single-side measures suffice.

Anthropometric Measurement Extraction of Saudi Women Using 3D Body Scanning Technology within a Cultural Context: Implications for Apparel Design #56

Faizah ALMALKI
University of Albahah, Al-Baha, Saudi Arabia

When designing, sizing, and customising apparel, it is necessary to take accurate measurements of the human form. The current research sets out to examine Saudi women's anthropometric features by means of a three-dimensional (3D) body scanner, taking into consideration the relevant ethical and cultural concerns. A 3D body scanner was used to collect data for 250 women aged between 18 and 55 years, yielding volumetric, linear, and circumferential measurements. The findings indicate that there is considerable variation in in terms of limb, hip, waist, bust, and height dimensions, thereby suggesting that imported size charts should not be relied upon. Moreover, the most common body shape categories revealed by cluster analysis are markedly different to those in the Western world. The research suggests that it is feasible to undertake 3D body scanning in a culturally sensitive way and the resulting data can be used by Saudi apparel brands to improve the fit of their garments, offer customisable features, and make their offering more competitive.

TECHNICAL SESSION 4: 3D/4D Body Scanning & Imaging Systems

Real-World Applications of MOVE4D Technology #14

Carmelo LIZARRAGA GIMENEZ
IBV Instituto de Biomecanica de Valencia, Valencia, Spain

MOVE4D applications are virtually limitless. It enables precise motion and body data capture with real-world uses in product design, biomechanics, computer graphics, and computer vision – bridging technology and practice to enhance ergonomics, performance, safety, and immersive experiences.

From Still Shots to Live Volumes: Building Reliable 4D Capture Studios #01

Thomas DETJEN
Emergent Vision Technologies GmbH, Kernen im Remstal, Germany

Abstract not available.

Anatomic Scanning Using the Structure Sensor 3 and the Structure SDK #17

Paulo E. X. SILVEIRA, Anton TOKAR, Dmitry GLADYSHEV,
Jane MULLIGAN, Ravi SHAH
Structure, Boulder, CO, USA

We present the Structure Sensor 3, an RGB-D stereo vision sensor optimized for anatomic scanning, along with the Structure Software Development Kit (SDK), a sophisticated SDK capable of precise 3D reconstruction using a range of depth sensors. We discuss features that set the Structure Sensor 3 apart from other sensors, including its operation at a wavelength that enables the filtering of sunlight, its ease of integration and use with a wide range of iOS devices, its robustness, accuracy and multiple presets, including unique ones that benefit from improvements in the signal-to-noise-ratio (SNR), frame rate and latency made possible by pixel binning. We also discuss the sensor's unique ability to filter pixels in the depth map based on its confidence threshold.
Next, we discuss how the Structure SDK was expanded and improved to support the Structure Sensor 3 while maintaining backward compatibility with Structure's long legacy of 3D sensors while being capable of easily integrating future sensors. We then discuss the Structure SDK's ability to effectively support 3rd-party sensors, such as Apple's TrueDepth and LiDAR sensors. Finally, we discuss the Structure SDK's ability not only to be easily integrated into iOS apps but also future plans to expand its use to other operating systems.

Presentation from botspot #47

Speaker/author n.a.
botspot 3D Scan GmbH, Berlin, Germany

Abstract not available.

TECHNICAL SESSION 5: 3D/4D Wearable Technologies

6dof EMob: Occlusion-Free 3D Position and Orientation Measurement Under Clothing #33

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Pearson WYDER-HODGE 1, Ye FAN 1,2, Dinesh K. PAI 1,2

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2 Vital Mechanics Research Inc., Canada

Measuring 3D human bodies under clothing remains a challenging problem due to occlusion. Yet, this is an ultimate goal of many human body measurement systems. In a recent breakthrough, we introduced a novel system called EMob for measuring under clothing using electromagnetic (EM) tracking. EMob utilizes remarkably small (as small as 1.8mm diameter) electromagnetic sensors that can be attached to the skin or hidden layers of clothing. A sensor (EMu, ElectroMagnetic unit) can be tracked at high rates (up to 960 fps, though we use 240 fps in our experiments) using a Polhemus electromagnetic tracking system.

However, the previous work only utilized the positions of these sensors. The electromagnetic sensors are capable of measuring orientations as well, enabling full 6 degree-of-freedom (6dof) tracking. In this work, we extend the EMob system to leverage both position and orientation data. This 6dof tracking significantly complicates the calibration process, as the electromagnetic sensors are subject to spatially varying distortions caused by environmental factors, which can lead to inaccuracies in both position and orientation measurements. We address this challenge by implementing a neural network that learns spatially varying corrections on SE(3), the group of rigid body transformations, to improve the accuracy of the EM tracking system. With our novel data-driven calibration, the EMob system can be effectively used in challenging environments, such as inside a 3D body scanner.

The 6dof EMob system offers numerous practical applications. Anthropometric landmarks can be accurately located under clothing during 3D body scanning and consistently tracked across different body poses. We have also successfully demonstrated the system's effectiveness in a real-world application, measuring and quantifying the relative motion between skin and clothing during dynamic activities.

Dynamic Body-Garment Simulation to Characterise Wearable Activity Recognition Performance #40

Lars Ole HAEUSLER 1, Lena UHLENBERG 1,2, Oliver AMFT 1,2

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We propose an application of 4D modelling of human body and clothing to estimate the performance of wearable inertial sensors. While inertial sensors, e.g. accelerometers and gyroscopes, can be embedded into garments to capture activities of daily living (ADLs) of their wearer, clothes may move differently and have different orientations than the human body, potentially reducing human activity recognition (HAR) performance. In practice, it is challenging to estimate all error conditions that garments may introduce to wearable sensors, due to their varying body fit and sensor positioning. Thus, empirical evaluations provide limited insight into HAR performance in uncontrolled conditions.

Recent scientific advancements in 4D surface modelling may offer a novel simulation approach to estimate HAR performance for cloth-embedded wearable inertial sensors. Approaches so far have primarily used body surface models to simulate body-attached inertial sensors, and thus did not account for the additional movement dynamics of garments. For example, a smartphone captures different signal patterns for activities, including walking, sitting, or jumping, when placed in a loose-fitting trousers pocket rather than a tight-fitted belt pocket.

