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Avatar Morphing for Virtual Fashion Prototyping

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Abstract

Morphing avatars in right size and shape is an essential part of any virtual clothing simulation process in order to ensure the proper fit and appearance of any virtual prototype simulated on to them. It is also a precondition for evaluating fit of virtual clothing and for taking decision on the accuracy of digital pattern pieces used in simulation. Commercial CAD systems come with a library of parametric mannequins and provide tools and facilities for adjusting their sizes and shape before using them for the purpose of virtual clothing simulation. This paper deals with the features and techniques of avatar morphing in different commercial CAD systems and identified the similarities and dissimilarities in them. It was found that body measurements used in traditional pattern cutting, as can be found in available textbooks, are too limited for use in avatar morphing. On the other hand, the available CAD systems cannot make proper use of the many measurements that can be extracted from Body scan data. It has been experienced that none of the CAD systems in use provided absolute freedom to adjust all avatar-morphing criteria to reproduce the target anthropometry completely.

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Introduction

Three mandatory ingredients for producing a virtual fashion prototype are: a virtual avatar, digital garment design (usually pattern pieces) and a fabric simulator. If all of them can be accommodated within a 3D CAD environment, a virtual 3D garment can then be developed. In that case, virtual avatars serve as the design platforms upon which virtual clothing can be developed. The early virtual mannequins developed in the late 1950s and early 1960s were targeted for use in ergonomic analysis and accident simulations in the aeroplane and automobile industries (Thalmann and Thalmann, 2004). Their use for clothing design can be seen in the work of Hinds and McCartney (1990) at the beginning of the 1990s. However, the initial avatars used for clothing design were mostly a virtual form of dress dummies and were not noticeably realistic in anthropometric point of view (Hinds and J. McCartney, 1990 and Okabe et al., 1992).

The common techniques that have been employed to produce virtual avatars fall into any of the three categories: creative, reconstructive and interpolated (Mao, Qin and Wright, 2009). Developing an avatar from first principles exploiting the 3D drawing and rendering tools available within 3D CAD software packages (e.g. 3D Studio Max®, Maya) is considered as a creative approach to develop human models. While they are smart enough to produce attractive cartoon and movie characters, they are not reliable enough to reproduce the body geometry and anthropometry as realistically as it is required for fashion prototyping. The reconstructive techniques utilise 3D information of a real human body or dress form captured by devices such as the still camera (Wang et al., 2003 and Lee, Gu and Thalmann, 2000), video camera (Plankers, Fua and D'Apuzzo, 1999), sliding gauge (Kang and Kim, 2000b) and 3D body scanner (Kim and Kang, 2002; Seo and Thalmann, 2004 and Cho et al. 2005). Depending on the quality and efficiency of data capture, these techniques can output realistic body geometry and structure. Therefore, these are considered as the most appropriate for producing avatar targeting clothing design. Among the data capturing devices, body scanners have emerged as the most efficient and convenient instruments for the capture of anthropometric information to construct a realistic virtual human model using the CAD techniques such as triangulation and simulation (Jones et al., 1995, Sayem et al., 2014, 2017). Therefore, these techniques are considered as the most suited ones for creating virtual avatar for virtual fashion prototyping. The third techniques as the name implies generates new body shapes through interpolating existing size and shape information (Seo, 2004 and Seo and Thalmann, 2004).

There are both parametric (resizable) and non-parametric (non-resizable) body models that can be used in clothing CAD systems. Kang and Kim (2000c) presented an algorithm to generate body models in different sizes from a standard body model using statistical calculation. Seo and Thalmann (2004) presented a technique for generating realistic and parametric human models that could be modified using eight anthropometric measurements (five girths and three lengths) as essential size parameters. Sayem (2004) demonstrated a parametric model that could be modified using 19 parameters comprising 16 closed-curve measurements and 3 additional breast parameters such as breast height, distance between breast points, and breast diameter. Cho et al. (2005) developed an interactive body model that offered eight slide bars for controlling shape parameters and three slide bars for controlling length. Later they demonstrated a posture and depth adjustable body model for use in the clothing industry (Cho et al., 2006).

Since 2001, a notable number of 3D CAD systems, namely Vsticher (Browzwear, Singapore), Modaris (Lectra, France), AccuMark 3D (Gerber, USA), TUKACAD (Tukatech, USA), OptiTex PDS (OptiTex, USA) and Vidya (Assyst-Bullmer, Germany), that support virtual fashion prototyping has started to become available on the market (Goldstein, 2009). These come with a library of parametric mannequins and provide tools and facilities for adjusting their sizes and shape before using them for the purpose of virtual clothing simulation. This paper investigates into the avatar morphing features and techniques in different commercial CAD systems to identify the similarities and dissimilarities in them.

