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COMPUTER MANIKIN FAMILY USAGE FOR HUMAN ACCOMODATION

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Abstract
Commonly percentiles are used to define users' bodily dimensions. The percentile approach is however not suitable for multivariate problems such as the design of car cockpits, i.e. where a range of body segment dimensions affects the design. An alternative way is to use a set, a family, of manikins for evaluation that better represents human variety. The aim of this study was to compare seat and steering wheel adjustment ranges obtained when using manikin families or a percentile approach as the user representation in human simulation software. Results obtained indicate that a more elaborate and careful consideration of users can be achieved when using a manikin family approach for human accommodation compared to a percentile approach.

Keywords
Computer Manikin Family, Percentiles, Human Simulation, Human Accommodation

1 INTRODUCTION
Virtual product development is intensively used in the automotive industry to uphold profitability and competitiveness by reducing development time and cost and by promoting product quality. An important ability in this context is the efficient employment of virtual tools such as computer manikin software for human simulation (Chaffin, 2001). These tools basically consist of an advanced computer model of the human body, and enable assessment of issues such as human fit, reach, view and comfort.

A car interior is designed to meet a large number of requirements, e.g. related to comfort, customer appeal and safety. Obviously, car drivers' ergonomic requirements are very important aspects to consider, meaning that an appropriate user representation is crucial. Benefits of simulation tools is the ease of defining manikins of varying sizes and the ability to perform evaluations in a three dimensional virtual world. Commonly, percentiles are used to define users' bodily dimensions, e.g. a 95%ile stature male representing a large user, 50%ile stature male an average user, and a 5%ile stature female representing a small user (Robinette and McConville, 1981). An alternative way is to use a set, a family, of manikins for evaluation that better represents human variety (Bittner et al., 1987). A representative family can be generated by employing statistics on anthropometric data, as is the case with the A-CADRE manikin family (Bittner, 2000). Furthermore, the SAE (Society of Automotive Engineers) provides seat and reach guidelines for occupant packaging data (Roe, 1993). The SAE seat position curves are based on a 50/50 male/female mixed population of US drivers. The curves assist prediction of appropriate seat track travel and steering wheel travel.

The aim of this study was to compare seat and steering wheel adjustment ranges obtained when using manikin families and a percentile approach as the user representation.

2 METHOD
2.1 Tool and procedure
To obtain the hip point location (M-1) and the grip point location (M-2) the human simulation software RAMSIS and RAMSIS/BodyBuilder were used (Siedl, 1997). A Saab car interior was imported and the car posture prediction module was used with seven constraints (see Figure 1).
C-1 Head clearance. Minimum 20 mm vertical distance between head top and roof.
C-2 Right pedal-point on accelerator, pressed down halfway.

C-3 Right heel point on floor.
C-4 Left pedal-point on foot support.
C-5 Left heel point on floor.
C-6 Line of sight. 5 degrees down from horizontal line.
C-7 Line of sight clearance. Minimum 100 mm vertically between line of sight and top of instrument panel.

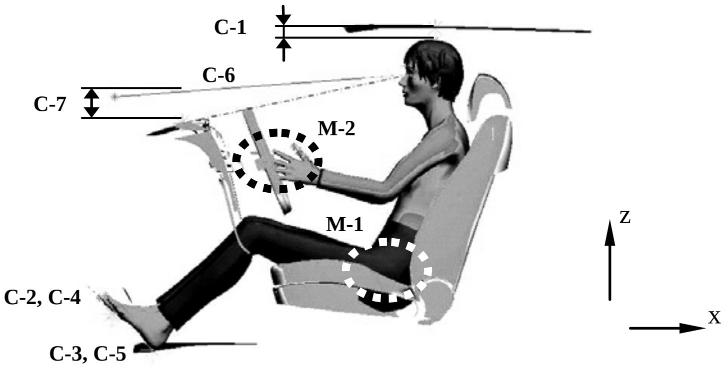

Figure 1. Human accommodation constraints and measure points.

2.2 User representation

The objective was to accommodate 90 % of the targeted population: German females between 18-70 years. *Stature*, *sitting height*, *waist circumference*, *upper arm length* and *forearm length with hand* were considered as key body measurements. Following five different user representation approaches were used:

A-1 a manikin family automatically generated by RAMSIS/BodyBuilder.
A-2 a manikin family designed using data from A-CADRE (Bittner, 2000).
A-3 a typical method employed at the Ergonomics and Usability Centre at Saab.
A-4 a 5^{th}, 50^{th}, 95^{th} percentile approach (stature).
A-5 a 5^{th}, 50^{th}, 95^{th} percentile approach (on the five key body measurements).