The goal of this work is to combine 4D garment and body surface models with inertial sensor models in a joint simulation approach that delivers HAR performance estimations ahead of any physical implementation of the wearable system. We employ textual ADL descriptions as specifications with a generative human motion model to obtain motion patterns. Subsequently, we use 3D Skinned Multi-Person Linear (SMPL) models parametrised for different body sizes to represent full volumetric body and garment motion. We place virtual inertial measurement units (vIMUs) at well-known positions of body and garment models to demonstrate how the effect of garments can be analysed. By simulating vIMUs in selected ADLs, we synthesise acceleration and angular velocity data, which is used to train a HAR model. To evaluate our approach, we generate synthetic inertial sensor data with and without garment simulations for various garment types and body sizes. We then examine the impact on HAR accuracy across specific ADLs in a public dataset, comparing performances between

body and garment sensor mounts, as well as the effects of garment type, size, and the performed activity.
Our results show that inertial sensor synthesis is clearly affected by clothing, in particular for loose-fitting garments. We detail HAR performance differences between garment and body-mounts depending on ADLs, body-garment fit, and vIMU positioning. Our approach may offer an alternative to train robust HAR models with synthetic sensor data and deal with clothing-related artefacts.

Integrating 3D Scans and CAD Tools for Custom-Fit Wearable Health Monitoring Systems #43

Pulkit MISHRA, Clara EMMERLING
Textilforschungsinstitut Thueringen-Vogtland e. V., Greiz, Germany

Emerging healthcare technologies are increasingly incorporating smart textiles to enable non-invasive, real-time health monitoring while reducing healthcare costs. A key innovation is the ECG-smart shirt—an intelligent garment embedded with sensors to track vital signs such as heart activity. For such wearables to function effectively, accurate sensor placement and user comfort are critical. This study presents a digital design workflow that combines 3D body scanning and 2D pattern generation to enable rapid prototyping of custom-fit smart garments adaptable to diverse body types.
The method utilizes Rhinoceros (Rhino) and its generative design plugin, Grasshopper, to automate the development of a sleeveless ECG-smart shirt. The workflow is divided into two concurrent tasks: importing high-resolution 3D body scan meshes containing anthropometric data and sensor landmarks, and constructing a garment pattern using traditional flat-pattern drafting methods. The body scan mesh is then aligned with a reference human model to identify garment contact zones with the skin, which are essential for precise sensor integration.
To transfer geometric data from a standardized reference mesh to individual body scans, the Grasshopper component MeshMap is used. It efficiently maps curve geometries between meshes with differing topologies by identifying corresponding points based on proximity, enabling the reuse of a single reference model across multiple body types.
These mapped zones are flattened into high-density UV maps (over 10,000 points), representing areas of tight garment-to-skin contact. Simultaneously, the constructed garment pattern is flattened into a 2D UV space with a 100x100 vertex grid. By comparing sensor landmark positions in both UV spaces, the method ensures accurate and low-distortion translation of sensor locations from the 3D mesh to the 2D textile layout.
In parallel, advances in CAD-based knitting technology are employed to fabricate garments that conform closely to the body, integrating complex 3D forms and embedded sensor pathways. This digital pipeline also supports user-specific modifications and virtual visualization, enhancing design precision and personalization.
By integrating 3D scanning, digital pattern generation, and generative design tools, this approach provides a fast, scalable, and precise method for producing wearable health-monitoring garments. It reduces prototyping time, improves fit and function, and enables the seamless translation of digital body models into ready-to-manufacture textile designs. The result is a flexible framework for the development of smart garments tailored for telemedicine, personalized health monitoring, and next-generation healthcare delivery.

TECHNICAL SESSION 6: Mobile 3D Body Scanning & Measurement

Scan-over-Clothes (SOC): Improved Body Measurement Accuracy when Scanning Loose-Clothed Subjects #04

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

At Size Stream we continuously strive to enhance the accuracy of our 3D body scanning technology while minimizing user friction. We have previously employed a model that detects loose clothing during scanning. In the cases of positive detection, we have prompted the user with a suggestion to change into tighter-fitting attire. We now introduce a method that effectively compensates for loose clothes for our avatar generation and measurement predictions. For scans of subjects wearing clothing that is marginally loose and only partially covering the body, this compensation results in an accuracy degradation of less than 10% compared to scans of those same subjects wearing ideal scanning attire. This improvement was achieved through two primary developments. First, we developed a

Body-Plus-Clothes (BPC) segmenter which, in addition to separating the subject from the background, distinguishes the clothing from the bare body. Aside from the added capability to segment clothing, this model also provides a substantial accuracy improvement in separating the subject from the background when compared to our previous segmenter (S2023). The BPC segmenter was trained using real images and supervised to manually-corrected output from an open-source segmentation model. Second, leveraging the BPC segmenter, we developed a Scan-Over-Clothes (SOC) Body Measurement Model (BMM) specifically designed to adjust for the presence of loose clothing during body reconstruction and measurement estimation. The SOC model was trained using a combination of BPC segmentation of real images and internally-generated synthetic data. This novel approach results in a solution that substantially enhances measurement accuracy for scans involving loose clothing, raising the possibility for reliable Ready-To-Wear (RTW) sizing with relaxed scan wear requirements.

Presentation from Esenca Sizing #49

Eduard COJOCEA

Esenca Sizing, Bucharest, Romania

Abstract not available.

Advances in Smartphone-Based Body Scanning: 3D Body Data in Minutes #07

Petri TANSKANEN

Astrivis Technologies AG, Zurich, Switzerland

Learn how software-only, smartphone-based 3D scanning streamlines workflows by delivering medical-grade 3D body data. Capture facial feature alignment, leg circumference measurements, and foot-to-last mapping - directly from standard iOS or Android devices

TECHNICAL SESSION 7: Medical 3D/4D Body Scanning Systems & Applications II

Virtual Environments in Surgery: Synthetic SLAM Validation in Knee Arthroplasty #24

Arne SCHIERBAUM 1, Tobias NEISS-THEUERKAUFF 2,
Thomas LUHMANN 1, Frank WALLHOFF 2, Till SIEBERTH 1