Methods

Four commercially available CAD systems, hereafter mentioned as CAD system A, B, C & D, were selected to investigate into their avatar morphing tools and features. One male and one female avatar representing the anthropometry of a young man and woman were selected from the mannequin library of each CAD system to review each of them individually and to compare among each other. Two standard body measurement tables (see Table 1 & 2) from Aldrich (2012, 2015) were selected for morphing the selected male and female avatars in all CAD systems. Body measurements extarcted following the SIZEUK body measurement definitions from two sample body scans (one male and one female), see Figure 1 & 2, in KX-16 bodyscanning system (TC[2], USA) were also utilised to morph the selected male and female avatars in the CAD systems in use.

Table 1: Standard body measurements of young men (Aldrich, 2012)

#	Parameters	Measurement (cm)
1	Height	173
2	Chest	96
3	Seat	98
4	Waist	82
5	Trouser waist (4-6cm below waist)	86
6	Half back	19.5
7	Back neck to waist	43.8
8	Scye depth	23.6
9	Neck size	39
10	Sleeve length one piece sleeve	64.2
11	Sleeve length two piece sleeve	81
12	Inside leg	79
13	Body rise	27.8
14	Close wrist measurement	17.4

Table 2: Standard body measurements of women (Aldrich, 2015)

#	Parameters	Measurement (cm)
1	Height	160
2	Bust	88
3	Waist	72
4	Low waist (5 cm below natural waist)	82
5	Hips	96
6	Back width	34.4
7	Chest	32.4
8	Shoulder	12.25
9	Neck size	37
10	Top arm	28.4
11	Wrist	16
12	Ankle	24
13	High ankle	21
14	Nape to waist	41
15	Front shoulder to waist	41
16	Armscye depth	21
17	Waist to knee	58.5
18	Waist to hip	20.6
19	Waist to floor	104
21	Body rise	28

