Book of Abstracts

5th International Conference on

3D Body Scanning Technologies

Lugano, Switzerland, 21-22 October 2014

Editor and Organizer

Hometrica Consulting - Dr. Nicola D'Apuzzo
Switzerland
www.hometrica.ch

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INTRODUCTION

Conference director's message #00

Nicola D'Apuzzo
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The 5th International Conference and Exhibition on 3D Body Scanning Technologies will take place from 21 to 22 October 2014, in Lugano, Switzerland.
The first four international conferences of 2010, 2011, 2012 and 2013 were all largely attended with over 200 participants from different countries, different technical fields and different industries.
The rich technical programs of the four events included a wide variety of works related to applications, developments and research on 3D body scanning from all over the world.
The conferences were accompanied by parallel exhibitions featuring live demonstrations of 3D body scanning equipment and solutions. Various manufacturers had chosen our events for presenting and announcing world premieres.
The past four events were also the occasions where births of new collaborations took place, as for example 3dmD (USA) and Max Plank Institute (Germany), TC2 (USA) and SpaceVision (Japan), UCS (Slovenia) and ElinVision (Estonia).
With the success of the 4th event of 2013, the conference confirmed again to be the most important international event for the sector of 3D body scanning technology. With this fifth event of 2014, we will continue the role as the world leading technical platform dedicated to these specific fields.
This book of abstract is divided in sections according to the conference's technical program and it includes the abstracts of the papers published in the proceedings of the conference. The corresponding papers can be easily found in the proceedings by the paper id number indicated in the table of contents and by each abstract's title.

TECHNICAL SESSION 1: MEDICAL APPLICATIONS

FaceSCAN3D – Photorealistic 3D Images for Medical Applications #52

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We present a technology for the creation of 3d-surface data of human faces. The radiation free technique enables the data acquisition in approx. 400 msec. The robust measurement principle uses the projection of sinusoidal fringe patterns to create three point clouds. The patented mirror setup allows to scan the patient easily from ear to ear. The data processing starts with the fully-automatic and accurate alignment of the three point clouds. Sophisticated pre- and post-processing algorithms enable then the creation of a curvature dependent thinned triangular mesh. Finally, a high-resolution 2d image is mapped to the mesh with sub-pixel accuracy to create a photo-realistic representation of the patient's face.
Especially in a clinical environment the acceptance of new equipment depends strongly on the convenience of the handling of the device. The *FaceSCAN^{3D}*'s simple user interface makes this as easy as using a digital camera. Operating the scanner can be learned in less than 20 minutes. The data can be exported in a variety of formats suitable for importing into analysis software. The applications range from radiation-free cephalometrics to overlay with CBCT data. The *FaceSCAN^{3D}* data is an additional channel for the surgeon not only to do state-of-the art patient education but also gives him the possibility to plan his operations based on what we call a virtual patient model. An accurate before-after comparison enables quality control of the outcome of the surgery.
In this paper the basics of our measurement principle are explained. After a short course about 3d data processing we focus on two interesting applications.

Visualization and Quantification of Female Breast Morphology During Breast Reconstruction #54

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Breast reconstruction is an integral part of the breast cancer treatment process and has shown to positively impact the patient's psychosocial adjustment and quality of life. Three-dimensional (3D) visualization and quantification of the breast for different types of reconstruction procedures can allow for a better understanding of the changes in breast shape during the reconstruction process. It is important to realize that the reconstruction process can take as long as 18 - 24 months and the breasts typically change shape over the recuperation period following completion of any given surgical procedure. In this study we present a novel approach for monitoring and quantifying changes in breast shape using 3D surface images of the torso

in conjunction with curvature measurements. The results of this study can help provide information to surgeons and patients about the dynamic changes in breast morphology occurring during the various stages of the reconstruction process. In our approach, we compare the curvature values of different regions of the breasts at longitudinal time-points of approximately 3-month intervals over the course of the reconstruction process. Results are shown for six patients. Three patients underwent the Transverse Rectus Abdominis Myocutaneous (TRAM) flap procedure for breast reconstruction, and the remaining three patients underwent implant-based reconstructions. Through our approach, we saw significant changes occurring along the lower pole of the breasts during the reconstruction process, which showed the importance of performing temporal evaluation in order to detect these changes.

Multi-View 3D Data Fusion for Visualization of the Inframammary Fold in Women with Ptotic Breasts #60

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Three-dimensional (3D) imaging is finding increasing use in plastic surgery, both for breast reconstruction after oncologic surgery and for cosmetic augmentation/reduction procedures. The upright view image is conventionally used for surgical planning and outcome assessment. However, the inframammary fold (IMF), a critical landmark for breast surgery and morphometry, is typically occluded from the upright view in women with ptotic breasts. In this study we used a custom designed tilt imaging system (3dMD Inc., Atlanta, Georgia) that enables the capture of 3D images in both the upright and supine position. Our results demonstrate that for 3D images of ptotic breasts, wherein only the lowest contour of the breast touching the abdomen is visible, we can employ multi-view 3D image data fusion to superimpose the position of the anatomical IMF from the supine position onto the image in the upright position. This approach thus enables the physician to visualize the position of the IMF in the upright images of women with high degrees () of breast ptosis.

The Latest Applications of 4D in Medical Projects #38

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In 2011 4dMD and UNC Chapel Hill School of Dentistry was awarded a ground breaking US NIH Grant (STTR Grant No. 2R42DE019742-02) to study the facial dynamics of children who had received corrective treatment for facial conditions. The recruitment of over 100 treatment and 100 normative cases makes this the largest funded clinical study based on dense surface 4D capture. The talk will discuss the new generation 3dMDdynamic equipment developed to support the grant, the challenges and successes assimilating and interpreting the data and finally summarise the many commercial projects now underway to support other medical disciplines.

Establishment of Reference Frame for Sequential Facial Biometrics #23

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Facial biometrics as an objective, accurate, living parts measurement methodology, is widely used in assisting diagnose and treatment plan within the practice of medicine and dentistry. It is particularly popular that the quantification of changes before and after a clinical intervention. However the measurement accuracy of volumetric changes over consecutive 3-D images has remained as a challenge to date. This paper reports one approach that uses the facial features within the facial images as the reference frame for consecutive comparisons, a template of region of interest as a fixed window for volume measurement and a disposable gage for facial posture control, to achieve precise volumetric measurements over consecutive facial scans. The errors of proposed the approach was evaluated and the reproducibility when using such an approach was found less than 1% with a real case.

TECHNICAL SESSION 2: BODY SCANNING FOR APPAREL I

The Use of 3D Anthropometric Data for Morphotype Analysis to Improve Fit and Grading Techniques – The results #17

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Today, apparel companies are able to offer well-fitting clothing to only 30 to 40% of their clients. This is due to body measurement tables which have not been updated in the last 25 years.
With the financial support of the Agency for Innovation through Science and Technology (IWT), over the last two years University College Ghent carried out a measurement campaign. The measurements and body shapes of the Belgian population were mapped using high-tech 3D body scanners . The results of this campaign led to defining new body measurement tables for women in four age categories and body measurement tables for men in three age categories.
Today, the construction of basic patterns and grading to other sizes is based solely on 1D body dimensions. The grading is proportional or rational, but never taking into account the body proportions. The last decade, several European countries have executed a 3D scanning campaign to depict their population, but these 3D data are often not accessible to the garment manufacturers. The industry does not have the necessary knowledge and skills to work with 3D measurements. In order to reduce the number of prototypes, time-to-market and thus money, many companies are developing software for checking fit, fabric drape and proportions on virtual mannequins in a virtual fitting room. Together with the new body measurement tables, University College Ghent defined for each size in each body measurement table a body model (avatar) which can be used as a virtual mannequin for fitting.
The importance of a proper fit and adequate sizing of clothing are the central themes in this paper.

The True Height of the Waist: Explorations of Automated Body Scanner Waist Definitions of the TC2 Scanner #18

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The waist is considered as an important measurement point for clothing and represents part of a control section from which lower body garments hang and garments are often required to fit. However, unlike many measurement sites on the body the waist has no single landmark from which to reference it for a population. The non-contact nature of body scanning further complicates this, though automated measurement systems connected to body scanning have developed methods to determine the waist relative to surface geometry. Whilst body scanning provides an opportunity to analyse large volumes of data, there is limited knowledge of how differences in waist definitions using automated systems of measurement compare to waist placement with reference to accepted upper and lower limits. This work employed content analysis methods to understand existing clothing waist definitions and developed different waist definitions within automated measurement software of a TC2 scanner. Measurement extraction using this explorative set of definitions was undertaken on a sample of 106 females whose upper and lower waist limits had been determined through measurement. The data was then analysed to establish how the definitions compared to the waist height determined as the midpoint between the upper (lowest palpable rib) and lower (highest point of the right iliac crest) limits. It was possible to establish that proportional relationships between lengths that could help in defining waist placement and provide checks in automated extraction. As a result of this study a number of suitable waist definitions are proposed for use in the automated measurement software of body scanning technology.

