Working Group Progress for IEEE P3141 - Standard for 3D Body Processing

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Abstract

The IEEE 3D Body Processing (3DBP) initiative is working towards standardizing 3d body technologies by creating use cases, identifying gaps in standards and identifying best practices for 3D body processing.

The 3DBP brings together an ecosystem of players to propose new standards around enabling 3D body processing for a variety of use cases. Companies include large retailers, scanner providers, virtual fit providers, and small to mid-sized start-ups. The range of body processing use cases involves apparel, footwear and accessories, such as eyewear and gloves. Body processing encompasses the capture, processing, storage, and sharing – all of which relies on “Of-the-body” landmarks and “On-the-body” models. The committee is making progress on recommending file formats, metadata and communication protocols for global file sharing and interoperability.

Thus far, the committee primarily focuses on the retail use case, especially with regard to fit and size estimation, product recommendations and improved sizing systems. For clothing manufacturers and CAD tool developers, the main use cases are: bespoke or custom manufacturing, and bi-directional transformations between 2D patterns and 3D models.

Technical work groups intend to improve interoperability between creators and consumers of 3D body models and accelerate the implementation of body model centric use cases. The first step is to identify gaps in existing standards and recommended practices as 3D body processing spreads beyond first adopters. Separate interoperability work groups are dedicated to metadata, file format, protocol, security and model accuracy estimation.

The metadata technical group intends to define mandatory and optional metadata, recommend landmark and measurement names and definitions (based on existing standards), and allow for vendor-specific metadata. The file format technical group intends to select between existing file formats that support model 3D data, such that all metadata defined earlier is contained within the same file. The protocol and security technical group intends to select an existing protocol that will allow for the request and sending of the body model, using generic APIs, while providing security.

The model accuracy technical group intends to create a ground truth database for assessing the accuracy of software packages with landmark placement and measurement values. The definitions for landmarks and measurements (L&M) are defined using the latest versions of various ISO standards. The raw data from the body scanners themselves are out of scope. However, the type and make of the scanner must be stated in the metadata for reference. The software will be evaluated after the 3D body model and the statistical models have been generated and compared to the L&M ground truth for accuracy.

Keywords: Standards, Body processing, 3D Body scanning, simulation & modeling, Body Models, Databases, Metadata, Body measurements, Landmarks, visualization, IEEE

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1 Introduction

An increase in 3D body processing hardware and software technologies is driving a proliferation of applications that harness the interplay of body sensing, scanning, simulation, modeling, visualization and immersion to create new and novel experiences across a variety of industries. On the other hand, these dynamics are also highlighting challenges associated with ecosystemic fragmentation and risks for adoption. Therefore, in order to address these challenges, IEEE 3DBP was launched as a cross-industry effort to collaborate on exploring and developing standardization of interactions across 3DBP technologies such as 3D body models and associated data. Standardization will improve interoperability, which will ease the development of innovative solutions using body models and accelerate the scalability of 3D body-model-based solutions and applications.

The IEEE P3141***, Standard for 3D Body Processing (3DBP)***, brings together an international, multi-disciplinary set of individuals representing many companies that are in the process of proposing new standards and/or practices to enhance 3D body processing interoperability between creators and consumers of 3D body data. The standards will be used in existing industries to develop new opportunities and businesses around 3D body models.

Companies involved in the 3DBP initiative include large retailers, scanner providers, virtual fit providers, CAD tool developers, product manufacturers and start-ups. They impact consumer goods such as, apparel, footwear, and wearable accessories, including eyewear and/or gloves. The industry use cases considered thus far range from *size recommendation* to *product personalization*, through bi-directional transformations between 2D patterns and 3D models, custom manufacturing, fit predictions and simulation.

Through its members, the 3DBP initiative is connected to many other organizations such as ISO, X3D, AIST and other governmental/societal organizations. The 3DBP does not intend to duplicate standards and practices. The goal is to create complementary standards and practices that promote an ecosystem that “lifts all boats” and drives future growth opportunities for players across the 3D body processing value chain. To help understand the ecosystem’s requirements for 3D body processing, the 3DBP looked in detail at the retail industry as the initial primary use case.