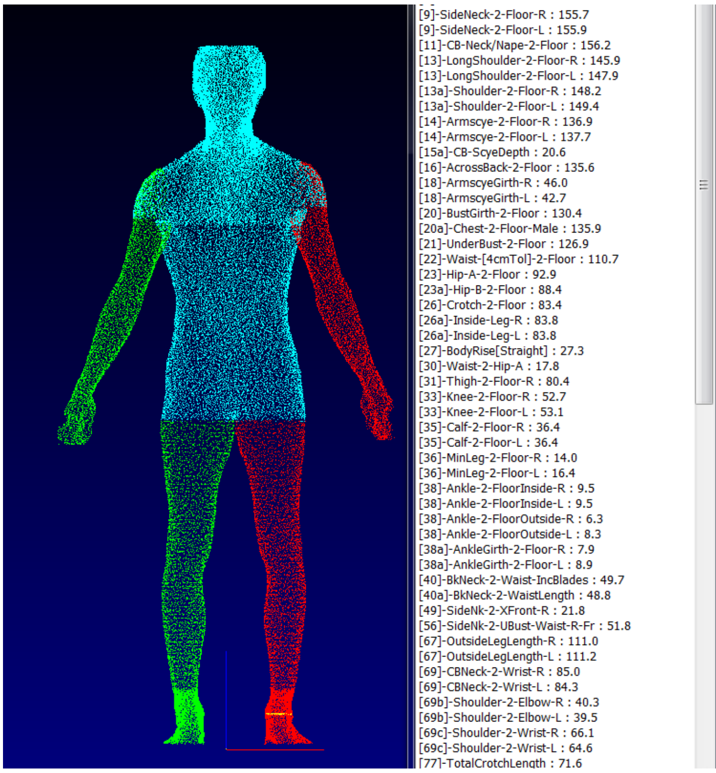


Figure 1: Male bodyscan and part of extracted measurements

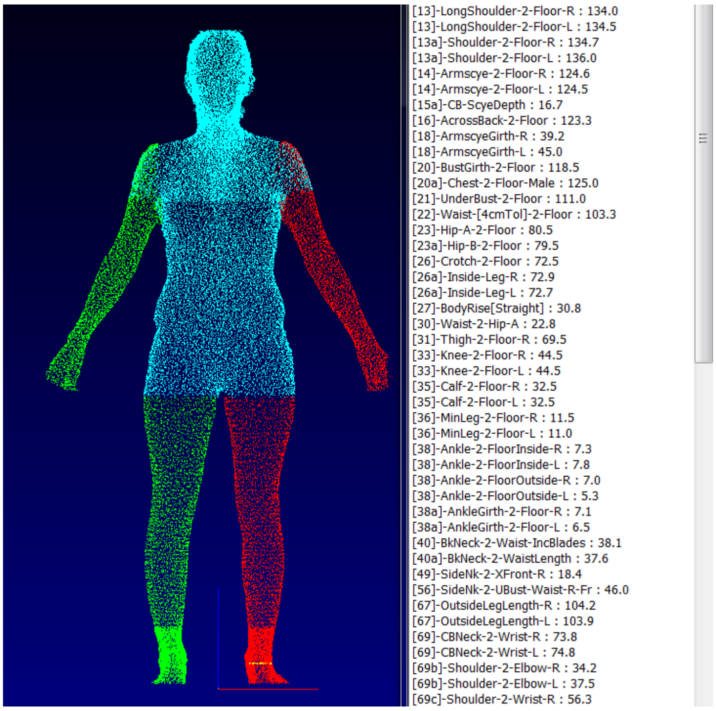


Figure 2: Female bodyscan and part of extracted measurements

Results & Discussion

a) General Features

Tables 3 and 4 show the number of anthropometric parameters used by the CAD systems to morph the male and female avatars. CAD A and B use more than sixty parameters for adjusting the size and shape of a male avatar, while C and D use thirty or less. Similarly in case of female avatar, CAD A and B use more than hundreds parameters, whereas C and D use forty or less. In most cases system A, B and C allow direct input of neumerical measurements as well as sliding-bar option. However, system D allows only sliding-bar option to adjust measurement, but no direct input. In general, direct measurement input was experienced as more accurate for avatar morphing. However, it has been experienced that none of the systems provided absolute freedom to adjust all avatar-morphing criteria to reproduce the target anthropometry completely. Tables 5 & 6 highlight the interconnected measurements, which are influenced by the change of others. This is a big obstacle in accurate avatar morphing.

Table 3: Morphing categories and anthropometric parameters of male avatars

Morphing Category/Segment	Number of Parameters			
	A	**B**	**C**	**D**
Height	2	2	1	1
Body silhouette & shape	15	15	6	8
Torso length	9	2	4	3
Torso width	3	1	2	0
Torso circumference	7	5	5	4
Arms (lengths & circumference)	5	6	4	1
Legs (lengths & circumference)	9	8	7	2
Pose	13	24	9	0
Face	0	2	0	0
Total =	**63**	**65**	**39**	**19**
i) How many accepts direct measurement input?	*33*	*39*	*2*	*0*
ii) How many needs sliding-bar adjustment only?	*30*	*16*	*30*	*19*
How many offers both i & ii options	*33*	*39*	*30*	*0*

Table 4: Morphing categories and anthropometric parameters of female avatar

Morphing Category/Segment	Number of Parameters			
	A	B	C	D
Height	2	2	1	1
Body silhouette	19	29	6	7
Torso length	11	2	5	5
Torso width	3	1	2	0
Bust	13	1	2	2
Torso circumference	8	6	6	4
Arms	6	7	4	1
Legs	13	9	7	1
Pose	12	27	9	0
Face	14	30	1	0
Total =	**101**	**114**	**42**	**20**
How many accepts measurement input?	47	68	32	0
How many needs sliding-bar adjustment?	54	46	34	20
How many offers both i & ii options	47	68	32	0

Table 5: Interconnected measurement parameters of male Avatars

CAD Systems	Interconnected Parameters
A	- Chest and under-chest - Outseam, hip height, high-hip height and waist to hip (in case of mannual imput) - Biceps and upper biceps are interconnected
B	- Shoulder and chest - Waist, high waist, hips and rise, - Thigh and knee - Outside leg, rise and inseam measurements
C	- Height influences across back, across front, shoulder length & slope, back height, bust, waist, mid hip and pelvis. - No other parametesr are interconnected.
D	- None

Table 6: Interconnected measurement parameters of female Avatars

CAD Systems	Interconnected Parameters
A	- Body depth, inseam, hip height, high hip height and low thigh height - Bust, over bust, under bust - Knee and calf - Bicep and upper bicep
B	- Bust, cup and under-bust - Hip, belly and high hip - Outside leg and inseam - Thigh, knee, calf and ankle - Armhole, biceps, arm, wrist. - Wrist, over arm measurement
C	- Bust, underbust, neck to bust apex - Waist-floor side length, bust apex, inseam and body rise
D	- None

b) Morphing from Body measuresents used for pattern cutting

The standard body measurements used for pattern cutting include only 14 and 21 size paratmeters for man and woman respectively, which are far less from the number of anthropometric parameters used by most of the CAD systems for avatar morphing. While the systems A, B and C can utilise most of the measuremenst from tabel 1 and 2 for male and female avatar morphing, system D uses only very few ones. When size and shape were modified using the measurements from table 1 and 2, significant differences in appearance and shape could be noticed (see figure 3 and 4).