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Oldenburg, Germany China

Knee arthroplasty is a commonly performed surgical procedure in which computer-assisted and partially robot-guided systems are increasingly used to improve precision. Traditionally, these systems rely on optical markers that are fixed to the femur and tibia. However, these invasive markers require drilling, which can prolong the healing process and increase the risk of infection. This work aims to lay the foundation for markerless navigation, eliminating the need for such fixation.
To achieve this, the visible surface of the knee is captured using SLAM (Simultaneous Localization and Mapping) with a handheld trinocular camera system. Challenges include the low-texture surface, reflections caused by wet surfaces, and the movement of the knee during surgery. Evaluating the accuracy of the SLAM-based systems is difficult, due to too few suitable test datasets and the limited availability of real 3D medical data. In addition, realistic annotated images of bones are missing, which are necessary for AI-based masking the knee during SLAM.
This paper presents a simulation environment developed using Blender, in which surgical scenes are created based on anatomical 3D models. The system simulates camera motion and generates image data for knee reconstruction, which can be evaluated against known ground truth. The simulation not only supports the geometric optimization of the camera system but also provides direct access to the image position of the bone. As a result, it eliminates the need for separate bone segmentation, which in real scenarios is typically performed using deep learning methods that remain prone to error. These segmentation inaccuracies can significantly impact SLAM performance and make its evaluation more difficult. By generating precise masks alongside the synthetic images, the simulation avoids this source of uncertainty and enables a more accurate and isolated assessment of SLAM algorithms. At the same time, the simulation environment is used to automatically generate training data for segmentation and to improve masking.

Analysis of Geometry Changes of the Body Wearing Compression Products Using 4D Scanning #38

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3 WE-TEAM, Ghent University, Ghent, Belgium

Compression products are specially engineered textiles applied for different diseases and situations. Compression therapy is an important stage of rehabilitation after limb amputation for subsequent prosthetics. Analysis and the prediction of the realized compression level at different areas are important for the health process. The main feature of compression cover for amputee is to create gradient pressure with a decrease to the top of the limb to prevent swelling and to form a stump for prosthetics. The required pressure level is set for ankle level with a recommended decrease to 80-50% at the calf and to 50-20% at the thigh. The wide range of acceptable pressure values and its changes along the limb is a huge problem both for achieving a therapeutic effect and for creating appropriate high-quality compression products. The existing standard establishes 5 basic measurement levels that determine the size of the product. However, the features and diversity of limb shapes, as well as their changes throughout the day or during movement, are not taken into account. The high speed (4D) body scanning is an excellent tool for limb shape assessment and the developed software for measurement provides additional effects, for instance during motion. This work discusses preliminary results from experiments with compression materials.

Mobile 3D Scanning Facilitated Custom-Fit Hearing Aid Shell Manufacturing Process #34

Aliana YEE 1,2, Alicia YEE 1,2, Frank MENG 1, Todd RICKETTS 3

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2 Thomas Jefferson High School for Science and Technology, Alexandria, VA, USA;
3 Vanderbilt University Medical Center, Nashville, TN, USA

Hearing loss is the third most prevalent chronic health condition that seniors face. Globally, over 1.5 billion people are impacted by hearing loss, yet fewer than 20 percent of those who require intervention and treatment seek help for their condition because of the high cost and inaccessibility. Patients prefer custom-fit hearing aids because they provide better comfort and retention. However, the conventional custom-fit hearing aids manufacturing process is lengthy and expensive, involving processes such as making physical ear impressions, shipping physical impressions to manufacturers, 3D scanning the ear impressions, digital sculpting, and shell fabrication and electronic assembly. In this paper, we present a low cost and accessible mobile platform-based hearing aid shell optimization and rapid prototyping method. Our method involves real-time mobile 3D scanning, cloud-based hearing aid shell modeling, and local office 3D printing. Patients at home will be able to self-scan their ears and upload the 3D scan data through a cloud-based server program; then, their hearing aid shells will be generated and can be downloaded for 3D print. Through preliminary studies, we estimate that the processing time from hearing aid scanning to 3D shell modeling would be about 10 minutes. To evaluate the 3D printed hearing aid shells, we created a 10-point Likert scale to gauge ease of insertion, comfort, tightness, retention, and voice quality. We conducted a comparison study among our 3D printed shells, a receiver in the canal (RIC) hearing aid, and a non-custom foam earpiece. Results indicated that our shells achieved comparable or superior fitting and retention scores on the Likert scale.

Presentation from Qwadra #55

Benoit LEBRUN

Qwadra, Vancouver BC, Canada

Abstract not available.

Parametric Design of Custom Prosthetic Limbs Covers Using 3D Body Scanning and Algorithmic Modeling for Additive Manufacturing #28

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Prosthetic limbs personalization has been revolutionized by the development of digital fabrication and computational design; yet, aesthetic features of prosthetic limbs are still mostly neglected. Based on an analysis of anatomical scanning accuracy and algorithmic modeling techniques, this article presents a complete generative design workflow for custom limb prosthetic covers. Captured 3D high-resolution surface data is imported into Rhinoceros where Grasshopper scripts create adaptive shell geometries guided by curvature, ventilation, pattern density, and symbolic motifs. A user-friendly interface enables individuals to incorporate cultural and personal preferences from decorative patterns to functional perforations supporting an iterative and collaborative design process. The digital models are tuned for several additive manufacturing techniques and materials to guarantee compatibility across prototyping methods. To validate the workflow, a series of functional prototypes were fabricated and evaluated through user centered testing. Usability testing was conducted with one participant using a lower limb prosthetic, who engaged in the design customization process and provided feedback through structured interviews and a Likert scale survey. Results indicated increased user satisfaction, perceived identity alignment, and a greater willingness to wear the device in social settings. Qualitative feedback emphasized the emotional value of symbolic motifs and lightweight ventilation features. By merging technical precision with expressive customization, this framework establishes a new paradigm for human centered, aesthetically enriched prosthetic solutions.

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

Digitisation of Body Modification Garments to Ensure Silhouette Accuracy in Historical Costume #22

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Arts University Bournemouth, Dorset, UK

Body modification undergarments have been used to alter, accentuate and create desirable silhouettes throughout history. In costume, historical body modification garments are important symbols for portraying wealth, position and historical context.

Garments that modify the body present a challenge for digital historical pattern creation as digital avatars are commonly solid 3D objects which are unable to 'realistically respond to external forces' e.g. 3D constructed/simulated garments. This study investigates harnessing body scanning and digital processes to create silhouetted avatars to permit the digital production of historically accurate patterns that are accurate of an actor's biometric data.

The research takes an empirical approach to test multiple 3D scanning workflows and develops a specific process for body modification avatars. The processes are then applied and assessed through production of a digital 16th century historical costume garment.

