Overview Paper: Datasets of 3D Deformable Digital Models of Clothes and Garments Usable in the Metaverse

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Abstract – **The reconstruction of 3D models of people and dressing them in digital clothes, also known as avatars in recent years, has seen a kind of evolution caused by the growing needs of our society in the online environment. The processes of digitalization and virtualization in every aspect of our lives will give rise to phenomena leading to changes in social relations and the construction of a new reality. In this scientific paper, an overview of all available datasets of 3D deformable digital models of clothes and garments is done. The intent of this survey is to review the state-of-the-art approaches in the area and analyse their strengths and weaknesses.**

Keywords – **3D Reconstruction, Deformable Models of Digital Clothes, Scanning and Digitalising Garments, Overview, Metaverse;**

I. Introduction

The processes of digitalization and virtualization in every aspect of our lives give rise to phenomena leading to change in social relations and the construction of a new reality. Our research is based on the prediction of the future impact of the virtual universe (Metaverse), as a kind of new social environment of communication that will change our current perceptions of reality and needs as humans. [1][2]

The Metaverse is a new sort of Internet application and social form that incorporates a number of novel technologies. It utilises augmented reality and computed vision technologies to grant an immersive experience, by using digital twin techniques to produce a mirror image of the real world, adopts the blockchain algorithms to establish an economic system, and tightly merges the virtual and real worlds into the economic, social, and identity structures, allowing each user to generate content and customise the realm. It is still a notion in flux, with different participants adding to its meaning in their own unique ways. [1][4]

The direction in which technology is evolving predetermines and requires the use of our online counterparts (avatars) in today's rapidly evolving environment with ever-changing conditions.

Digital commerce is currently the most active – and increasing – consumer segment for many manufacturers and retailers. According to some researches and reports [5][6] more than a third of manufacturers expect ecommerce sales to expand by at least 25% in the two-year period 2023-2024. AI, digital marketing, and self-service solutions are some of the most preferred expenditures and technology integration are among companies, according to other researches.[7][8]

As a result, all kinds of businesses are trying to wiggle themselves in the new social media platform and the new upcoming Metaverse in a variety of ways [1][3]:

- Amazon – has been developing a new virtual shopping space in the Metaverse;
- Facebook – renamed themselves "Meta" and in 2019 released a VR social platform;
- SK Telecom – created a virtual universe where members may host and attend meetings as cartoon avatars;
- Gucci – launched a VR shoe trying platform and developed a virtual sport's shoe collection;
- An increasing amount of fashion brands are creating NFT designs and virtual clothes compatible with other social platforms, games and virtual universes. [9][10] (see Figure 1)

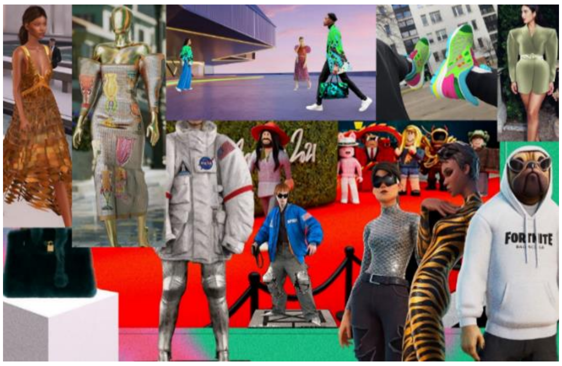

Fig.1 A collage consisting of visual examples of virtual clothes: NFTs, garments from games, AR filters etc.

As digital environments come of age, they transform from linear and transaction focused spaces into multi-dimensional, experiential and collaborative virtual worlds. Virtual clothing is picking up momentum across a range of digital environments. Digital fashion is the natural extension of applying social media filters on platforms like Instagram and Snapchat.[10][11]

II. Catalogue of Datasets

The main goal of this scientific paper is to provide a full list of available datasets of 3D deformable digital models of clothes and garments after conducting an in-depth analysis of the latest revolutionary algorithms in the field of 3D garment reconstruction. Table 1 contains a short summary of the content

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TABLE I
LIST AND SUMMARY OF DATASETS OF DIGITAL MODELS OF CLOTHES AND GARMENTS