3D models of the human body or body parts have been in use for some time now for various applications and are becoming ubiquitous in industries such as the apparel manufacturing and retail business. A good number of companies are already working on applications that will take advantage of the availability of 3D body models to provide previously infeasible benefits to customers. Specifically, 3DBP sees this taking place in the online retail.

While the online sale of clothing is increasing year-over-year at a faster rate than the overall market (17.5% versus 6%), it is still only a fraction of the overall apparel world market (5% in 2015) [1]. One of the main roadblocks to increasing online sales is overcoming the problem people have in relating an online representation of clothing, both in terms of correct size and in terms of fit (“how do I look in this garment”) to how the clothing will actually look and fit on themselves.

2 Current Publications: White Paper #1

In February 2017, the working group published a white paper entitled ‘IEEE Industry connections: 3D Body Model Processing Initiative, An Introduction’ [2]. This white paper is the first of a series of white papers planned for 2017 and 2018.

The white paper covers three main topics through a possible Virtual Fit example: a detailed description of the need for interoperability, the finished model and relevant aspects for model generation; possible 3DBP use cases and the attributes that are relevant to these use cases; outlines of guidelines for selecting file format, network protocol and the type of metadata to be embedded in a 3D body model file. Security aspects are discussed as well.

Figure 1 depicts an example of 3DBP data flow in the context of the use case, “Virtual Fit” of True Fit [3]. This example ties not only the flow of 3DBP model generation but also the use cases of Fit and Size estimation, retail, clothing manufacturing, CAD tool development and the process of body model storage.

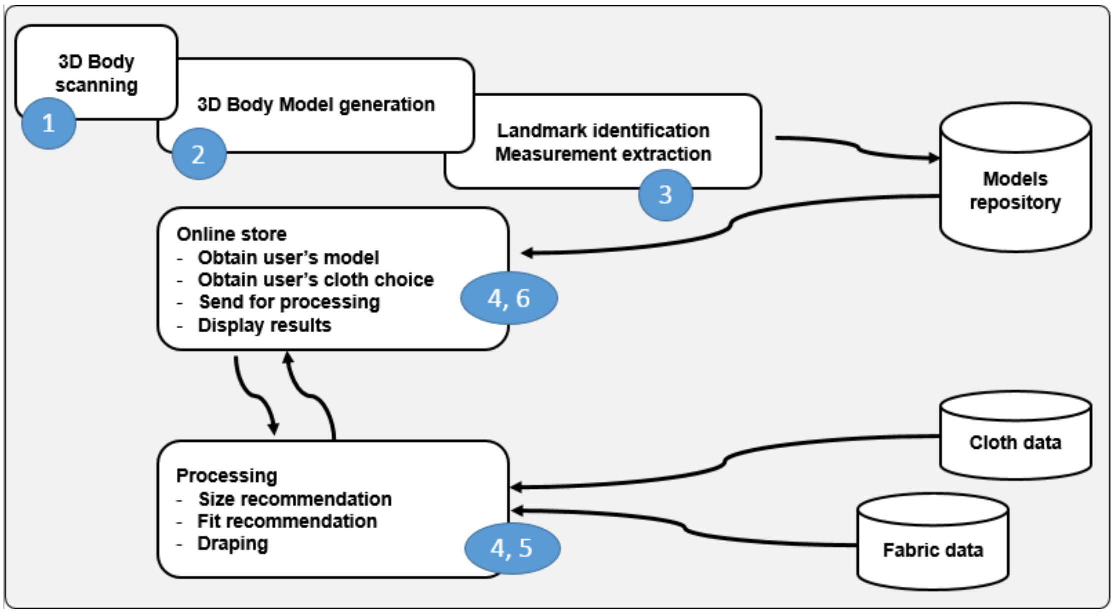

Figure 1: Example of 3DBP data flow in "Virtual Fit" use case of True Fit [3]

As an example, White Paper 1 described each of these steps by relating it to the Virtual Fit use case:

1) Scanning creates a raw 3D point cloud. The point cloud includes: noise, missing information (e.g. under the armpits) and may be piecemeal as a result of breaking data accumulation into several steps, (such as scanning the subject a number of times to get the front, sides and back data). In some cases, no point cloud is generated.
2) After the point cloud is generated, a variety of algorithms, public or proprietary are used to generate a 3D body model mesh. Processing includes smoothing the data, stitching it (if there are a number of raw point cloud files) and estimating missing information. Some implementations fit the data to statistical models when generating the final model.
3) Once a model is available, it can be used as input into software that estimates the location of landmarks and body measurements. This software is not necessarily tightly coupled to the model generation step and can run on body models regardless of the scanner used to create them. Some restrictions may apply. For example, the code may be expecting the subject to be scanned in a certain pose. Recognition and isolation of body parts may take place in this step as well.
4) Additional body-to-garment processing is required to produce a useful product. For example, digitized clothing can be virtually fitted over the body model. Digitized clothing provides attributes for cut, size, color, texture, stretching, and other attributes. The sources for this data can be local databases or remote repositories maintained by other companies (e.g. fabric manufacturer for fabric attributes; clothing manufacturers for clothes cut and size charts). Further aggregation may include downloading the body model itself from a model-repository (using some credentials to ensure the correct body model is fetched); downloading a model of a garment; and downloading fabric attributes. An aggregating engine collects this data makes it available to the next step.
5) The data is combined to create an end-user experience. For example, the end result can be a photo-realistic draping of a pair of trousers on a given body model.
6) The last stage provides the results in a relevant format. The results can be displayed on a screen and written to a database.

3 Technical Working Sub-groups

Within the 3DBP, there is an umbrella technology working group where separate sub- groups are focused in four areas: Quality, Metadata, File Format, and Communication/Security.

3.1 Quality Sub-Group

The Quality sub-group intends to provide methods, tools, benchmarks, resources and testing procedures to define and quantify the quality of 3D models, as well as the quality of the critical metadata for use cases, such as body landmarks and measurements.

Quality quantification is intended to be part of the quality-related metadata which will provide complementary information about what the user receives and to what extent it is reliable, accurate and trustworthy. Quality quantifications within the metadata focus are those that cannot be easily learned from the data itself, but does not consider trivial calculations, such as vertex count or the number of elements of the mesh.

Among the different steps within 3D body processing pipeline (Figure 2), the sub-group is initially focused on (A) 3D scanning, (B) Mesh Surface Reconstruction, (C) Digital Landmarking and (D) Digital Measuring since they are the more relevant for the considered use cases.

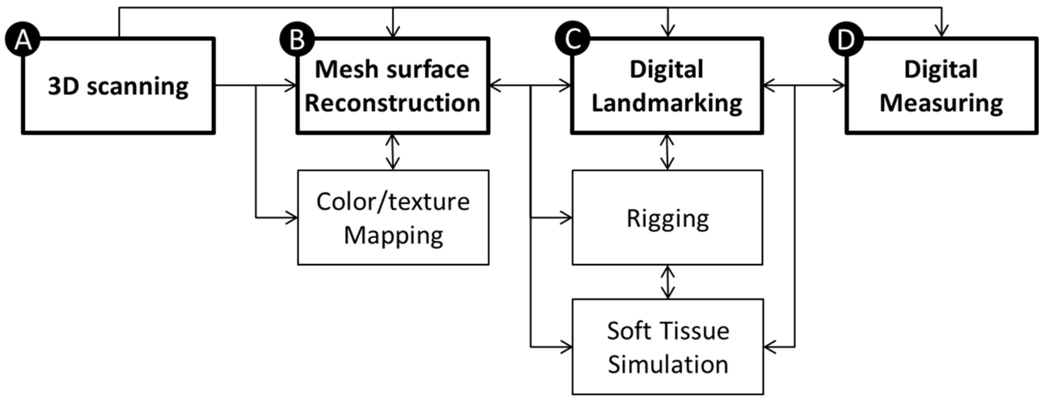

Figure 2: 3D Body Data Processing Pipeline [4]

Within these processes the quality attributes considered are related to:

- Descriptive information about the process, e.g., vendor, scanner specifications, software version, scanning pose or scanning attire.
- Qualitative descriptors and quantitative metrics for of the processed 3D surfaces related to noise, artifacts, redundancies, holes, smoothing and surface reconstruction
- Reliability of body measuring software
- Compatibility of digital body measuring and landmarking to methods dependent upon different digital software and/or traditional methods