The generation of 'silhouetted period avatars' using 3D body scans and historical body modification garments supports the digital creation of costumes with increased efficiency and historical accuracy

Posture Descriptors (PARCS), What We Know and the Gaps #37

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Experienced pattern makers understand the nuances of body shape in their "fingertips". However, articulating and transferring this internalized knowledge to others is challenging due to the lack of shared language. It is important to bridge the gap in vocabulary and conceptual nuances within the field to enable effective collaborations among practitioners and researchers from diverse disciplines. Previously presented work on the role of posture in clothing design and fit described it by the mnemonic of PARCS: placement, alignment, rotation, curvature and symmetry. This mnemonic

provides a language to describe intrinsic knowledge to understand body shapes and clothing design and makes it possible to talk about how garments are designed in a cross-disciplinary manner. However, there are still gaps in knowledge relating to posture. In this paper, we examined each word (i.e., placement, alignment, rotation, curvature and symmetry) within the PARCS mnemonic and reviewed the status of knowledge for these words. Placement and symmetry are relatively well understood. However, the understanding of words of alignment, rotation and curvature is limited. Therefore, this paper focused on examining alignment, rotation and curvature in the following areas where posture significantly affects clothing fit: hip alignment and rotation, shoulder rotation (forward or backward, side to side) and back curvature. These factors are important to determine the functional and aesthetic performance of clothing that ranges from everyday garments such as trousers and jackets to personal protective equipment (PPE). The paper concludes by providing recommendations to address the identified knowledge gaps and discussing their implications for pattern development. It also emphasized how bridging interdisciplinary communication gaps can lead to more effective collaboration and improved clothing fit.

The Subtle Shift: How Arm Position Affects Full-Body Posture in 3D Scanning #48

Marina GERY

PersonalFashion LLC, Los Angeles CA, USA

This presentation explores how even moderate changes in arm position, such as raising the arms to 30-60 degrees, can noticeably influence a person's posture during 3D body scanning. Using multiple scans of a single subject with varied arm positions, the presentation highlights how pose choices affect apparent body shape, symmetry, and the accuracy of the scan. While the study focuses on one individual, the observations align with broader patterns seen through years of hands-on scanning experience across a diverse range of body types.

Common scanning poses such as A-pose and T-pose are often selected for practical reasons, including software requirements or ease of processing. However, they can unintentionally introduce distortions, especially in the chest, shoulders, and spinal alignment. This session examines these effects, including shifts in measurements, posture changes, and the difficulty of maintaining a natural stance during the scan process.

Through visual comparisons, such as distance maps, x-ray overlays, and short video clips, this presentation illustrates how small pose adjustments can influence the overall body geometry captured in a scan.

These findings may be particularly relevant for custom garment production, and they also offer insight for developers of scanning hardware, software, and workflows.

Cross-Platform 3D Workflow for Developing Asymmetric Dress Forms for Wheelchair Users #13

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Central Michigan University, Mt. Pleasant, Michigan, USA

This study investigates the development of a custom dress form for wheelchair users employing various 3D body scanning and 3D modeling technologies. Four wheelchair users are recruited. Depending on the participants' conditions, two different methods were used to acquire 3D body data: 3D body scanning and designing custom avatars. Both methods provided accurate data of participants' bodies with some drawbacks in using 3D body data from custom avatars, such as limitations on creating asymmetrical body shapes and the drooping belly between thighs when an avatar is in the seated pose for participant who has big bellies. While working on different applications, scaling issues were found to be problematic as the data was opened in the incorrect scale. The implementation of this 3D workflow has demonstrated the possibility of a customized dress form for wheelchair users. The dress forms were tested by young designers as a tool to help understand body shapes and sizes that are different from "standard models" and to help facilitate the pattern development process as well as fitting. The feedback was positive. The young designers found the dress form beneficial and helped them be less intimidated in designing and constructing garments for real people who have different sizes and body shapes.

TECHNICAL SESSION 9: 3D Body Scanning in Medicine, Health & Sport

Improvements in 3D Body Shape and Measurement Accuracy from Size Stream #03

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Size Stream LLC, Cary NC, USA

Mobile 3D scanning offers a low-cost, user-friendly solution for capturing body measurements critical to health and fitness monitoring as well as the construction of custom made-to-measure apparel. Ongoing advancements to the Size Stream platform have significantly improved the accuracy of both 3D body shape and body composition estimates, particularly body fat percentage—an increasingly important metric in the context of semaglutide-based weight loss treatments. Since our last release, body fat mass (kg) estimates have achieved R2 values of over 0.96, demonstrating substantial gains in accuracy. Improvements in silhouette-based 3D shape reconstruction also enable more accurate representation across a wider range of body types, with notable gains for users with high BMI. The measurement of various circumferences, areas, and volumes of crucial body features has also improved, especially in terms of repeatability, so users can better track their progress. This paper details the latest enhancements to our mobile platform and their impact on the precision and reliability of biometric measurements for both apparel and health applications. Mobile scanning continues to prove its value as an accessible tool for tracking body metrics over time.

BodyLoop - Use of 3D Body Scanning in Sports, Medicine, and Longevity #52

Florian KRICKL
VITRONIC Machine Vision GmbH, Wiesbaden, Germany

Optical 3D body scans are used in sports, medicine and longevity as a standard tool for holistic diagnostics covering injury prevention, body tracking and rehabilitation. The scan results and their interpretation help to define individual therapies, training plans and further diagnostics. The advantages of optical scans are their comparative ease of use and precise anthropometric body assessment.

Optical scans are non-invasive and therefore an ideal technology for frequent routine measurements. In this way, anthropometric changes can be detected as early as possible and necessary therapy adjustments can be considered.

VITRONIC's innovative full-body scanning platform BodyLoop supports both longevity and performance diagnostics as well as medical applications where anthropometry is critical to human health. BodyLoop and its application in the therapeutic environment will be presented with relevant use cases, practical experience from the fields of prevention and rehabilitation as well as an outlook on everyday life in the future.

Personalized 360 Obesity Profiling: A Single-Case Study Integrating 4D Body Scanning, Functional Analysis, Infrared Thermography, Medical Imaging, and Biomarkers #15

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Traditional obesity assessment based on BMI and waist circumference cannot capture inter-individual variability in fat distribution, functional capacity, or metabolic risk. To address this gap, the Instituto de Biomecanica de Valencia (IBV) developed the Human Analysis Laboratory (HAL) as part of the FITME project. HAL integrates 3D/4D body scanning (MOVE4D), infrared thermography, and markerless motion analysis into a fully synchronized multisensor platform. HAL combines 16 structured-light sensor units, 16 synchronized RGB cameras, and 8 thermal cameras, all co-registered through hardware triggering and Precision Time Protocol. This configuration produces unified datasets that capture morphology, movement, and skin temperature with sub-millisecond accuracy. Additionally, the 3D Avatar Body App generates personalized digital avatars, enabling automatic extraction and visualization of hundreds of anthropometric indices. The strict temporal and spatial alignment across modalities allows the creation of new composite indicators that link body shape, functional performance, and thermographic biomarkers.