Applicability of 3D Garment Prototyping in Assessment of Garment Fit #32

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The aim of the study is assessment of CAD software implementing a virtual simulation of the garment, its prototyping and fit. The study is an attempt to compare the numerical model of dress: "stitched virtually" on a digital avatar issued from the body scanner and its “scanned” real form made for the same user in order to prove a proper design and garment fit to the given user morphology.

Applications for 3D Virtual Sampling and Body-Scanning in Fashion Schools and Universities, Apparel Retailers, Brands and Manufacturers #02

Thierry Moncoutie
LECTRA, Paris, France

For many years, Lectra, world leader in integrated technology solutions dedicated to industries using soft materials, has supported education by offering its technologies and expertise. Our partners are fashion and design schools/universities, engineering schools (particularly those related to textiles and information technology) and professional associations.
As a responsible industry leader, Lectra contributes to the development of programs preparing students for their long term careers. To date, 850 schools and universities worldwide have integrated Lectra solutions into their curricula. Modaris, the most widely-used pattern-making, grading, and 3D-prototyping solution in the world, is used for both pattern-design teaching and research programs.
At the crossroads of design and production, Modaris simulates realistic virtual samples by bringing together flat patterns, fabrics, colors, trims, logos, and virtual 3D mannequins. The solution enables better fit thanks to a combination of intelligent pattern development tools and virtual sampling. Modaris supports collaboration across internal company departments and with suppliers in the apparel industry contributing to a more efficient supply chain from concept to production.
Some of our educational partners have also combined Modaris with 3D body-scanning technology in their courses and research. This will be presented as part of our commitment to sharing experience and expertise concerning industry business matters, market analyses, organization/process management, new technologies/trends and more. These education and research case studies will be mirrored by Modaris and 3D body-scanning case studies from fashion brands, retailers and apparel manufacturers.

A Flexible Multi-Platform 3D Virtual Product Configurator #74

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At its core, the Taylormatic platform is a 3-dimensional virtual product configurator. It allows users to select customizable products from a virtual catalogue, which they can subsequently configure and customize to their liking. Configuration options include the selection of product components, their materials, as well as their colours. Taylormatic is not limited to specific product types.
Taylormatic can provide a very realistic 3-dimensional visualization of the configured product, with a realistic simulation of visual material properties. The end-result is a virtual product which can be viewed from all angles, up close in full detail, and which at the same time closely resembles the physical product. Users can therefore be confident that the product they configured will be what they end up purchasing.

TECHNICAL SESSION 3: ERGONOMICS & PRODUCT DESIGN

Latest Trends in Sport Equipment Realization - Case History Presentation #58

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This article aims at discuss the use of 3D technologies in the manufacturing industry.
In particular, it explores how such technologies can benefit to traditional measurement, as well as to the surface modelling of products. The article provides an overview about 3D scanning technologies and reverse engineering software, focusing the attention towards the manner in which complicated and detailed elements can be digitally recorded in a rapid way, to provide a permanent acquisition of dimensions and forms. Furthermore, it will show how the data set produced through the use of a 3D scanner can be elaborated to create a 3D surface mesh.
In particular, this work will describe a real application case about how the use of 3D scanner integrated with computer aided design (CAD) skills can support manufacturers in building customized equipment for the sporting environment: carbon fiber shin guard for football players.
The article concludes that 3D scanners in the manufacturing industry facilitate the collection of highly accurate information in a very short time and allow to develop perfectly fitting, custom and highly performing equipment for sport.

Ergonomic Design and Evaluation of a Pilot Oxygen Mask for Korea Air Force Pilots #16

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The present study developed a virtual fit analysis (VFA) method to design an oxygen mask which fits Korean Air Force (KAF) pilots. The VFA method used 3D face scan data of 336 KAF pilots to find the most proper shape of an oxygen mask for KAF pilots. The oxygen mask design revised in the study showed a 27% design improvement effect on average in terms of fit evaluated by the VFA method. Additionally, this study evaluated the revised oxygen mask prototypes with 88 KAF pilots to experimentally verify the design improvement effect in terms of discomfort, pressure, and suitability for military equipment (slippage and stability in flight-like situations). The discomfort of the revised mask was 33 ~ 56% lower on average than the existing oxygen mask. In terms of the pressure, the revised mask showed 11 ~ 33% of improvement on average compared to the existing mask. Furthermore, on high gravity situation, the slippage distance of the revised mask was 24% shorter on average than the existing mask. The proposed VFA method can be applied to the design and evaluation of wearable products that require an ergonomically better fit for a target population.

Development of a Foot Sizing System for Malaysian Women #11

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In this study we used the INFOOT USB 3D scanning system (I- Ware Laboratory Co., Ltd, Japan) to collect foot size data measurement. Based on this study, we used five measurement definitions based on their anatomical landmarks: foot length, ball girth, instep length, foot breadth, and fibulare instep length. The reliability and accuracy of the observers were evaluated using intra- and inter- observer errors measurement. Accuracy of the measurement is based on Technical Error Measurement (TEM). A TEM value of less than 2 mm for the determined landmarks is considered accurate and consistent. Result from the experiment showed that the reliability is between 93.3% and 98.3%, respectively thus, foot-landmarking was consistent and reliable. We hope to develop a new shoe sizing system based on the Malaysian women's foot sizes and shapes, and to replace the current sizing system used in the country. This research will eventually advocate the interest and needs of shoe manufacturers to produce women footwear based on the new sizing system and ensure customer satisfaction for shoe size and shoe fitting.

Individualisation of Multifunctional, Concealed Body Armour's Design - Acronym: SECRET #21

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The main objective of the project „Individualization of multifunctional, concealed body armour (ballistic vest) design" is to develop a procedure for individualization of the construction of concealable ballistic vest to be worn under the clothing, based on the 3-dimensional (3D) scanning technology.
3D scanning technology involves the use of a novel non-contact method of acquiring the anthropometric data, which is the most accurate method of human body measurement.
Application of this method allows for fast, professional determination of the size and shape of the ballistic vests, taking into account the specifics of an individual wearer's silhouette. Such a vest protects the most vital internal organs of the user against wound from firearms bullets and is intended for discrete personal protection.
An essential part of the process of the vest individualization, will be the use specialized software that allows for automatic adjustment of standard templates to individual user dimensions. Another software will enable the visualization of the product and assessing the degree of fit and drape on the avatar, that simulates the body shape of individual user. The vest should ensure increased user comfort and freedom of movement due to proper anatomical design.
The special clothing products of the ballistic vest type are usually stiff, hardly adjustable to the individual shape of an user. Applying the 3D scanning technology will enable achieving the best fitting a vest to the individual size of user, respecting the characteristics of the wearer's physique.

Currently, in order to match a ballistic vest to the needs of an individual user, the right size of vest is selected from the manufacturer's offer, who mostly offer 3 up to 5 sizes of a product. The vests are usually equipped with a special fastening system, that adjusts properly vest. The project proposes a method, which takes the laser measurement of the human figure into account, and supports automatic adjustment of standard templates to individual user profile, will refine the process of developing a vest tailored to the needs of an individual customer and significantly reduce the time of manufacturing such a vest. This method brings also a number of other benefits that will be presented during the project.
It will be developed also the procedures of privacy protection that will ensure the protection of storage and processing of gathered data according to related polish and EU law documents.
It is expected that results of the project – the implementation of new products, new innovative technology and procedure solutions, will reduce the number of adverse events in production of chosen personal equipment.

TECHNICAL SESSION 5: 3D SCANNING IN MEDICINE

Latest Trends in Prosthesis Application - Presentation of real case of Total Upper Rehabilitation #57

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This article presents a clear example about how 3D technologies are strongly entering as fundamental elements in the medical field.
In particular, it explores how the use of 3D technologies can implement the dental prosthesis planning and realization by presenting the relationship between the body posture and the digital dentistry in a real total upper rehabilitation with Toronto Bridge. The article provides an overview about 3D scanning technologies, digital smile design and CAD software, focusing the attention on the application of 3D body scanning technologies in the digital dentistry workflow for the analysis of the prosthetic treatment result.
The article concludes that 3D technologies are implementing everyday more and more the work of both dentists and dental technicians by providing more precise and accurate working protocols. Moreover, the application of 3D body scanning in this field is a new trend, which elevate the pre and post treatment analysis at a very specific level, which allows to understand the cause and the effect of each single pathologic case.