Independent organisations such as International Standards Organization (ISO), American Society for Testing and Materials (ASTM), International Society for the Advancement of Kinanthropometry (ISAK) have already developed standards that are related to these topics and to a degree cover the requirements of the working group (Figure 3). In particular: ISO 8559:2017 [5] and ASTM D5219-15 [6] provide body measurement definitions for garment construction; ISO 7250-1:2017 [7] provides body measurement definitions for ergonomic design; ISAK [8] provides body measurement definitions for shape tracking in health, sports and fitness; ISO 18825-1 and 2:2016 [9-10] provide body measurement definitions for virtual models; ISO 20685:2010 [11] and ISO/DIS 20685-1 [12] provide 3D body scanning attire and compatibility thresholds between traditional and digital body measurements; and ISO 20685-2:2015 [13] provides testing and reporting procedures for spatial quality (sphere), as well as, procedures for landmark repeatability of life-size human dummies and determination of hidden areas.

The quality group makes use of existing standards, e.g. acceptability thresholds, measurement and landmark definitions, and scanning process reporting (Figure 3). It is focused on the gaps not covered by existing standards. In particular it focuses on: defining new metrics and methods for quantifying and qualifying 3D body surface quality, gathering test-bench datasets and reference values and determining quality thresholds for the different metrics.

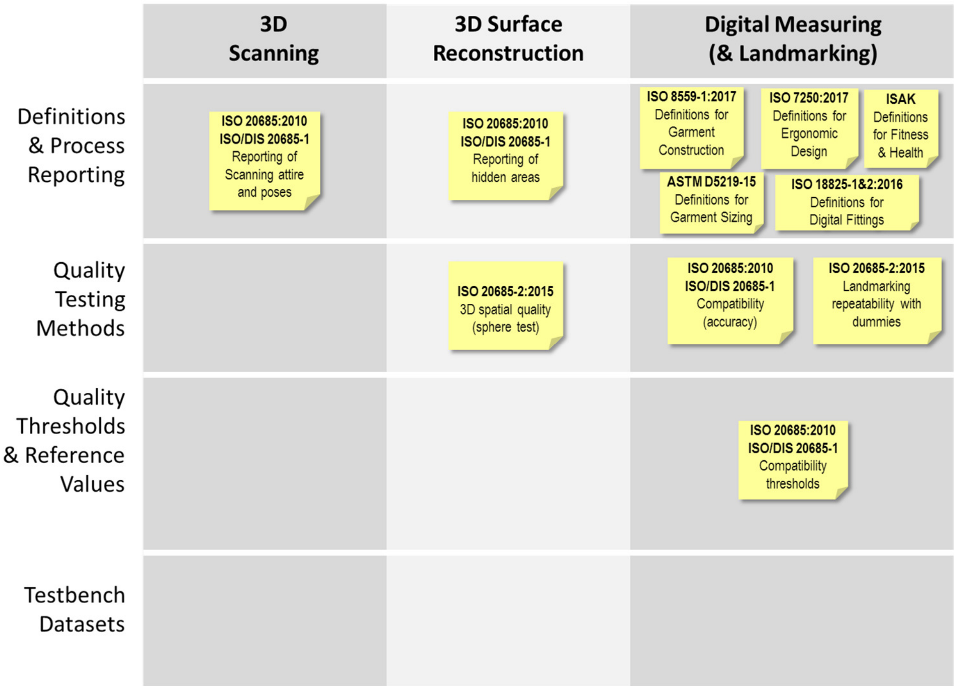

Figure 3: Map of current coverage of existing standards and gaps to be covered by the Quality Sub-group [14]

3.2 Meta Data Sub-Group

The Metadata working group intends to define mandatory and optional metadata, recommend landmark and measurement names and definitions (based on existing standards), and allow for vendor-specific metadata. The mandatory metadata includes gender, units, scanner brand and model, and scanner software version. The vendor specific metadata includes camera focal length and scan mode. Going forward, the Metadata group content may be absorbed by the quality and file format groups, as there is much overlap.

3.3 File Format Sub-Group

The File Format working group intends to narrow the recommended existing file formats that support model 3D data, such that all metadata is to be contained within the same pertinent file. As there are many existing file formats, the goal is not to invent yet another format that will need infrastructure to maintain it, but to find existing format(s) that provide the functionality required for 3D body scanning. The format(s) must also support embedment of metadata as part of the file, support file authentication and support encryption of the entire file or its parts.