In practice, each acquisition generates time-synchronized streams composed of dense 3D point clouds (about 4 million points per frame), high-resolution RGB imagery, and calibrated thermal maps at 30 Hz. Temporal coherence is achieved through a master–slave synchronization architecture, where the MOVE4D scanner acts as the reference clock delivering hardware pulses and employing Precision Time Protocol (PTP) synchronization to align the RGB and long-wave infrared (LWIR) subsystems.

This guarantees frame-by-frame correspondence across modalities with an accuracy better than 1 ms. Spatial calibration relies on hybrid optical-thermal reference tools, allowing thermal pixels and RGB textures to be projected directly onto the 3D mesh.
The result is a fused avatar in which each vertex carries geometric coordinates, color values, and surface temperature information, providing a rich basis for computing multiparametric features such as thermal asymmetry indices aligned with anatomical landmarks, or kinematic descriptors linked to specific body regions during motion analysis.
The FITME methodology builds on HAL as its non-invasive core, while integrating functional assessments, DXA and low-dose CT imaging, and biomarkers (blood tests and microbiota profiling). This multivariable framework enables correlations between external body shape, visceral and subcutaneous adiposity, physiological function, and metabolic health, paving the way for predictive multiparametric models of obesity risk.
A central outcome of the project is the generation of an enormous and valuable heterogeneous dataset, combining multiparametric information. This dataset not only supports validation of non-invasive predictors but also provides a unique resource for the development of advanced AI-driven models and future clinical applications. Its richness and diversity will make it a reference resource for both the scientific community and healthcare innovation.
A brief case study illustrates the added value of this approach: a woman with class I obesity (BMI 32.9 kg/m2) exhibited high visceral adiposity, altered thermographic patterns, and reduced functional capacity - features not evident from BMI alone. This confirms the potential of HAL and the FITME methodology to provide personalized 360° obesity profiling, supporting risk stratification, tailored interventions, and longitudinal monitoring in both research and clinical settings.
Looking ahead, ongoing work within the FITME project involves validating HAL with larger participant cohorts, refining cross-modal AI models, and developing clinical decision-support tools. This will strengthen the predictive capacity of the system and facilitate its translation from research laboratories into hospitals, wellness programs, and preventive health applications, positioning HAL as a reference platform for next-generation body scanning in healthcare.

TECHNICAL SESSION 10: 3D/4D Body Processing, Body Modeling & Avatars

Why Does the Apparel Use Case Need a Different Approach to the Rig/Weight Systems? #12

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Current rig systems have been developed for use in games, film, and virtual environments. Based on 2D images. The utilization of these rig systems impacts fashion waste. Examined rig systems are focused on art and speed related to imaginary environments. These systems unfortunately do not help the design use cases for apparel. Current rig systems are useful for understanding poses for humanoids. However, overlooking natural posture, shape, mass, movement, and curvature of humanoid(s) cause mathematical fidelity to suffer, and impacts the quality of digital garment displays, and therefore the fit accuracy of the modeled coveroids (garments or footwear). This is essential for humanoids based on body data of an actual humans obtained by 3D body scanning or data input. Utilizing the PARCS descriptors for posture (placement, alignment, rotation, curvature and symmetry), to accurately describe the rig that is obtained for humanoids, allows for a better understanding of differences between the modeled rig and actual skeletal requirements. In the rig/weight system presented, rigs can be adjusted for gender and/or body mass differences, as this is essential for intimate apparel design.
After creating the rig for the humanoid, weighting for the vertices follows. Weighting is the technique of designing how much influence each joint has on each mesh vertex. This binds the mesh skin to the joints (rig) and allows for mesh morphing alignment with the joints during movement. If the weighting is restricted to limit the number of vertices to each joint, the subtilty of movement cannot be fully described. In the weighting system presented, weighting can be graded for body mass or body movement.
Multi Person models use an average to configure and calculate folding variables and form a skin (mesh). However, the modeling of the fabric for coveroids needs to interact properly with the humanoid and coveroid. It is critical to be able to attach rig systems from the humanoid to the coveroid for proper

movement of the coveroid, in addition to setting up the collision values that relate to the shape, mass, movement and curvature of the humanoid.
Apparel has a need for a new system that works as an apparel engineering tool versus a simulation tool for designers to reduce waste and deliver mathematically sound products. Appropriate programming for deep learning and AI is not possible without better data.

OSSO vs SKEL: A Comparative Study of Skeletal Inference from 4D Body Scans #29

Ingrid PERAZA, Yordan KYOSEV, Ann-Malin TAL
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4D scanning techniques make it possible to accurately capture the posture, movement, and external shape of the human body. The resulting meshes generated with 4D scanners are highly detailed, with over 49,000 vertices and 99,000 faces, making them well-suited for analyzing surface deformations and dynamic motion. However, they are limited to describing only the outer surface of the body, and do not provide any information about internal anatomic structures, such as bones. And although internal structures can be reconstructed with MRI or CT scans, these imaging devices are typically found in medical facilities and are significantly more expensive than 3D or 4D scanners.
As an alternative, automated systems that infer skeletal position based on the external shape of a body model provide an alternative way to add internal detail to 4D and 3D scan data. Currently, systems such as OSSO and the more recent SKEL, both open-source tools developed by the Max Planck Institute, can be used to infer skeletal structure from a 3D body mesh, after it has been converted to the standard topology of a parametric model like SMPL, helping to create more accurate human models for different applications such as finite element simulations. Previous work has evaluated the use of OSSO to infer skeletal structure from SMPL-converted 4D scan data. This study builds on those results by introducing and analyzing SKEL, which represents advancements in computational efficiency and biomechanical accuracy. The paper compares the skeletons generated by OSSO and SKEL to assess structural differences, fitting into the body models and inference quality.