Laser Based Spatial Spine Curve Determination in Scoliosis #50

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We present the development of a novel method for the automatic determination of a spatial spine curve based on the measured 3D shape of the human back (automatic curve) with the 3D laser profilometer. The measuring system is based on a line laser triangulation, its measuring range at the distance of 1 m is 300×700×500 mm, the measurement takes about 10 seconds and the single point measurement accuracy is 0.1 mm. The method allows us to compare an automatically determined spatial spine curve with a spatial curve, determined by the physician (reference curve) with the method of root mean square deviation (RMSD) in the frontal and sagittal plane. To validate the method both automatic and reference curve were compared on one subject in three different upright postures with arms in positions: 1. arms released beside the body, 2. upper arm in the horizontal position and forearm in vertical position upwards, 3. arms vertically at full stretch upwards. The results showed that the repeatability of the presented method for all three postures in the frontal and sagittal planes was 0.9 mm and 0.2 mm, respectively, thus allowing to assess a valid quantitative analysis of spine curve course on the surface of the human back regardless of the human upright posture.

Integrating a 3D body Scanner into an Active Bariatric Surgery Clinic: Practical Experiences, History, Tips and Pitfalls #56

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In late 2005, a 3D whole body scanner began to be used to measure morbidly obese (bariatric) patients prior to surgery. This scanner was located in a cosmetic surgeon’s office. The volume of scans for these bariatric patients soon began to overwhelm the cosmetic surgery practice’s staff. In early 2007, a 3D scanner was placed directly into the bariatric surgery clinic. Protocols were written to streamline and define the bariatric

clinic's staff involvement and to seamlessly integrate the scanner into the clinic's daily operations. Meaningful reports were designed and a mechanism was created to distribute them to the patients. A billing system was also introduced. Since that time, improvements to scanner technology has led to several scanner replacements, with only slight changes to the overall protocol framework.
To tell the reader that this is a scientific paper presenting the statistical results of applying a 3D whole body scanner to measure a sample of the morbidly obese population or subjects that underwent a cosmetic surgery procedure would be misleading. Those papers and their associated presentations do exist, and the reader is encouraged to look up the other authors of this paper to find them. Rather, this is a narrative about pioneering deployment of 3D scanning systems into two distinct medical environments, from scratch, and with no previous guidelines to act as signposts along the way. As such, you will not find a reference section at the end of this paper.
It is a history of an idea. It is a journey of trial and error…a lot of errors, actually. Some of these errors were self-inflicted, others simply appeared along the way. But this is how one learns. It has been said that "the pioneers take all the arrows, and the settlers take the land". In that vein, this paper offers insight and advice to those looking to deploy a 3D body scanner into a medical environment. Some of this advice may fall under the "well that's obvious" category. Some of the advice may also fall into the "it will never happen to me" bin. Don't be fooled. The big picture is important, but you will find, as we had to, that even the smallest stuff really does matter.

3D Scanning in Myofascial Dysfunction Detection #71
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Aim: The main goal of this study was to asses the usefulness of 3D body scanning in detecting myofascial dysfunctions.
Material and Methods: The study was conducted on a 14 healthy young volunteers, scanned with whole body scanner based on Prime Sense Carmine 1.09 sensor and Profactor ReconstructMe QT software.
Results: In 86% of examined patients occurred the various compensations, including the global ones which concern the head and shoulders.
Conclusions: Using the 3D body scanning to detecting the myofascial dysfunctions seems to be an effective and useful method.

TECHNICAL SESSION 6: ANTHROPOMETRIC STUDIES & SURVEYS

Data Processing and Analysis for the 2012 Canadian Forces 3D Anthropometric Survey #40
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The 2012 Canadian Forces 3D Anthropometric Survey is the first major 3D anthropometric survey of Canadian Forces personnel. 2200 full-body scans were conducted, together with traditional anthropometric measurements. This survey aims at providing accurate, detailed, and up-to-date body shape information for equipment design and procurement. In this paper, we describe the data processing and analysis of this dataset. This includes de-noising, template fitting, landmark identification, and statistical shape analysis. We also compare the military personnel with the general North American population using the CAESAR dataset.

Establishing a Pre and Post-3D Bodyscanning Survey Process for Able-bodied UK Women Aged 55 Years+ to Determine an Appropriate Waist Position for Garment Development #10
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Change in human body morphology is well-documented for developmental growth from childhood to adult. However, the morphological change from adulthood to older age is less detailed and less discussed within literature concerned with anthropometric application and clothing construction. This, perhaps, explains why females aged 55+ are the demographic most frustrated with the fit of ready-to-wear garments. A prerequisite for the accurate generation of size chart and pattern development relies on precision in the location and demarcation of landmarks, therefore an understanding of the changes in body size and shape, how this impacts on anthropometric practice, and, more specifically, the body landmarks is fundamental to provide correctly fitting garments patterns for mature women. Consequently, the aim of this research is to establish a

pre- and post-3D body scanning survey process for able-bodied UK women aged 55 years and over, giving them the opportunity to self-select a suitable waist location for clothing from four defined waist positions.
A pragmatic, mixed-method methodology was developed to evaluate anthropometric theory and praxis, landmark placement, and subjective body image estimation, to determine the success of their practical application in developing appropriate garment patterns for this demographic.
The methodology consisted of four stages: recruitment of eighty (80) women aged 55+ using the three strategies of convenience, snowball and random sampling; the 3D body scanning of each participant using two TC[2] scanners; the use of a visual aid to allow the self-evaluation of personal waist position for garment development; and the evaluation of the visual and numerical scan data against this self-evaluation.
The findings indicated that recruitment of this demographic is problematic as it is reliant on subject willingness for participation and this group of subjects were often critical of their body morphology. The questionnaire response rate was 67% which reduced the sample size down to 52 women. The visual aid indicated that the participants were able to readily identify the position of their waist regardless of body morphology.
Rectangle, hourglass, triangle and bottom hourglass body shapes were represented in the sample set. The most common body shape shared by this demographic was that of the rectangle and analysis of waist height from the floor position before and after waist landmark modification indicated that the rectangle was the body shape which was most prone to waist placement error from the participants point of view. All body shapes required waist height modification to the original waist height landmark based on participant evaluation of where they felt it comfortable to wear their waistband. Comparative analysis confirmed distinct variation in subjects' evaluation of waist positioning for a garment and scanner MMU MEP definitions. 59% of participants' waists landmarks were placed differently by the scanner compared to the placement by the subjects themselves.
This study concludes that to improve landmark placement accuracy providing a visual aid to the participant for evaluation in tandem with the practitioner evaluation would be a practice that is useful for common but difficult to locate landmarks, such as the waist. Responses from this visual aid operator evaluation the scan data and more specifically the landmarks.

The Body Shape of Brazilian Woman #33
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SENAI CETIQT, Rio de Janeiro, Brazil

This study developed within the SizeBR Project, seeks to raise questions about the regional differences in culture and ethnicity and how it affects the body shape of Brazilian women and modeling their clothing. Started in 2010, the SizeBR Project is the main Brazilian anthropometric study developed with 3D body scanning technology and has been applied in major consumption centers spread across the five major regions of the country, South, Southeast, Central-West, Northeast and North.
Due to the vast territory and mixtures of ethnical backgrounds in Brazil, it is concluded that it is unfeasible to determine a standard female body country-wise. Therefore a detailed regional analysis by region is necessary.
The determination of the body shape of the Brazilian women followed the description defined in the study conducted by Istook, Simmons and Devarajan called "FEMALE FIGURE IDENTIFICATION TECHNIQUE (FFIT) FOR APPAREL". Data obtained in 3D Body Scanner was used to identify female figure types in order to categorize the main types of bodies. Those results will allow developing a system of appropriate size for each body type for each region in Brazil, thereby allowing a better planning in the mass customization of garments.
For comparison, a comparative analysis of the body shape of Brazilian women in relation to other peoples and cultures was conducted using data from American and Korean female population.