Dataset Name	Year	Access	Main Aspects	Basis	Focus
CLOTH3D [12]	2020	private	7000 non-overlapping sequences of 300 frames each at 30fps, yielding a total of 2.1M samples. Garments are automatically generated for each sequence.	SMPL	sample variability
TailorNet [13]	2020	open	20 aligned real static garments, simulated in 1782 poses, for 9 body shapes, totalling 55800 frames.	Marvelous Designer 3D	realistic wrinkles
Santesteban et al. [14]	2021	open	4 unseen sequences and 17 different body shapes with two garments.	SMPL	wrinkleless simulation
DeepWrinkles [15]	2018	private	Each image contains a coloured mesh with 200K vertices.	Scan	model is learned independently from body shape and pose
GarNet++ [16]	2020	open	Fitting a T-shirt, a sweater, a dress and a pair of jeans represented by 3D triangulated meshes with 10k vertices over 600 synthetic bodies.	NvCloth	can be applied to real-time applications
DeepFashion3D [17]	2020	open	2078 models reconstructed from real garments, which covers 10 different categories and 563 garment instances.	Scan	accurate reconstruction
Sizer [18]	2020	restricted	100 different subjects with 10 casual clothing classes in various sizes in total of around 2,000 scans.	Scan	size variation
Multi-Garment Net [19]	2019	open	356 3D scans of people with various body shapes, poses and in diverse clothing.	Scan	realistic look
3D GwSP [20]	2021	open	19 garment groups, seven of which are recommended to be used for evaluation only while others could be used for training.	Pattern	complex garments
Vidaurre et al. [21]	2020	private	19 different garment pattern designs, two different topologies per design, and 201 values for body shape.	Pattern	can cope with a large family of garments
BCNet [22]	2020	open	Synthetic Dataset - pairs of the color image and corresponding body and cloth shapes with 48000 neutral garments for training, and 6467 for test.	Pattern	synthesized neutral garments
		private	HD Texture Dataset - 285 rigged avatars with high-quality geometry and realistic texture.		HD and visually realistic
TightCap [23]	2022	restricted	880 human models with 228 different garments (segmented top/down clothing/shoes) under various human postures.	Scan	large variety of clothing styles
ERCS [24]	2021	private	3 databases of 3 garments: T-shirt (12.2k verticles), long-sleeved shirt (12.0k verticles) and pants(11.7k verticles).	LBS	includes real-time cloth animation method
DNG [25]	2021	private	3 coarse garment templates with five different target garments: 3 types of long skirts, a short skirt and a full-bodydress.	Scan	complex and voluptuous garments
GAN GG [26]	2020	open	Over 100 different garment types in the dataset, including dresses, t-shirts, pants, skirts and swimsuits of varying patterns, and materials.	Pattern	big variety of sewn garments
3D VGM [27]	2019	private	3,000 images of tops with 13 defined landmarks and 3,000 images of pants with 7 defined landmarks.	Scan + Pattern	2D garments ready for 3d reconstruction