3.4 Communication Sub-Group

The communication working group intends to select an existing protocol that ensures the secure sharing of personal 3D body data and metadata along the data value chain (from producers to users) using generic APIs. As there are many existing protocols, the goal is the same as the file format(s), to find existing protocol(s) that provide the functionality required for 3D body processing. The protocol(s) is/are required to be secure and provide encryption options for private data, and must support simple File Request/ File Send operations.

4 Ongoing Activity and Forthcoming Publications

4.1 White Paper #2

Landmarks and measurements are often defined differently by existing standards. Consequently, the source of the definitions must be identified. A second white paper, expected to be published sometime in Q4 2017, compares existing standards related to the landmarks and measurements that can be utilized from 3D body models. The three main sections of the white paper cover: examples of how landmarks and measurements are used in 3DBP applications and clarifies the role that landmarks and measurements accuracy plays in use case feasibility; discusses the current landscape of standards that deal with scanner accuracy and standards that define landmarks and measurements; and recommends a minimum list of landmarks and measurements for Retail 3DBP. The appendices provide a short description of the content of the associated standards along with the landmarks and measurements in each standard reference, along with a complete list of defined landmarks and measurements.

4.2 Procedures for Gathering a Canonical Database of 3D Body Scans

It is important to compare and contrast the L&M accuracy derived from scans to traditional anthropometric methods which typically involve two steps: (a) Identification of landmarks on the subject's body by palpation and (b) using these landmarks to take measurements manually using measuring instruments, e.g., a stadiometer, different types of calipers and measuring tapes. Within these procedures, the two main sources of errors are the intra-observer error and the inter-observer errors

The measuring protocol was developed by the 3DBP Quality sub-group after determining which landmarks and measurements were required in a Retail environment, and using these landmarks and measurements, the measuring protocol was developed by the 3DBP Quality subgroup. It is an adaptation of the process for 3D body scanning described by Kouchi and Mochimaru [15].

The measuring protocol consists of three consecutive sessions per subject: Session A, Session B and Session C. Half of the subjects will start with Session A and half of the subjects with Session B. Session C will always be conducted with enough time between Sessions A and Sessions B such that the Markers do not remember previous landmark placements. For landmarks and measurements that can be left- or right side-oriented, the same side per subject should be marked and measured for all Sessions. Details including results from a soon-to-be–released protocol will be published in a future white paper.

This protocol is planned to be used to set up a canonical database of raw 3D body scans and their respective ground truth body landmark positions and measurements extracted by two expert anthropometrists using traditional methods as shown in Figure 4). This can be used as an initial test-bench for the assessment of the accuracy (compatibility) of digital body measuring software compared to traditional anthropometry. The repeated scans gathered and the 3D scan data within this protocol can be used as initial benchmarks for other quality attributes, e.g., reliability of measurements. Moreover, the Intra- observer and inter-observer errors gathered could be used for the estimation of new accuracy (compatibility) thresholds and as benchmarks for traditional anthropometry. Before the 3DBP recommends the protocol to scan provider companies, the protocol will have been vetted for ease of use and repeatability.