Three-Dimensional (3D) Anthropometry Study of the Malaysian Population #06
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Three-dimensional (3D) anthropometry has become an emerging field with the advancement of 3D body scanning technology over the recent years. Conventional method of anthropometry data measurement is time consuming and error-prone. The 3D whole-body surface scanner, which was initially developed for the clothing industry, contributes to healthcare application by providing accurate anthropometric measurements and data visualization in body size, shape and skin surface area. The body scanner utilized 3D photogrammetry technology to generate high quality digital anthropometric information about shapes and sizes of an individual. The aim of the study is to investigate body size and shape of Malaysian females. A

cross-sectional study was conducted using random sampling technique. Recruitment of subjects were randomized and based on age and ethnicity. A preliminary study of 160 female subjects was carried out. In addition to the scanning procedures using the body scanner, selected manual anthropometric measurements for height, weight and skinfold thickness were obtained using manual methods and demographic data such as age and ethnic groups were recorded. All manual measurement followed the requirements and procedures stated in the respective ISO documents, involving body posture, landmark and the instrument used. Descriptive statistical analysis for body dimensions and calculations were carried out. The 3D scanners undoubtedly produced highly accurate, consistent and repeatable measurements. However, the scan data can be slightly different from traditional anthropometric data especially for circumference measurements such as chest, waist and hip. Therefore, scanned anthropometric data and manual measurement data are more useful together. We envisage that this study would be beneficial for healthcare providers for growth monitoring and early diagnosis of health problems related to obesity especially for the Malaysian population. Although the study focuses on the healthcare sector, datasets can also be utilized by the industry in the design and production of consumer products related on the human body.

TECHNICAL SESSION 7: 3D SCANNING TO 3D PRINTING

An Open Source, Low-Cost, Multi Camera Full-Body 3D Scanner #45

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This paper discusses the possibility of using low-cost camera's and single-board computer modules[1] for building a full body 3D Scanning system with the purpose of creating mini-figures / 3D selfies of people, both adults and kids. The design, architecture and results of a 3D scanner based on the Raspberry PI camera and the advantages over a DSLR based system will be discussed.

ReconstructMe – Towards a Full Autonomous Bust Generator #20

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In the most recent years, 3D data acquisition was revolutionized by consumer grade real-time capable 3D depth cameras with appropriate data quality. A wide range of different 3D applications was developed since the release of these cameras. Especially the area of 3D body scanning became cost efficiently and the number of applications started to grow. A new trend is to generate 3D self-portraits and print them on commercial available 3D printer. This paper introduces a low-cost scanning system to generate printable 3D upper torso busts at home using commodity computation hardware.

The workflow of the system is optimized to work without the need of any manual interaction with the user and any additional persons. It's designed to generate 3D printable busts automatically which allows people without 3D knowledge to create their own 3D busts. The user just has to perform a full rotation (360 degrees) to capture the upper torso data from all views. The end of the full rotation is detected automatically. When the scanning procedure is done, a post processing routine is triggered. This routine includes cleaning the scan from noise, estimating the geometry and color of unseen areas and cutting the bust to a certain height. The final result is a watertight, scaled and oriented triangle mesh. This allows the user to put the final mesh to common 3D printer drivers and immediately print its 3D bust.

In our tests, the workflow was proven to be very robust and we were able to generate hundreds of 3D busts with high recognition value of the persons. However, our tests showed different results depending on the conditions. In this paper we will introduce our experience of how the setup can be improved and thus the quality of the results can be enhanced.

In future, this principle could be extended by using more than one sensor at the same time to capture the whole body shape of a person and to generate clean 3D full body models.

Scan to Print within 5 Minutes – 3D Figurine Production with VITRONIC's Body Scanner VITUS #53

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The world has recently witnessed the widespread of 3D printing technology. In the shadow of this development a new means of freezing time was born: 3D figurines. A 3D figurine is a mini version of oneself, manufactured by 3D Printers. Hence a 3D figurine is a little sculpture and a high quality alternative to a digital photo. It is also often referred to as "Mini Me". For the production of a 3D figurine one needs to obtain a 3D scan of an individual. This is however not as easy and trivial as shooting digital photos with a camera. The quality of a 3D figurine depends to a significant degree on the quality of the 3D scan. What are different

technical approaches to obtain 3D scans? On what does the quality of a 3D scan depend? What solution does the German company VITRONIC offer to obtain 3D Scans? These are the topics to be presented and discussed.

A Low Cost 3D Scanning and Printing Tool for Clinical Use in the Casting and Manufacture of Custom Foot Orthoses #68

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Custom foot orthoses are currently recognized as the gold standard for treatment of foot and lower limb pathology. Applications include, but are not limited to: pain relief, increased heel cushion, correction of flexible deformity, increased foot stability and/or prevention of skin breakdowns, such as ulceration. While foam and plaster casting methods are most widely used for the fabrication of custom foot orthoses, technology has emerged, permitting the use of 3D scanning, computer aided design (CAD) and computer aided manufacturing (CAM) for fabrication of foot molds and custom foot orthotic components. Adoption of 3D printing, as a form of CAM, requires further investigation for use as a clinical tool. This study provides a preliminary description of a new method to manufacture foot orthoses using a novel 3D scanner and printer and compare gait kinematic outputs from shod and traditional plaster casted orthotics. One participant (male, 25 years) was included with no lower extremity injuries. Foot molds were created from 3D scanning and printing methods, using the Microsoft Kinect scanning device and desktop Makerbot® printer, respectively. Foot molds were also created from the traditional plaster casting method. Custom foot orthoses were then fabricated from each positive foot mold. Lower body plug-in-gait with the Oxford Foot Model (OFM) on the right foot was collected for the 3D printing orthotic, plaster casted orthotic and control (shod) conditions. The medial longitudinal arch (MLA) was measured using an arch height index (AHI) measurement extracted from the OFM outputs, where a decrease in AHI represented a drop in arch height. The lowest AHI was 21.2 mm in the running shoes, followed by 21.4 mm wearing the orthoses made using 3D scanning and printing, with the highest AHI of 22.0 mm while the participant wore the plaster casted orthoses. This preliminary study demonstrated a small increase in AHI with the 3D printing orthotic compared to the shod condition, indicating that the orthotic restricted motion of the MLA during midstance. A larger sample size may demonstrate significant patterns for the tested conditions.

TECHNICAL SESSION 8: BODY SCANNING FOR APPAREL II

Realistic Virtual System "Female Body - Dress" Based on Scanning Technologies #03

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With the advancement of 3D technologies, such as body scanning, modeling and try-on systems, the realistic visualization of clothes outside shape under textile material properties influenced has become possible. With the body scan system, the 3D body shape can be imported into the virtual environment to serve as the avatar in the simulation which provides fitting and shaping information including the fabric properties' indicators. While distinct advantages of 3D technologies for improving clothes design and pattern making process, there are significant areas of challenge. Although the maturing clothing industry emphasis more on fit and fabric characteristics for 3D try-on module, to predict the shape of clothes around each body is very difficult to achieve as it has been proved. In our study, the 3D shape obtained from the woman bodies and dresses that made from 3 kinds of fabrics were obtained by the body scanners. Through the dividing of the female torso into 6 sections from bust level to hip level, the volumetric air gaps between the body and dress were calculated to model and analyze the relations existing in "body-dress" system between the body sizes, pattern block indexes, and fabrics properties. The strong equations established by regression analysis include the fabrics properties' indicators tested by the KES-FB system and the volumetric ease. Thus the legitimately prediction for outside shape of female dress in the "body-dress" system is realizable through testing physical and mechanical properties of fabric by the KEF-S devices.

3D Color Body Scanning for Improved Sample Fit and Accuracy in Garment Design #30

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For hundreds of years, muslin has been used as the basic fabric from which most garment patterns, first round samples, or prototypes, are made. In the 21st century much of the industry has moved into CAD

systems for pattern making, however, muslin remains the stand alone fabric used in pattern making for the evaluation of fit for a large part of the industry.
Muslin is known for its low cost, simple structure, and the ease for which it can be used. Unfortunately, many end-use fabrics, particularly in apparel where a wide range of fabric structures are used, are not comparable in characteristics to muslin. In fact, muslin may only be a good basis for cotton fabric woven with a plain weave structure due to the strikingly different behaviors of various yarn sizes, fiber types, and weave or knit structures (Brown, 2001). Therefore, using muslin to drape a pattern or fit a first-sample garment can actually be detrimental to the fit process, particularly in draping where the creation of the pattern depends solely on the fabric (Joseph-Armstrong, 2008). Consequently, for an improved fit, a fabric more comparable to the ultimate end use fabric might be more appropriate when used for sampling and pattern draping.