Figure 3: Male avaters morphed using the measurement from table 1

Figure 4: Feale avaters morphed using the measurement from table 2

c) Morphing from Body Measurements extracted from Bodyscan data

Following the SizeUK measurement definitions, as high as 144 measurements could be extracted from both the male and female scans. These measurements include individual measurements for both left and right limbs and parts of the body. However, as clothing is usually made symetrical, average of the left and right limbs/parts in relevant cases, for example biceps, thigh girth etc., are enough for avatar morphing. Systems A, B and C utilise majority of the torso measurements from bodyscans for morphing both male and avatar morphing. However, visible differences in the appearance and shape can be noticed in the morphed avatar (see Figures 5 & 6) as the CAD systems includes some morphing criteria that do not accept any numerical measurement inputs. Moreover, bodyscanning system offers opportunities of extracting many critical measurements from body that can be used for effective avatar morphing. For example, for shoulder area several measurements (see Figure 7 & 6) can be extratced (TC^2) for better reproduction of shape on virtual avatar. Currently none of the CAD system makes use of them.

Figure 5: Male avatars morphed using extracted measurements from bodyscan

Figure 6: Female avatars morphed using extracted measurements from bodyscan

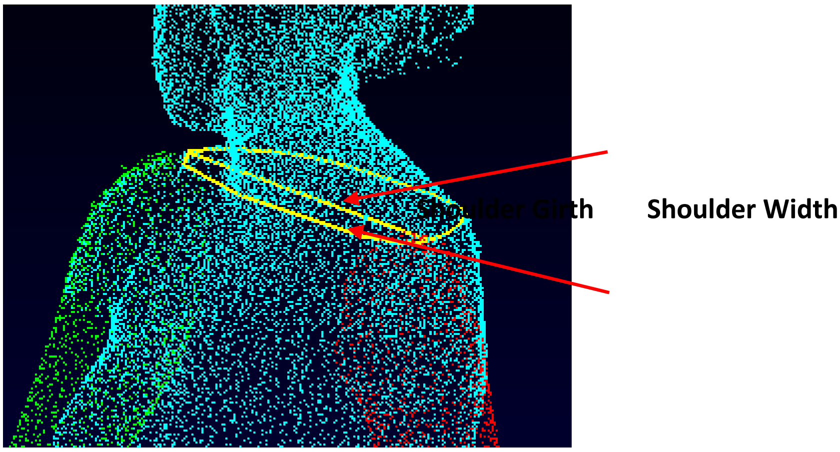
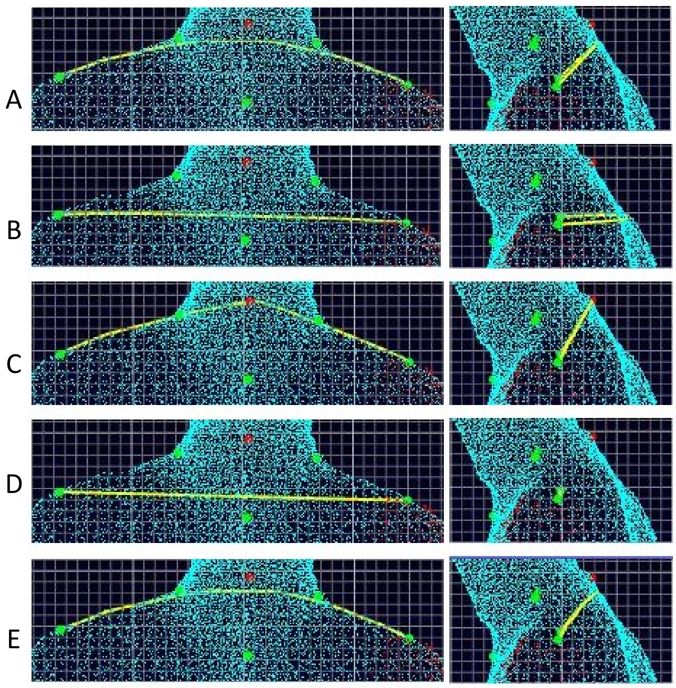


Figure 7: Shoulder Girth and width measurements from bodyscan



Figiure 8: A) Shoulder to Shoulder@45 Degrees, B) Shoulder to Shoulder Horizontal, C) Shoulder to Shoulder thru back neck, D) Shoulder to Shoulder Caliper, E) Shoulder to Shoulder (shortest path)

Conclusion

Althoulgh commercial 3D CAD systems are available on the market since 2001; an equal development of avatar technology has not taken place across the CAD systems. The aim of this paper was not to identify which CAD system is more efficient in avatar morphing, rather to highlight the areas of further development in virtual fashion technology. It is merely impossible to produce virtual clothing and to do virtual fit analysis accurately if the avatars in the CAD systems cannot be morphed to the required size and shape. This limitation with existing CAD systems is one of reasons why virtual fashion technology has not been adopted in the industry in any remarkable level although the technology is around for more than a decade now.

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