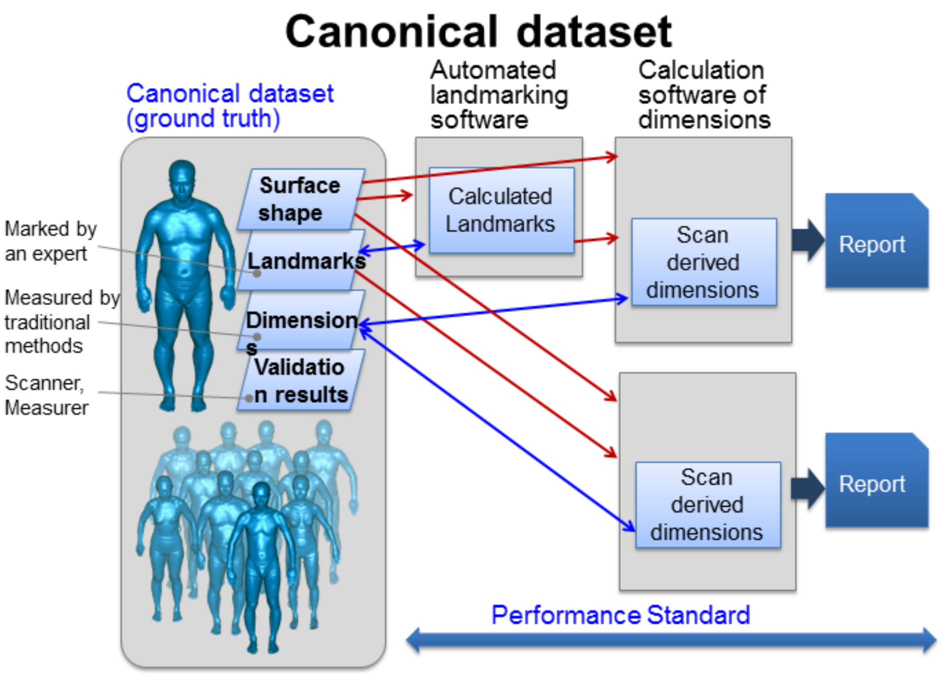

Figure 4: Canonical database [14]

4.3 Results of questionnaire to industry

In addition to researching the current state of standards and practices, surveys were conducted that covered all of the subgroups of Quality, Meta data, File formats, and Communication/Security. Since 3DBP fully represents companies involved in the supply data chain from its creation to its final use, the surveys were distributed to all members of the group and to other external interested parties. If the representatives of the companies (members within the working group) could not answer the questions, the surveys were forwarded to the appropriate people within their respective companies.

The companies and organizations that participated were: 3Daboutme, 3dMD LLC, National Institute of Advanced Industrial Science and Technology (AIST – Japan), Avametric, University of California - Berkeley, Bauerfeind, Bauerfeind ag, Body2Garment Solutions, Browzwear, Elasizer, ELSE Corp, Gneiss Concept, Human Solutions GmbH, Instituto de Biomecánica de Valencia (IBV), Intel, Lectra, Metail Ltd., Novaptus Systems Inc., United States Army Natick Soldier Research, Development and Engineering Center (NSRDEC)- Anthropometry Team, Picanova (3D.me), Polytechnic University of Tirana (Faculty of Mechanical Engineering, Textile & Fashion Department), QuantaCorp, Size Stream, Target, Texel, True Fit, Technische Universiteit Delft (TU Delft), University Of Michigan - Ann Arbor, United States Air Force, Web3D Consortium and ZelusFX.

The results of the survey along with the recommendations will be addressed in a future white paper.

4.3.1 Quality Topics/Questions

Since the quality of the surface of the scan can impact the scan's usefulness for use cases, such as Fit and Size estimation, and for clothing manufacturing, most of the Quality questions were related to the quality of the surfaces generated by the scan. Participants were asked to choose "*allow/ not allowed"* in response to the questions regarding: highly creased edges, surface spikes, surface self-intersections, small objects in the air (i.e. hair), surface holes, non-manifold edges, and small tunnels.

The results implied that the scans will need to document quality attributes for users and identify the existence of the conditions listed previously.

4.3.2 Metadata Topics/Questions

Since the pose of a subject can impact the Fit and Size estimation, most of the Meta questions were related to the pose and attire of the subject, and included poses involving inanimate objects, such as foot supports. Questions regarding the Meta data were to be answered in the format: *must be present / may be present*. The questions concerned: describing what pose is in the file, describing finger configuration in the file, describing palms rotation in the file, describing arm bending in the file, describing leg bending in the file, describing hairstyle in the file, describing clothes in the file, and describing extra objects in the file

The survey results showed that the pose should be noted in the Meta data, but any other pertinent details concerning pose and attire was considered optional.

4.3.3 File Format Topics/Questions

File Formats impact the usability of the scan file for Retail, Clothing manufacturers, CAD Tool Developers and Body Model Storage providers.

The questions posed with regard to File Formats requirements were: file format is optimized for rendering, support for storing measurements with curves, extensibility to add data, file format supports storing everything in one file, open specification of file format, ready to use open source implementation of import/ export in at least one programming language, ready to use open source implementation of import/ export in a number of programming languages, good documentation for import/export integration with common use case examples and file format is in active development by its community. Participants were requested to evaluate the attributes according to a five point scale ranging from "not needed" to "must have".