Evaluation of Change in Air Gap Underneath the Garment for Various Pro-longed Body Postures Using 3D Body Scanning #13

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Heat and mass transfer through the garment on wearer's body is affected by the change in the air gap thickness and the contact area more than by the material of the fabric. For thermally relevant evaluation of the thermal properties of clothing, e.g. during work or leisure time, it is important to analyse the air gap thickness and the contact area for prolonged, stationary and ergonomically correct body postures. A flexible manikin, which has similar body size and flexibility of joints as an adult male, was used to mimic realistic human body postures (standing and driving). To obtain accurate and reliable 3D scans, stands with fixations and the garment with easy openings were designed and Artec MHT 3D scanner was used. The presented study indicates that the distribution of air gap thickness and contact area between the body and the garment was depended on the posture of human body due to the gravitational force and the pressure from the chair on the flexible garment. The results of this study can contribute to an improvement of clothing design for functional garments and can be applied to heat and mass transfer modelling in clothing for various postures.

New 3D Scan-Method for Quantification of Discretion; Application to Body-Close Incontinence Protection #63

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The present study presents an objective method to quantify discretion in terms of body close fit of incontinence care products. A 3D scan-method based on a structured light sensor and industrial inspection software was developed to record and evaluate different product designs dressed on a mannequin. All of the instrumentation and software are commercially available and performance evaluated in order to assure reproducibility. The methodology is applicable to dry as well as wetted products and has proven useful for comparisons of different pull-on type of disposable incontinence products.

TECHNICAL SESSION 9: HAND HELD SCANNING SYSTEMS

Hand-Held Body Scanning Concept Adds a New Dimension to the Process of 3D Image Capture #65

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Microprocessors and innovative sensor technology are rapidly converging into aspects of our modern day experiences and provide incredible value. With the ubiquity of smartphone and mobile computing platforms, consumers and retailers alike are doing more work and performing more tasks on mobile devices.
Technology breakthroughs have repeatedly shaped our world and technological advances in the retail setting are no exception. Consumers expect technology to assist with countless aspects of their shopping experiences and place a high value on smart filtering tools capable of product recommendations.
Unique Solutions recognizes these needs and is focused on "fit" for retail clothing for individual consumers to working with large uniform suppliers to size and fit a large workforce. To accomplish these objectives, Unique Solutions builds, deploys and services 3D holographic body scanners based on our millimeter wave scanning system to recommend great-fitting clothing to customers. Unique Solutions is actively leveraging specialized camera technology and pairing it with its successful
millimeter wave technology to capture 3D body scans and taking scanning technology to a new level.
The retail floor space is a premium resource and current scanning technologies consist of large kiosks.

Unique Solutions' latest development activities address these challenges and offer a solution taking the form of a handheld 3D body scanner.
The handheld version of the system provides the accuracy of the millimeter wave system and leverages camera technology to give the operator freedom to perform a scan and achieve high-quality results.
The addition of an imaging system offers exciting new measurement and customer service possibilities, as it will be used to augment the motion tracking of the scanner and support many aspects of the system. Additionally, the secondary sensor output will compliment the 3D data from the penetrating millimeter wave sensor used in the fitting algorithms. This novel and patent-pending handheld scanning concept will provide operators and customers with a unique presentation of the relationships between garments and the body, which is what customers value and expect from a state of the art fitting technology.

Measurement of Head-to-Trunk Orientation Using Handheld 3D Optical Apparatus #51
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The system for head-to-trunk orientation is presented. It is based on the 3D measuring of the upper trunk and head of the measured person and registration of the partial head and trunk surfaces to the reference position. The rotations of the head and trunk, necessary for the registration, are monitored. By the subtraction of the head rotation with trunk rotation, we get the orientation of the head with the respect to the trunk. It is insensitive to the movement or rotation of the 3D measuring system or measured person as a whole.
The accuracies of the method and proposed measuring system were verified *in-vitro* and *in-vivo*. For the *in-vitro* verification the mannequin with a movable head was used, to which the reference orientation tracker was attached. The shape of the surface of the mannequin with handheld 3D apparatus (HA, accuracy 1.5 mm) and 3D laser scanner (LS, accuracy 0.3 mm), which is inappropriate for in-vivo measuring, were measured simultaneously. To calculate the orientation of the head the proposed method was used in both cases. Analysis of the acquired angles showed that precision in the case of OT and LS is 0.3°, while in the case of HA the precision was 2°. In the case of in-vivo verification, the precision of the system was 3°.

Handheld 3D Scanning System for In-Vivo Imaging of Skin Cancer #64
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We present a handheld scanning system for measuring in-vivo the 3D topography of the human skin surface. The system has been envisaged for analyzing the 3D shape of skin cancer lesions, providing a more precise characterization of the lesions compared with the conventional examination done by using the naked eye and dermoscopy methods. The 3D scanning system is composed of cost-effective and commercially available components, including two monochrome cameras placed in a stereo configuration, a color camera, and a compact projector unit. The 3D measuring principle is based on the technique of stereovision combined with the projection of structured light patterns. A first scanning prototype has been recently developed for imaging skin surface areas of 19 x 14 mm^2. A graphical user interface (GUI) has been also implemented to operate with the prototype. Preliminary experimental results showing the performance of this initial prototype for imaging different skin surface zones are also presented.

TECHNICAL SESSION 10: BODY SCANNING ASSESSMENT & USE

3D-Based Resources Fostering the Analysis, Use, and Exploitation of Available Body Anthropometric Data #39
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Today, there is an increasing availability of human body 3D data and an increasing number of anthropometric owners. This is due to the fact of the progressive conduction of large national surveys using high resolution 3D scanners and due to the increasing number of low-cost technologies for acquiring body shape with electronic consumer devices like webcams, smartphones or Kinect. However, the commercial use and exploitation in industry of digital anthropometric data is still limited to the use of 1D measurements extracted from this vast 3D information. There is a lack of universal resources enabling: to conjointly use and analyse datasets regardless from the source or type of scanning technology used, the flexible measurement extraction beyond pre-defined sets, and the analysis of the information contained in human shapes. This paper presents four software tool solutions aimed at addressing different user profiles and needs regarding the use and exploitation of the increasing number of 3D anthropometric data.

Posture Dependency of 3D-Body Scanning Data for a Virtual Product Development Process in Apparel Industry #35

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Nowadays the product development process in apparel industry is mainly influenced by the customer- the so called target group. Companies spending mass of time and effort to analyze the target markets- national and international- to gain valuable information assisting them in building up company dependent body measurement charts, final measurement charts for their products and necessarily grading tables for the size range offered.
Most companies are working with fitting models- representing more or less the “vision of the brand” and- if well selected- the basic size of their measurement charts and hopefully the customer. Unfortunately in most cases the fitting is done- due to time and costs- with one model and leads to the fact of a tailor made fitting process for this person with a non-defined physical and mental state on this day. Virtual Product Development is a powerful tool to overcome these barriers. By using statistical avatars representing the target group aimed for, and scanatars from various fitting models it is possible to check the sizing and to screen the fit of a product on slightly different bodies and postures of the same size in a quite short time. However it is not negligible to control the body scanning process in detail to get really the information wanted.

Practical Considerations of Applying Body Scanning as a Teaching and Research Tool #04

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Used in specific ways, body scanning technology can provide greater understanding of the body and its relationship to clothing. However, body scanning is still a developing technology and little is known about the practical applications and limitations of its operation within the education environment. Further to this, whilst there have been many high profile body scanning surveys, there still appears to be little accessible information on the practical issues of body scanning or data derived from scanning. With reference to live industry and academic projects, and the application of this technology within a UK university, recommendations are provided in the following areas: supporting structures and methods to enable; long term research, short term; accruing of data that can be seen as comparable to that collected in other locations and by other teams. Importantly processes and data captured during scanner use have little standardisation and each operator is expected to develop their own structures for training, data collection, assessment, storage and application. This can be extremely difficult without accessible examples of structures and processes previously applied. The team operating this scanner have found a diverse number of uses and developed protocols for ethics and storage that ensure data collected can have long term relevance as a resource in the increasing global arena of big data and collaboration anticipated by existing funding sources. Fundamentally, recommendations are made regarding body scanner supplier interventions that would enable the easier application of this technology and ensure data is comparable and has the greatest value for each and all operators. It is hoped through the adoption and provision of resources to support consistent scanning and data storage the current data collected on a small scale by varied users can have the greatest opportunity for future use collaboratively across different user groups.