Creation of Avatars in Sportive Poses through a Digital Human Model for Skin Shape Prediction #19

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Accurately predicting how skin shape deforms during sportive movements is essential for developing better-fitting ergonomic products, from high-performance apparel to athletic equipment. A digital human model (DHM) with an anatomically parametrized skeleton was developed to combine the potential of skin shape reconstruction and movement analysis. The DHM is used to predict the skin shape of a person when changing the posture through the linear blend skinning method combined with a data-driven approach to improve the accuracy. A personalized anatomically parametrized skeletal model is used to estimate the positions of joint centers and drive the skin deformations. The DHM parameters were determined using a database of 4D scans from adults (15 men and 15 women) performing sportive movements. Previous studies related with the DHM development are available.
At the current stage, the skin prediction quality is evaluated. To this end, the DHM was used to predict the posed skin shape from an initial shape in A-pose and the predictions were compared with scanned posed data. The posed skin predictions were performed for 4 women and 4 men with body mass indices (BMI) on the underweight, healthy weight, overweight, and obese categories. The predictions were performed in 6 varied sportive poses. The prediction quality was expressed as the average vertex-to-surface error for the body without head, hands and feet.
It was concluded that the DHM developed allows predicting the skin shape of people in the tested sportive postures starting from their A-pose shape. The evaluation was conducted on both men and women with a variety of body mass indexes (BMIs), from underweight to obese. This demonstrates the model's potential for broad applicability across different body shapes. The use of an anatomically parametrized skeletal model is a significant strength. This suggests the model's deformations are not just statistically inferred but are also constrained by a plausible underlying anatomy, which is crucial for biomechanical accuracy. In the following stages of the study it would be of interest to evaluate the skeletal model and its potential for movement analysis.

TECHNICAL SESSION 11: 3D/4D Face Scanning Systems & Applications

Presentation from Copresence #09

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Copresence, Heidelberg, Germany

Abstract not available.

Precise 4D Facial Imaging System Composed by Multiple Infrared Structured Light Sensors and Color Cameras #52

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This paper presents a high-precision, multi-view 4D facial imaging system based on structured light. The system comprises three structured-light devices operating at distinct infrared wavelengths. Imaging devices equipped with projectors operating at the 730 nm, 850 nm, and 950 nm bands are deployed at the left-front, front, and right-front positions relative to the face, respectively. Synchronous multi-view scanning is achieved by using distinct wavelength bands combined with an external trigger. In each device, the infrared camera work in conjunction with the projector to reconstruct a 3D point cloud, while the RGB camera at the same view synchronously acquires the corresponding texture. To meet real-time processing requirements, we use CUDA to optimize and accelerate core algorithms, including structured-light decoding, point-cloud meshing, point-cloud reprojection, and normal-map generation. Experiments show that the system maintains a reconstruction accuracy of 0.1 mm while achieving up to 29 Hz full-face 3D reconstruction and high-fidelity rendering exceeding 50 Hz. This provides high-precision, low-latency 3D sensing for real-time applications such as medical diagnosis and virtual reality.

3DGrowthNet: A Deep Learning Model for Synthetic Aging and Conditional Shape Generation Using 3D Facial Meshes #27

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7 Facial Sciences Research Group, Murdoch Children's Research Institute, Parkville, Australia;
8 Department of Plastic and Maxillofacial Surgery, Royal Children's Hospital, Melbourne, Australia;
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10 KU Leuven, Human Genetics Department, Leuven, Belgium

Accurately modeling facial growth is essential for applications in forensic science, clinical genetics, and developmental biology. We present 3DGrowthNet, a multi-task geometric deep learning framework that performs continuous synthetic aging, age and sex estimation, and conditional shape generation from 3D facial meshes. We introduce a multi-task training strategy that unifies existing synthetic aging frameworks with conditional shape generation and a continuous label embedding mechanism into a single CVAE-GAN architecture. This integration enables the network to disentangle age from identity while learning to generate anatomically plausible faces across the full age range of 0-88 years.
Trained on over 5,000 scans and validated using a smaller longitudinal dataset of 60 children, the model achieves a mean prediction error of ~2 mm, improving age-invariant identification performance by nearly 20%. It also generates realistic, demographically consistent synthetic faces with high coverage (98.7%) and low Minimum Matching Distance, supporting robust data augmentation. Biomedical relevance is demonstrated through simulations of sexual dimorphism across age, revealing expected developmental trends even in sparsely sampled age ranges. Experiments show that the model is capable of generating a wide variety of realistic and demographically consistent 3D faces and

supports robust data augmentation across the age spectrum. In addition to its generative capabilities, 3DGrowthNet performs age and sex estimation resulting in a median absolute age estimation error of 2.0 years and an overall sex classification accuracy of 87.7%, with performance varying across age groups. These results confirm that the model effectively encodes biologically relevant demographic information.
3DGrowthNet sets a new benchmark for realistic, demographically informed mesh synthesis and provides a foundation for advancing personalized growth modeling, forensic identification, and clinical assessment of facial dysmorphism

Experimental Investigation of the Fit of Face Masks During Speaking Using 3D and 4D Scanning #39

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Face masks were intensively investigated during the COVID-19 pandemic, but several engineering aspects of their design still remain open. In real world conditions, humans wear masks while speaking or even shouting, which is connected to a larger opening of the mouth. During the motion of the mouth, the position of the jaw changes and therefore the geometry of the lower face. Thus, variations in face shape while speaking should be considered in the evaluation of mask fit.
The objective of this investigation is to evaluate two different scanning methods in terms of analyzing two mask fit indicators, leakage and mask shifting, under dynamic conditions. First, the face of a test person is scanned without and with a mask in two static positions (mouth closed and mouth maximally open) using a 3D scanner. Then, the same test subject is scanned without and with a mask while continuously opening and closing their mouth using the high-speed (4D) MOVE4D scanning system.
The findings of the investigation can be used to decide which scanning method is best suited for which type of mask fit evaluation. Furthermore, more elaborate scanning procedures and analyses for mask fit evaluations using 3D and 4D scanning can be developed based on the presented approaches.

TECHNICAL SESSION 12: 4D Body Scanning, Volumetric Capture & G. Splatting

Presentation from AdventuryXR #57

Lennard WOLFF

AdventuryXR, London, UK

Abstract not available.