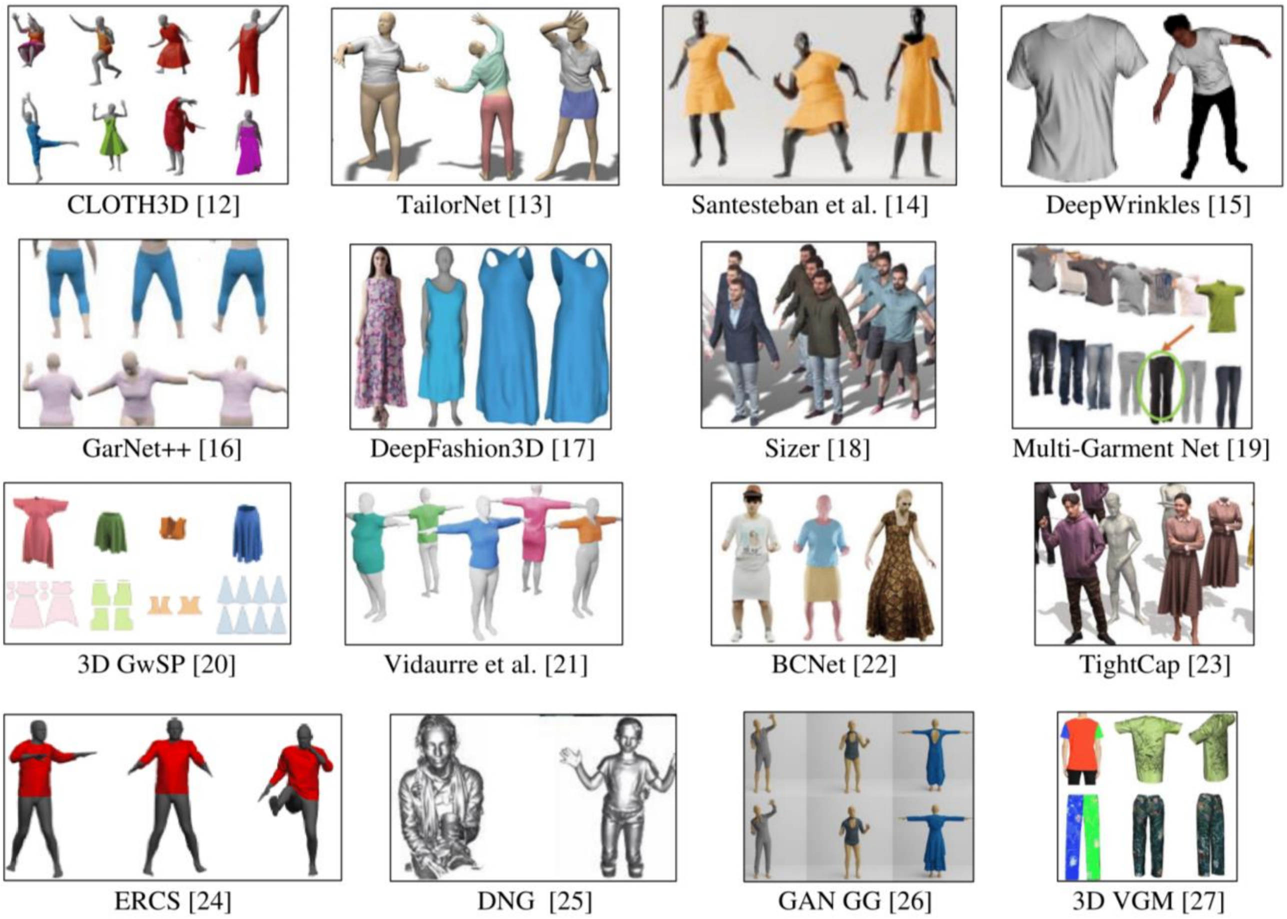

Fig.2 Samples from all the analysed datasets of 3D deformable digital models of clothes and garments.

of the datasets and a brief phrase reflecting their focus. The number of presented datasets is 16.

The first column contains names; the second contains the year of their publication. Column "Access" represents the type of accessibility of the datasets. "Open" means that the data can be accessed by anyone without the need for special permission. "Private" means that the information is not available to the public and is not intended to be used by others. "Restricted" means that in order to get access to the dataset, certain information is required to be presented beforehand (proof of being a student and/or researcher). Column "Main Aspects" contains a concise description of the visual connotations. The "Basis" column shows an aspect that characterises the foundation of the reconstruction method. The last column is a subjective summary of the best attributes of the datasets. Figure 2 contains visual examples of all datasets.

III. Key Findings

After conducting thorough research in the area, a numerical statistic can be derived. A majority of the detests are not freely accessible for public use, amounting to about 53.1% of all entries. Of them, around 40.6% are fully private and cannot be found online, the other 12.5% are semi-private, or, in other words, restricted, and can be accessed after an authentication, of the person attempting to obtain them, consisting of proof that the data will not be utilised in a commercial way. The residual percentage of research of 46.9% is labelled as open access, but the non-commercial use clause is still in effect. In the best-case scenario, a researcher can operate and work with about 59.4% of the existing datasets, which comprise 3D deformable digital models of clothes and garments. These statistical results can be explained by the modest amount of experimentation in the field and the complexity of the task. A greater amount of available data will be a big benefit and may reduce the development time of future scientific research and fieldwork overall.

Another interesting aspect of this overview is the analysis of the foundation on which the methods used for the reconstruction of 3D garments are based. The most popular approach is reconstruction based on real 3D scans of either clothed people or garments only, it is used in about 40% of the cases [15][17][18][19][23][25][27]. The second-most-used method is based on realistic sewing patterns [20][21][22][26][27]. In this case, found in around 30% of papers, the construction of the clothes is derived from 2D schemes called patterns. The 3D VGM[27] dataset uses a combination of both scan-based and pattern-based approaches, where an article of clothing is scanned, analysed, and turned into a sewing pattern for future reconstruction. CLOTH3D[12] and Santesteban et al.[14] base their research on the well-known SMPL[28] algorithm and use the shape of a person's body to adapt clothes. The last three[13][16][24] conduct the reconstruction on either the socialised software fashion design tool Marvelous Designer 3D[29], the Nvidia library named

NvCloth [30] that offers simple access to an interactive real-time clothing solution, or an original method Linear Blend Skinning method (LBS) [24] where the shape of the clothes is derived as a linear blend skinning from the pose of the model.

IV. Conclusion

Although most datasets are visually similar and, from a user's point of view, all are viable options for any use, the truth is that in terms of structure, construction method, and output file type, there is huge diversity. That is because of the lack of standardisation in the area and in 3D reconstruction and visualisation in general. The absence of a solid foundation slows down future progress.

The main two problems derived from this research show that there is still a lot of work to be done and that some kind of standardisation is needed.

This study narrowly touches on the problems and limitations this area has. It is mostly based on statistics and visual examples provided by the authors of the datasets, which makes it a very subjective research. The results are taken as all true. A recommendation for future work is to focus on an experimental overview and comparison of all accessible datasets.

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