Perception vs Reality: 3D Body Image, Self-Esteem and Vanity Sizing #47

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Purpose: Many studies have been conducted since the arrival of the 3D body scanner measuring body sizes and looking at shapes either for national sizing campaigns, or specific target markets, or simply to learn about particular parts such as head or foot. Very little has yet focused on the perception of oneself and its definite 3D image, thus about vanity.
The purpose of this research is to investigate how people perceived themselves, compared to their 3D image. This research also parallel participants’ self-esteem [vanity/ *body cathexis*] with their understanding [appreciation] of apparel sizing.
Design/methodology/approach: To achieve our objectives, our main method, is to survey participants at the Montreal 2014 *Fashion & Design Festival*. Participants are ask to: (i) complete a threefold questionnaire and

(ii) to voluntary be scanned. The first section of the questionnaire measures global self-worth [own perception and self-esteem] of individuals with an existing and tested 10-item scale found in the literature. The second section measure participants' perception towards vanity sizing. Questions were elaborated based on literature statement. Lastly the third section compiles participants' demographic data.
After completing the questionnaire, participants are scanned using a 3D body scanner (NX16) from $[TC]^2$. Participants receive initiatives to participating in the survey and a copy of their 3D image.
Findings: According to our pilot test, results validate that self-esteem is link with (dis)satisfaction of ones' appearance, the visible aspect of a person, but not necessary to its "3D depiction". Results also show a negative correlation between vanity and vanity sizing. Indeed, when one's perceives her/himself negatively, (s)he has a good impression about vanity sizing, (meaning one is affected by the size label favoring a low digit), whereas one's with a positive self-esteem doesn't seem to be trouble by the size label, therefore does not embrace vanity sizing. These results are significant since they should result in practical implication.
Research limitations: First research of its kind and was done only in Montreal. It would gain to be extended to other geographic areas and to a larger scale including people of diverse age groups, ethnicities, etc.
Practical implication: Literature shows that a commercial practice such as *vanity sizing* is a marketing tool, but our results show it also has "benefits" on people with low self-esteem. On the other hand literature shows that vanity sizing has an economic impact and give rise to costly returns.
Therefore the apparel industry may want to rethink these commercial practices in regards to sizing in a way it benefits all parties.
Originality and value: For the first time we are able to validate the prominence of the size label effect on self-esteem, related to body shape and perception [vanity].

My_Healthy_Shape Guide: An interactive educational-health tool for Malaysian Based on Body Shape #12

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This study is concerned with developing an interactive educational-health tool, My_Healthy_Shape Guide for Malaysian based on gender, height, weight, body shape and age. In addition to manual anthropometric measurements of height and weight, a three dimensional (3-D) body scanner is used to collect digitized body shape and the data obtained are stored in a specialized human shape database. The scanner captures high quality digital information of the body shape of an individual in just a few minutes. The body shape data as well as the manual anthropometric measurements will be use to study the individual's health status in relation to his/her dietary behaviors and physical activities. This paper presents the conceptual framework of our study, consisting of (1) establishing a web-based 3D human shape database for Malaysian using MySQL (2) formulating mathematical models to generate feasible solutions for predicting healthy diet for an individual based on his/her body shape and (3) developing an interactive educational-health tool, My_Healthy_Shape Guide for Malaysian that would provide healthy daily diet recommendations that promotes good health and lifestyle for an individual.

TECHNICAL SESSION 11: BODY SCANNING FOR SPORT & HEALTH

Athletic Sizing Based on Performance #31

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For many sportswear companies, the sizing of athletic garments follows the same guidelines as sizing for everyday casual garments. This research team feels this is not a precise way to size clothing for athletes as their body shapes tend to be different than that of the general population. Elite athletes' body shapes and sizes are similar depending on the sports they partake in. Proposed in this paper is a new sizing system for athletes based on athletic performance.
In order to appropriately create a size distribution for athletes, specific data on athlete body types and performance must be gathered. Researchers at NCSU have collected data sets to find these details by scanning athletes at a sprint triathlon in the Raleigh, North Carolina area. The research team chose to collect scans at a sprint triathlon because it is significantly shorter than a full triathlon, which will encourage people of all body types to participate, and because it allows for collection of data for running, swimming, and cycling.
Participants were scanned using the Vitus Smart XXL laser body scanner provided by Human Solutions. This is a laser-based body scanner made by Human Solutions Assyst AVM. The Vitus Smart XXL is ideal for this research because it uses the optical triangulation method with four separate lasers to find measurements that are accurate to +/- 1 mm. (Human Solutions, 2002). The scans taken after the race were compared to

the athletes' finishing times. The sample of runners have been segmented into groups based on their finishing times. The scans within each group were averaged into one avatar with Human Solutions' Anthroscan Scan Database software. These avatars represent each group's average measurements. Each segment has a significantly different body type, which has been converted into measurements for sizing. By using this segmented population that were not adverse to body measurement we believe we can develop a more uniform sizing criteria that could then benefit other segmented groups.

Kinanthropometry Applications of Depth Camera Based 3D Scanning Systems in Cycling: Repeatability and Agreement with Manual Methods #22

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Recent literature suggests that 2D and 3D anthropometric measures are better predictors of sports performance, than traditional 1D measures. The emergence of 3D scanning systems offers a cheap, easy and effective method of estimating these measures. Therefore the aim of this study was to investigate the repeatability of a depth camera based 3D scanning system, and its agreement with manual methods in the extraction of simple thigh measurements. Using 15 healthy, recreationally active male participants, five measurements of the thigh (upper thigh circumference, mid-thigh circumference, knee circumference, knee to mid-thigh length and mid-thigh to upper thigh length) were taken using an anthropometric tape measure and digital callipers, and scanned using a 4-camera Kinect based 3D scanning system (using custom analysis software). Agreement and repeatability was subsequently determined. This study demonstrated a low cost Kinect-based 3D scanning system is capable of extracting length and circumference measures within ~2% and ~3-4%, respectively, with high repeatability, technical error measurements (TEM) of ~1.80% and ~0.7% respectively. The 3D scanning system was able to measure the thigh in good agreement with manual measurement methods, with the presence of systematic bias in circumference. Whilst maintaining a very high degree of repeatability, suggesting it is a suitable method to extract simple thigh measurements.

Theory and Practical Steps to Introducing a New 3D Public Health Indicator to Remplace BMI Using Existing Population-based Multidimensional Reference Sets #55

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Body Mass Index is an aging public health indicator obesity measurement, based solely on height and weight. Despite its shortcomings, it has gained acceptance over time primarily because of its simplicity, and it has been applied not only to individuals, but also to various population groups. Calls to replace BMI with a more modern indicator within the medical community have been growing louder, but the medical community moves very slow and acceptance of a multidimensional health indicator appears to most to be far off. However, by using multinational 3D sizing studies done over the years by the clothing industry, the introduction of a 3D public health indicator as well as a multidimensional population measurement reference set can be implemented in the very near future.

Body Mass Components in the Young Soccer Players in R. Macedonia #42

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Introduction: Body composition assessment involves the presence of the subcutaneous adipose tissue and assessment of the presence of muscle and bone mass in the human organism. A good knowledge of the anthropometric characteristics and body components plays an important role in the process of selection and choice of the models for programming the training processes.
The goal of this research is the determination of the absolute and relative components of body mass in soccer players under the age of 14.
Matherial and methods: This study included 96 subjects, aged 8-14 years (mean age 11.4 years). Body mass components were determined using the Mateigk's methods.
Results: Analysis is conducted on the body height (BH= 151.36 ± 13,48 cm); body weight (BW= 43.34±11.79 kg); relative and absolute muscle mass (MM%=49,06; MM=21.44±6.72 kg); relative and absolute bone mass (BT%=19.83±1.79; BT=8.56±2.18 kg); relative and absolute mass of fat tissue (FT%=14.88; FM= 6.62±2.8 kg) and the body mass index (BMI=19.9 ±3.28).
Conclusion: The obtained results are a base for the database values of body components in young players in our country that may be a benefit to the sports and health professionals to compare and evaluate the

physical body status in young football players.