Development of an Automated Method for Removing Objects from 4D Scan Datasets #21

Lilly ROEMER, Ann-Malin SCHMIDT, Yordan KYOSEV

Chair of Development and Assembly of Textile Products, ITM, TU Dresden, Germany

The analysis of human movements based on 4D scan data is playing an increasingly important role in various fields of application, such as digital clothing development, ergonomics and motion research. 4D body scanners provide time-resolved point cloud sequences that can be used to capture movement sequences and body deformations in detail. In realistic recording situations, however, test subjects often use aids such as stools, steps or boxes to perform certain movements. These objects are included in the raw data and cause considerable problems in the subsequent generation of homologous meshes. Especially in close contact or movement, humans and objects can merge in the point cloud, leading to faulty mesh surfaces and significantly impairing the accuracy of simulations and visual representations. The aim of this work was to develop three automated methods for removing such static and dynamic auxiliary objects from 4D scan data sets. The methods developed are based on clustering algorithms (DBSCAN), color weighting and registration methods (ICP). Depending on the application scenario, they enable the reliable separation of the human body from surrounding objects. The methods were evaluated using three practical motion scenarios: running on a treadmill (static object without body contact), stepping onto a step (static object with contact) and lifting a box (dynamic object with contact). The results show that each method has specific strengths in terms of object type and scene complexity. Overall, the use of these methods significantly improved the network quality in all cases. The tools developed represent an important step towards the automation of 4D scan

processing and open up new possibilities for realistic simulations of human movements in practical scenarios.

Presentation from GeniusXR #58

Azad ABBASI
GeniusXR, Montreal QC, Canada

Abstract not available.

Cost-Efficient Volumetric Capture: From Neural Rendering to Gaussian Splatting Rig #45

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Volumetric content enables realistic, spatial storytelling across VR, AR, and cinematic applications. We present two complementary technologies that democratize high-quality 3D human capture using affordable hardware and novel software pipelines.
Our first approach replaces expensive volumetric studio rigs with a portable setup based on commodity cameras, software synchronization, neural rendering, and dynamic background modeling. Using neural implicit representations (e.g., NeRF and SDFs) and body pose priors, we achieve smooth geometry and fine textures without green screens or hard camera sync. We refine textures via differentiable rendering and correct camera pose drift through mid-sequence calibration, enabling clean reconstructions even in uncontrolled environments.
Building on this vision of accessibility, our second approach introduces a highly mobile Gaussian Splatting Rig. The rig features 8 GoPro cameras mounted on a rotating handheld structure that can be moved freely around the subject. This configuration enables high-fidelity, full-body scans by capturing dense multi-view video data from all angles. The footage is processed using state-of-the-art 3D Gaussian Splatting algorithms to create photorealistic volumetric representations. These splat-based models exhibit exceptional surface detail, lighting consistency, and view-dependent effects.
To increase downstream utility, we convert the resulting point-based splats into watertight meshes with minimal quality loss. This enables compatibility with standard animation pipelines. We further apply off-the-shelf retargeting methods to map motion to the avatar mesh, making it suitable for game engines or real-time avatars in XR applications.
Together, these two methods offer a practical continuum: a garage-built studio setup with neural pipelines for multi-person scenes, and a compact scanning rig for single-person high-fidelity avatars. Both approaches significantly reduce production costs while maintaining or exceeding visual quality compared to traditional systems. We believe these tools will empower creators, researchers, and developers to bring volumetric capture to new contexts and audiences.

PANEL DISCUSSION

3D/4D Scanning and/or AI 3D Content Generation?

Moderator: Nicola D'APUZZO, Hometrica Consulting, Switzerland

Panelists: not available.

The quality of AI-generated 3D content has recently seen drastic improvements, enabling the creation of high-quality 3D avatars and realistic animations from just single images or text prompts.
This raises a critical question: Is investing in costly 3D/4D scanning equipment, complex 3D modeling software and sophisticated 3D data processing solutions still justified?
At the upcoming panel at 3DBODY.TECH 2025, experts will discuss the future of traditional methods such as 3D/4D body scanning, 3D body modeling, and 3D body data processing. We will explore how these classical approaches can withstand and/or can embrace AI advancements.

TECHNICAL SESSION 13: 3D Foot Scanning Systems & Applications

Foot Landmark Detection with Structure #18

Jane MULLIGAN, Kazi MIFTAHUL HOQUE, Anton TOKAR,
Dmitry GLADYSHEV, Paulo E. X. SILVEIRA
Structure, Boulder, CO, USA

Characterization and measurement of foot shape is an important tool in the design and customization of shoes and orthotics. Advances in 3D scanning technology provide the opportunity to automate and improve the accuracy and objectivity of these assessments, as well as support a streamlined manufacturing process by moving easily from 3D model to 3D printer. The Structure SDK provides robust and accurate 3D mesh reconstruction using iPhone TrueDepth, LiDAR, or Structure Sensor devices. In addition, Structure apps provide markerless foot anthropometrics analysis to identify landmarks and metrics on the mesh, including length, width, girth, anterior transverse, lateral and medial arch lengths, and arch height of the foot. To evaluate the accuracy and reliability of our automated foot shape analysis, we first established ground truth measurements for a realistic model foot, then acquired repeated Structure 3DFootScan app scans and metrics for the model. The process was repeated for each of 6 Apple TrueDepth devices (iPhones and iPads) and all three generations of the Structure Sensor. The resulting measurements were analyzed with respect to the reference data to quantify the performance of the system.

Digitizing Military Footwear Provisioning through Foot Measurement and Shoe Matching #41

Andres PRADA GONZALEZ
Footprint Technologies GmbH, Berlin, Germany

While many armed forces are advancing toward digital transformation, several core logistical processes remain largely manual and error-prone. One such process is the provisioning of properly fitting footwear for soldiers - across a range of models including different combat boots, leather shoes, sneakers, flip-flops, and even ski boots. Today, sizing decisions often rely on limited trained personnel and are made under stress and rush, leading to discomfort, inefficiency, and returns for the soldiers.
In this work, we present a cost-efficient digitized solution for optimizing shoe size recommendations. Our system enables any operator - without prior training - to measure a soldier's feet using a mobile web application on any smartphone and receive accurate size suggestions for multiple shoe models at once. We collaborated with footwear manufacturers to collect precise inner shoe dimensions and tuned key recommendation parameters, including toe allowance, foot width-to-length ratios, and toe splay, among others.
The tool was tested in a production environment with over 300 soldiers at a military site, following an initial calibration phase involving measurements from 120 individuals. We evaluated size recommendations for more than 10 shoe types, across male and female soldiers. The system achieved over 90% accuracy in fit feedback, significantly reducing the need for size changes. Notably, certain models showed better compatibility with specific foot types, where sex-based morphological differences were evident, while others offered more universal fits.
This approach led to more than 50% reduction in sizing process time, while introducing full traceability and consistency across evaluations. Every sizing session is stored, allowing feedback integration and future learning. Upcoming deployments for different military clients will scale the system to over 60 equipment sites, reaching more than 20,000 soldiers annually.