The results of the survey implied that 1) extensibility to add data, 2) data storage, 3) import/export capabilities and 4) active development were all critical requirements for the file format(s) chosen.

4.3.4 Communication/ Security Topics/Questions

It is imperative to communicate the impact of scan file security to consumers, Retail, Clothing manufacturers, CAD Tool Developers and Body Model Storage providers. Without security at the appropriate level for consumer data, consumers may not want to be body scanned at all, and this would delay implementation of the 3DBP infrastructure and adoption of 3DBP technologies across all industries.

The Communication group questions focused on native versus external file encryption. The questions were: native encryption of parts of the file, i.e. vendor specific metadata or attributes (instead of storing them in external encrypted file), native whole file encryption (instead of packing it to encrypted ZIP-archive or similar solutions), native document signing support (instead of storing signature in external sidecar file), and small file size (file format native support of efficient data compression, instead of simple storing of body model file(s) in ZIP-archive). Participants were requested to evaluate the attributes according to a five point scale ranging from “not needed” to “must have”.

4.4 Industry Collaborations - 3D Retail Coalition and Design Charrette

Currently, the 3DBP is entering the standards development stage and is actively establishing a range of collaborations with consortia and standards efforts. One key partnership is with the 3D Retail Consortia (3DRC), a consortia of top brands and retailers from around the world. Currently chaired by Target, the 3DRC, in collaboration with IEEE 3DBP has held a few activities. The collaboration began with a panel at CES in Jan 2017. This panel included speakers from a sampling of members (Size Stream, Target, Gneiss Concept, Intel, IEEE and True Fit), where each shared how their organizations are framing the role of standardization as part of their technology development and deployment. The next activity was a webinar, hosted by 3DRC, where IEEE 3DBP leaders shared an overview of the 3DBP initiative as well as a summary of the 2016 3D body scanning conference in Lugano. Most recently, IEEE and 3DRC collaborated to organize and run a design charrette” workshop as part of the (Product Innovation) PI Apparel conference held at IEEE’s NYC office on June 2017 around the topic of 3D Digital Transformation. The 3D Digital Transformation charrette was designed to help representatives from brands and retailers explore and develop an increased understanding of drivers of uncertainty for retail from various perspectives as well as ways for how 3D technologies and strategies could enable digital transformation. In this highly interactive, team-based workshop, groups of 5-6 people worked through their persona, tools, scenarios and challenge questions to simulate the 3D digital transformation process. The day was divided into two rounds, one in morning and one in the afternoon, each round with a set of discussion topics, followed by rapid brainstorming and cognitive prototyping. These activities are examples that IEEE believes will help promote collaboration.

5 Next Steps

The next steps for the 3DBP will be to identify and resolve gaps required to establish a robust ecosystem aimed at growing opportunities and innovations around 3D body processing. As discussed, the goal of the 3DBP initiative is to create complementary standards and practices that promote an ecosystem that “lifts all boats” and drives future growth opportunities for players across the 3D body processing value chain.

The various standards need to be organized into a coherent body, such that industry has the same quality level understanding, file formats/ protocols are compatible, and security levels are defined. Certification programs for scanning processes, methods, and software would help industry qualify the quality of 3D scans.

Presently, training for 3D scan users and body measurers have been localized to the company or organizational level.

Training in the traditional measurement methods is not easy to accomplish, since body models are required. Many practice hours are required before one is considered an expert. The definitions of landmarks and measurements of the human body have been defined differently depending on the standard followed.

Security risk threat models still need to be developed to protect customer data for the long term.

Going forward, the Working Group's intend to execute the canonical protocol and publish the results in a white paper. One yet-to-be published white paper will compare existing standards with recommendations from the retail sector. Results from the aforementioned industry surveys will be published and will include recommendations for file formats, meta-data, quality standards, avoidance of security threats and protocols. Collaboration with other Standards committees and organizations is encouraged and will continue.

6 Summary

This paper describes a summary of activities and progress that the IEEE P3141 - *Standard for 3D Body Processing* has made since Q4 2016, as well as future goals. The first of a number of white papers have been published, internal group surveys for data and file requirements have been completed, the test protocol for gathering a canonical database of 3D body scans has been written, and collaborations with other organizations have been established.

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