Analyze of Anthropometric Parameters of Soccer Players Aged 14 to 17 Years in R. Macedonia #43

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Introduction: Body composition in young athlets is very important indicator for their state of health and also for the sport selection. Determination of anthropometric features is part of regular health examinations in soccer players, whic help in evaluation of the efficacy of the training process. Athletic performance is highly correlated with fitness and other physical caracteristics
The aims of the study were to evaluate anthropometric parameters of soccer players aged 14 to 17 years in R.Macedonia.
Matherial and methods: This study included 140 male soccer players from several football teams in Macedonia, aged 14-17 years , divided into two groups according to the age – younger 14 to 15 years and older 16-17 year. Analysis is made by using the Mateigk's equations for next parameters: the muscular component (MMkg and MM%), the bone component (BC kg and BC%) and the body fat (BF kg and BF%).
Results: Te estimation of three body mass components showed that in the whole group of young soccers the body mass component were as follow: MM=34.25 kg; MM% = 51.67%; BC = 11.8 kg and BC% = 18.04; BF= 10.31 kg and BF%= 15.5. Subgroups aged 14-15 years have shown: MM=29.8 kg; MM% = 49.64%; BC = 11.8 kg and BC% = 18.37 and BF= 8.96 kg and BF%= 15.04. The older subgroup (16-17 years) have shown the body components as MM=36.16 kg; MM% = 52.42%; BC = 12.29 kg and BC% = 17.91; BF= 10.81 kg and BF%= 15.67. We observed small but significant differences between two subgroups, young group had higher values for bone component, but smaller muscular and fat component than older subgroup.
Conclusion: The acquired anthropometric data could be used as normative data for young soccer players in Macedonia for comparative and interventional aims.

Analyze of Body Mass Components in Young Basketball Players #44

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Introduction: The aims of the study were to present the body composition of young male basketball players and tp show the differences in respected age groups.
Matherial and methods: This study included a total of 96 male basketball players, divided into four groups according to the age: group under 12 (9.79±1.19), under 14 (13.15 ±0.9), group under 16 (16.08 ±0.5) and group under 18 (17.17±0.4). In different age groups were monitored some body mass components using the Mateigk's methods.
Results: The estimation of three body mass components – the muscular component (MC%), the bone component (BC%) and the body fat (BF%) showed that in first group body mass of young athlets has an average value for MC=49.49 ±4.79 %; BC =20.36±2.18 % and BF=16.74±2.74 %. Second group has MC=50.21 ±2.82 %; BC =19.75±2.19 % and BF=15.86±3.17 %. Third group has an average values for MC=52.61 ±2.67 %; BC =18.43±1.18 % and BF=15.00±1.58 %. The fourth group received the following mean values for body mass components MC=53.00 ±1.87 %; BC =19.52±0.78 % and BF=14.48±1.05 %. We observet significant differences in body composition parameters of young basketball players.
Conclusion: Comparison between age groups showed that BF% was lower in group under 18 vs. Group under 14 and 16, and under 12. The acquired data could be used as standard values for Macedonian young basketball players and other athlets.

TECHNICAL SESSION 12: BODY MODELING & AVATARS

Obtaining Personal Figure Mannequin Using Two Photographs for Three-Dimensional Corsetry Design #61

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In designing of corsetry the essential feature is figure's torso and breast form and size setting. Personal figure digital mannequins, obtained by the most 3D Body Scanning technologies, don't provide the ability to modify the shape of the breast and monitor the preservation of its main parameters during model design.
We have developed a mannequin mathematical model and an adjustment method to recover personal torso and breast geometry. For making breast simulated model, setting of different figure types, either in brassieres of different designs, or without them, methods of geometric and physical modeling were used. As

a geometric model the part of ellipsoid was chosen, which represented a rotary body, formed by certain function graphics. For obtaining ellipsoid forms which are typical for the large breast size and for women of the older age group, physical modeling was used. Eight different parameters, sufficient to generate all possible forms of breast, are defined.
Our adjusting procedure needs only two photographs and 6 measured values.
Shape of torso is adjusted automatically using outlines deposited on the pictures, and values of the chest, waist and hips girths. Breast shape is adjusted interactively by changing the values of 8 parameters of the mathematical model. These parameters can be used further for modeling of brassier effect on the breast when 3-dimension corset wear construction is made.
Adjusting process takes less than 5 minutes, after which the designer can create a model of the corset, draw seams, reflect the properties of materials and receive a set of patterns automatically, without any usage of various methods of receiving patterns. Advantages of our program are visualization of clothes appearance, availability of fitting it on the individual figure and automated algorithm to convert three-dimensional details of clothes in the patterns.

A Pose Invariant Statistical Shape Model for Human Bodies #26
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We present a complete pipeline for constructing a statistical shape model that is invariant to deviations in the scan pose while encoding the space of human pose and body shape in an efficient manner. A dense cross-parameterization between a large set of high-quality 3D scans is computed using a fast and robust volume aware non-rigid registration method. Our approach uses a novel encoding that automatically decorrelates shape and pose leading to a statistical model that is oblivious under transformations induced by pose. This allows us to efficiently compensate pose variations in captured input data leading to a compact representation for pose as well as body shape. We present a local as well as a global skeletal encoding and compare both approaches. Finally, we analyze the generalization properties and accuracy of our approach against two state-of-the-art methods. We apply our model to the data clustering problem and use it as a prior for non-rigid shape matching.

Methodology for Transformation of Individual Scan Data into Realistic Animated Human Models #29
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Animating individual scan data in an efficient and easy way is still quite a big challenge. Even more if anatomical correctness is required concerning the deformation by body movement.
We present a methodology for transforming individual scan data into realistic animated human models by adapting the scan data to a template model based on anthropometric coherences (skeleton, muscles, tendons and chondrals). The methodology is demonstrated for a female body. It can be used for a male body or even fictive creatures as well. For modeling and animation 3ds Max is used, but the technique is not fixed to a specific commercial system.
This approach allows an easy examination of the correlation between the posture of a person and the ideal pattern for a specific pose or movement. As the pose of an athlete differs significantly from the standard standing pose this solution can be used for garment design for high-performance sports. Another possible application is the construction and comparison of patterns in standing and sitting position to be used for wheel-chaired people.

Framework of Understanding Somatological Constructs Relative to the Fit of Apparel #28
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Past research in the field of somatology (human body measurement) related to the fit of apparel has focused on the current apparel manufacturing process flow. In the current system, three dimensional (3D) body form is converted to one dimensional (1D) sizes and two dimensional (2D) shapes in order to utilize shaping methodology in the conversion of 2D fabrics into a 3D garment that fit the 3D human body form. The somatological constructs of size, build, shape, and form are often used interchangeably in academia and industry. This treatise intends to clarify definitions and bring deeper meaning to these constructs. This clarity and meaning will be used to develop a framework of understanding to use as a lens to view apparel product development and manufacturing as they relate to the fit of garments to the human body. The framework of

understanding has the potential to revolutionize the apparel industry by refocusing development efforts toward a more effective process flow and to change the way the fit of garments is measured and evaluated.

A 3D Dynamic Database for Unconstrained Face Recognition #41

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In this paper, we present a new 3D dynamic face dataset dedicated to the development and test of algorithms which target face recognition under unconstrained conditions, from 3D videos. Several challenges which can occur in real world like scenarios are considered, such as continuous and freely-pose variation, expressive and talking faces, changes of the distance to the 3D camera, occlusions and multiple persons in the scene. In this database, a full 3D static model is collected for each subject, together with eight 3D video sequences. Each video lasts about 20 seconds, including challenging variations under continuous and freely pose variation. Single-view structured-light 3D scanners are used in the acquisition process. This dataset contains 58 subjects. To provide baseline recognition performance on this database, a 4D-to-4D subspace learning face recognition approach is introduced and experimented. To the best of our knowledge, this database is the first 3D dynamic database designed for the purpose of face recognition considering freely-moving 3D faces. As such, it provides to the research community a new benchmark that can stimulate investigation of face recognition algorithms under new and challenging conditions.

TECHNICAL SESSION 13: SCANNING WITH DEPTH CAMERAS

A Low Cost and Easy to Use Setup for Foot Scanning #08

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We present a low cost acquisition setup for the accurate reconstruction of feet and shoe lasts geometry. It is based on the use of a single close range depth sensor (Primesense Carmine 1.09) that is moved around the object using a PC-controlled mobile robot.
The mobile robot is built using a simple electric car constrained to move in a circular guide and controlled by an Arduino Uno board allowing the custom software to control the engine's speed.
In the acquisition phase multiple point clouds are captured and registered in a common reference frame. The vehicle trajectory has been designed to maximize the reconstruction accuracy and robustness against changes in the scene illumination.
Registered point clouds are filtered in order to remove the floor, reduce the noise and refine the alignment, and are finally merged in an unique simplified cloud that can be triangulated with standard techniques. The resulting foot model is then aligned in a standard way and segmented identifying relevant landmarks for measurement.