The Role of 3D Technologies in Improving Design and Technological Processes of Orthopedic Footwear Production #44

Liliia CHERTENKO, Tymofii LYPSKYI, Olexander UDOVENKO, Dariia KAPTIUROVA
Kyiv National University of Technologies and Design, Kiev, Ukraine

Digital technologies today play an important role in all areas of design and production of industrial goods. However, in the footwear industry, the implementation of 3D technologies still causes numerous difficulties associated with the multi-component structure of the design object and the complexity of the production technology.
However, it is the complexity of the shoe shape that is the reason for the widespread use of digital technologies, as this will help reduce the complexity of the industry's design processes and bring them under a scientifically grounded approach. In addition, digitalization of production is a way to reduce dependence on complex manual operations, which is necessity in conditions of a shortage of

professionals with required qualifications. The active implementation of 3D technologies in the production of orthopedic footwear is especially important.
Orthopedic footwear is one of the most important products related to additional rehabilitation aids, and is manufactured individually for each patient, taking into account his medical diagnosis, anthropometric parameters, recommendations of a rehabilitation doctor and personal requirements of the consumer. Today, inclusive products must meet high standards, as they play an extremely important role in improving the standard of living and normal activity of people with disabilities.
The process of manufacturing orthopedic shoes is one of the areas of shoe production, the target object of which is a medical device for the patient's rehabilitation. Although the process of manufacturing such shoes is close to the typical technological process of shoe production, orthopedic shoes are distinguished by the special shape of the personalized shoe last, as well as the presence of special orthoses, orthopedic insoles and other elements that perform a corrective, therapeutic or fixing function. It is the development of the shoe last and orthopedic inserts that represents the greatest complexity and should be digitalized in order to improve the properties of the final product.
The development and production of personalized orthopedic lasts in digital design and technology laboratories equipped with a 3D scanner, 3D printer and special software for 3D modeling can help solve the problem of producing the right orthopedic footwear on an individual order even in the absence of highly qualified specialists in the development of orthopedic shoe last at local production.
The process of developing and manufacturing the elements of the form of orthopedic footwear involves such main stages as 3D scanning, 3D modeling and 3D printing.
The 3D foot scanning method allows us to obtain and collect initial information about patients' feet without the need to use huge areas for storing plaster models. Also, the digital information obtained is of great value for analyzing the processes of progress or regression in the clinical condition of consumers' feet.
European orthopedic footwear production is very actively involving 3D printing technologies for manufacturing shoe last, orthopedic inserts, orthoses, test shoes, as this is an environmentally friendly way to manufacture elements of any complexity and purpose, which is a logical continuation of the sequence of 3D scanning and 3D product development processes.
3D modeling is the main design process, the result of which is a digital orthopedic shoe last and elements of the required shape, ready for 3D printing. To design a footwear last shape, a reverse engineering method is used, when a new product is modeled by modifying the basic shape. And this is where we encounter a large number of difficulties in the case of orthopedic footwear:
- The choice of software that provides the selected method and high design accuracy, has a wide functionality for implementing multi-stage modification of the shape of the shoe last and other elements of footwear,
- The need to develop and manufacture the shoe last and other elements of a rational form for medical purposes, taking into account the medical diagnosis, the results of 3D scanning and baropodometric research, as well as technological requirements for production,
- The complexity of the aimed form elements, the need to use complex mathematical apparatus to describe the shape of the shoe last for further manipulations and the transition from 3D form to 2D patterns with sufficient accuracy of the results.
Work on the study of various design algorithms and methods for modeling the complex spatial shape of a shoe last has been carried out by many scientists for the past twenty years. And despite this, the development of a personalized orthopedic shape of shoe last based on the shape and dimensions of the customer's foot is still a big problem. One of the main problems is the complexity of converting anthropometric parameters of the foot shape into a 3D model of the insole.
The following most relevant approaches to modeling a personalized shape of an orthopedic shoe last can be identified:
- Parametric modeling, when the shape elements are created based on algorithmic processes, and the target shape is achieved by changing the parameters of the elements of the basic shape. This method is implemented in special programs that support parametric modeling, or with the involvement of special plugins for the development of appropriate algorithms
- Visual SubD modeling, when the basic shape of the shoe last is modified by editing the SubD surface frame in accordance with the shape of the 3D copy of the patient's foot
- NURBS modeling. A traditional method of modeling complex 3D shapes, based on manipulations with spatial surfaces using shape-forming curves and nodal points, which ensures high design accuracy.
Considering the advantages and disadvantages of the methods, the work used a combined approach that includes elements of parametric and SubD modeling to develop an improved method for designing a personalized orthopedic shoe last in the Rhinoceros CAD. The use of SubD greatly facilitates the

process of 3D shape modification, but has insufficient design accuracy, to compensate for which a step-by-step verification of the main shape parameters and control curves is performed.

CLOSING SESSION

Closing Speech from the Conference Director and Announcements for 3DBODY.TECH 2026

Nicola D'APUZZO

Hometrica Consulting, Ascona, Switzerland

3DBODY.TECH 2025 - The 16th International Conference and Expo on 3D/4D Body Scanning, Data and Processing Technologies was successfully closed in Lugano on the evening of 22nd October 2025.

The program of the conference was structured, during two full days, in 1 opening session, 13 technical sessions in dual track, 1 plenary panel discussion and live demonstrations sessions, accommodating in total over 70 technical and scientific presentations, grouped according to various topics and application areas.

The conference confirmed also this year to be the most important international event focused on 3D & 4D body scanning, body data and body processing technologies.

The proceedings of the conference are available for purchase in digital form. The proceedings, organized as a website, provide details of the technical sessions, and give access to all abstracts, to all published papers (as single PDF documents), to all recorded presentation videos and to all recorded sessions (opening session, technical sessions, exhibitors' live demonstrations).

3DBODY.TECH 2026 - The 17th International Conference and Expo on 3D/4D Body Technologies, will take place on 20-21 October 2026, in Lugano, Switzerland.

3DBODY.TECH 2026 will be held as a full in-person event with conference & expo taking place onsite in Lugano, with all speakers (100%) and the large majority of attendees onsite (85%). Online participation will be available for remote attendees (15%). All contents of the conference will be live streamed and recorded for later view.

Our goals/expectations for 2026 are:

200+ onsite & 50+ online participants

80+ presentations

20+ exhibitors

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