A Validation Study of a Kinect Based Body Imaging (KBI) Devices System Based on ISO 20685:2010 #49

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To replace the traditional anthropometric data collection processes with the 3D acquiring system it is important that the validity of the data is not compromised. To do this, a validation study, based on the guideline of ISO 20685, can be performed. This paper presents the results of a comparison between traditional measurements and measurements taken with a 3D acquiring system using only four Kinect sensors. The results obtained were then compared with the maximum allowable error indicated in ISO 20685, concluding that this system cannot give sufficiently reliable data that can substitute the manual procedures.

3D Reconstruction of Body Parts Using RGB-D Sensors: Challenges from a Biomedical Perspective #24

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The patient 3D model reconstruction plays an important role in applications such as surgery planning or computer-aided prosthesis design systems. Common methods use either expensive devices or require expert personnel which are not available in every clinic. Thus to make patient-specific modelling more

versatile, it is required to develop efficient methods together with feasible devices. Body parts such as head and torso present valid challenges with different degrees of complexity, especially because of the absence of relevant and abundant features.
Considering Microsoft Kinect, it is a low-cost and widely available sensor, which has been successfully applied in medical applications. Since single depth-map acquired by Kinect is often incomplete and noisy, different approaches have been proposed to perform the reconstruction by merging multiple depth-maps, by registering single view point clouds generated form each point cloud. As human body is a non-rigid model, most of previous reconstruction methods using Kinect fail to perform accurate reconstruction since they do not address non-rigid surfaces.
In this paper we present the challenges of using low-cost RGB-D sensors to reconstruct human body. Additionally, we analysed coarse registration stage to understand its impact on the quality of reconstruction on both rigid and non-rigid data. Also comparative research has been performed to study different coarse registration methods such as Spin Image (SI), Curvedness, and Principal Component Analysis (PCA). Studies showed that the quality of reconstruction is directly related to robustness of reconstruction method to the rotational and translation noise. Regarding analytical comparisons, results indicate the positive impression of applying coarse registration on both rigid and non-rigid data. Moreover, evaluations show PCA presents better results among other considered methods. Finally it is shown that down-sampled models present less error.

Use of Kinect Tool to Measure the Physical Capabilities of Patients for Wolf Motor Function Test in Centre Hospitalier Universitaire de Grenoble (CHU) #25

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This study was performed in the G-SCOP Research laboratory in collaboration with Grenoble University Hospital Center (CHU) in France. The objective is to develop a tool for the automatic evaluation of motor skills of patients in clinical settings. The proposed method takes place in the context of medical activities carried out daily at this Hospital. Our study was in physiotherapy department to standardize the assessment phases of motor skills using Microsoft Kinect sensor. In our research, physiotherapists proposed to work on the WMFT (The Wolf Motor Function Test) measurement protocol which is recognized and used regularly for patient evaluation. In the first stage, it is tried to understand the protocol together with required elements. Then, a Kinect tool is prepared for the model which can be able to connect two points: the combination of the Wolf Motor Function Test (WMFT) with the Kinect output. Our initial experimental results of testing on both patients and 10 healthy persons in the G-SCOP laboratory showed the capability of the tool to measure the activities of the WMFT protocol. Furthermore, the results of this study can be the bases of future researches for the use of the Kinect in this domain and implementation of this tool directly in the Grenoble hospital.

TECHNICAL SESSION 14: BODY SCANNING FOR APPAREL III

3D Digital Technologies for Virtual Fitting of Garments in Tailor-Made Application #59

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Digital 3D technologies are very powerful tools in many fields of application. Apparel industry has been adopting these technologies in order to optimize its design and fabrication processes. Recently, these digital approaches have been applied to try-on stages by using body scanners and are now foreseen for fitting of tailor-made garments. Virtual try-on consists of performing the registration of two 3D models: a human model and a garment model to try-on. Different methods of registration can be used, which have been well described in literature. The precision of the registration depends on the selected method. In the case where the old-fashion tailor-made work is involved, usually the tailor performs manual measurements using a measuring tape directly on the customer. Then a set of measurements is created and the tailor-made garment can be fabricated.
This research explores the use of 3D technologies for performing virtual measurements and try-on. A friendly user 3D manipulation software tool has been developed, which performs virtual measurement using scanned data of the actual body. The set of measurements can be sent to a customer database which includes scanned data and mensuration. A second software tool will be used to perform the try-on for fitting a virtual garment. Different adjustments on the garment are possible by using control points of deformation on the meshed model. The try-on involves the creation of a virtual mannequin based on the customer mensuration.

Virtual Fitting by Single-Shot Body Shape Estimation #14

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We propose a novel virtual fitting system for seamlessly adjusting 2D clothing images to users by inferring their 3D body shape models from single-shot depth images. To increase fitting accuracy between virtual clothes and the body of the user, the system transforms and overlays the clothing image onto the body image in real time. Observations indicate that the system attains high fitting accuracy when overlaying clothing images captured from a person with a body shape similar to that of the user. We therefore develop a method for rapidly acquiring body shape models and selecting suitable clothing images based on shape similarity. We show a number of fitting results, and evaluate the fitting accuracy of both our method and an existing method without the consideration of the body shape.

Anthropometric Study by Diagnosing and Antagonising the Feel Factor of 'Ideal Fabric' with 'Reference Fabric' for Frugal Engineering of Foundation Garments #48

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An attempt has been made to develop DREF III friction spun yarn after structural modifications with an objective to analyze its feasibility for apparel end use by diagnosing its quantified reduction in harshness. This harsh feel is due to the wrapper fibres of sheath which wrap the core during yarn formation (to give adequate strength). Therefore, removal of sheath is being sought by incorporating water soluble PVA fibres (Poly Vinyl Alcohol), without compromising the fundamental 'quality requirements of fabric'.
An independent study is carried out to develop a regression model, for simultaneous optimization of the desirability of physiological comfort and handle related properties of a knitted fabric, made up of the modified friction spun yarn, with pre-defined constraints in desired atmospheric conditions for specific end-use and comparing it with knitted fabric made up of conventional friction spun yarn named as 'Reference fabric'. To optimize the desirability of value added garment, response surface methodology is used as a tool to develop a mathematical model.
In this work, 'Physiological Control System' (PCS) of both comfort & handle is being upgraded to 'Engineering Control System' (ECS) by conversion of conceptual model to a mathematical model. Optimizing the fabric handle properties is based on the basic concept of neuroscience; artificial neuron model; physiological control system & engineering control system. Re-optimization of both comfort and handle by reverse engineering process is done to identify the best sample with maximum overall desirability termed as an 'Ideal Fabric' to achieve value added quality garment. 'Ideal Fabric' is identified as per the synergistic target & goal i.e. which satisfies & saddles both the parameters of comfort and handle in a compromise zone either as per the functionality of frugal engineering or by concurrent engineering.
Optimization & quantification of the responses in good zone of FAST fabric finger prints with maximum enhanced physiological comfort; to achieve a unique resultant value in a compromise zone known as an 'Overall Desirability'; as per engineering control system by developing a 'Feed Forward Back-Propagating Mathematical Model' with 'Artificial Neural Networks' (ANNs), also called cloudburst technology or parallel distributed processing systems (PDPs) and connectionist system, are intended for modeling the organizational principles of the central nervous system. Simulation and achievement of 'Ideal fabric' in terms of simultaneously re-optimized physiological comfort and handle properties in a compromise zone, for rapid prototyping of garment.
Indexes are used to calculate comfort for summer wear i.e. TWCI (Total wear comfort index); TPCI (Thermo-physiological comfort index); Gagge et al produced comfort sensation scale with 43 points; CALM (Comfort affect labeled magnitude) scale is also used; KVP Singh et al. quantified and optimized the overall desirability of physiological comfort and handle to achieve value added garment.
Anthropometric study is being done with diagnostic case study by comparing the 'Feel Factor' of 'Ideal fabric' with 'Reference fabric' and quantifying its reduction in harshness assuming body metabolism and microclimate as constant and stationary respectively as biologically inspired cloud computing capabilities of the ANN allows the cognitive and sensory task, as per database management, to be performed more easily and more satisfactorily than with conventional serial processors.
Antagonistic case study of 'Feel Factor' of 'Ideal fabric' with 'Reference fabric' will further be applied by using anthropometry with NX 16 3D body scanner (scheduled and controlled automated network system) on a digitized 3D model of human body to assist the spatial analysis of clothing appearance , body measurement , garment fit and for amity multitasking or rapid prototyping of apparels and medical textiles.

Published by
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