For the generation of a representative manikin family in RAMSIS/BodyBuilder (A-1), the multi-dimension segment size was set to 90%. Due to the multivariate problem this resulted in larger sizes for the separate key body measurement segments (97,6%). A family of 21 members was generated with stature varying from 1509 to 1796 mm. Key variable percentiles are shown in Table 1. For the manikin family designed using data from A-CADRE (A-2) the same five key variables were used, a reduction from 19 variables in A-CADRE, done as an attempt to support comparison between approaches. Since *waist circumference* is lacking as a variable in A-CADRE, percentiles were taken from the weight variable. The family consisted of 17 members, the same number as in A-CADRE, and stature varied from 1505 to 1800 mm. In the third approach (A-3) a set of predefined options was used. Out of the 45 possible combinations of *body height* (very short–short–medium–tall–very tall), *sitting height* (short torso–medium torso–long torso) and *waist circumference* (slim waist–medium waist–large waist), the following typical set of manikin configurations was selected to reflect practise: (1) very short+short torso+slim waist, (2) very short+long torso+slim waist, (3) very tall+short torso+large waist, (4) very tall+long torso+large waist. This was determined by interviewing a RAMSIS user at the Ergonomics and Usability Centre at Saab. Stature varied from 1552 to 1759 mm. In the fourth approach (A-4) stature was set as 5%ile, 50%ile and 95%ile, leading to statures from 1548 to 1757 mm. In the fifth approach (A-5) all five key body measurements were entered as 5%ile, 50%ile and 95%ile, leading to the same stature range as for approach four. Measurements were obtained from the integrated anthropometric database. RAMSIS automatically derives statistically likely dimensions for variables that have not been specified by the user.

Table 1. Percentile values for key variables of five different user representation approaches.

	BodyBuilder (A-1)					A-CADRE (A-2)					Current approach (A-3)					Percentile (A-4)					Percentile (A-5)				
Manikin	stature	sitting height	waist circumference	upper arm length	forearm length with hand	stature	sitting height	waist circumference	upper arm length	forearm length with hand	stature	sitting height	waist circumference	upper arm length	forearm length with hand	stature	sitting height	waist circumference	upper arm length	forearm length with hand	stature	sitting height	waist circumference	upper arm length	forearm length with hand
1	50,0	50,0	50,0	50,0	50,0	99,0	96,6	96,9	99,0	98,5	6,4	2,5	15,2	14,5	10,9	5,0	14,5	53,9	16,7	14,3	5,0	5,0	5,0	5,0	5,0
2	50,0	50,0	1,2	50,0	50,0	91,0	89,7	95,5	78,4	57,9	5,7	30,7	11,3	7,6	4,3	50,0	50,0	50,0	50,0	50,0	50,0	50,0	50,0	50,0	50,0
3	50,0	50,0	98,8	50,0	50,0	82,7	31,5	89,9	93,2	93,7	95,3	70,1	89,5	93,5	92,8	95,0	85,5	46,1	83,3	85,7	95,0	95,0	95,0	95,0	95,0
4	50,0	50,0	50,0	1,2	50,0	95,4	91,0	34,1	94,0	94,1	93,7	97,9	89,0	88,8	87,5										
5	50,0	50,0	50,0	98,8	50,0	75,6	93,6	87,4	79,3	85,3															
6	98,8	98,8	50,0	98,8	98,8	52,0	85,0	13,2	51,9	67,0															
7	1,2	1,2	50,0	1,2	1,2	24,4	21,6	71,5	49,4	66,0															
8	50,0	50,0	50,0	50,0	98,8	38,3	83,2	83,8	23,5	17,9															
9	50,0	50,0	50,0	50,0	1,2	61,7	16,8	16,2	76,5	82,1															
10	1,2	1,2	50,0	50,0	1,2	75,6	78,4	28,5	50,6	34,0															
11	98,8	98,8	50,0	50,0	98,8	48,0	15,0	86,8	48,1	33,0															
12	98,8	98,8	50,0	50,0	50,0	9,0	10,3	4,5	21,6	42,1															
13	1,2	1,2	50,0	50,0	50,0	17,3	68,5	10,1	6,8	6,3															
14	50,0	50,0	98,8	98,8	50,0	4,6	9,0	65,9	6,0	5,9															
15	50,0	50,0	1,2	1,2	50,0	24,4	6,4	12,6	20,7	14,7															
16	1,2	1,2	50,0	1,2	50,0	1,0	3,4	3,1	1,0	1,5															
17	98,8	98,8	50,0	98,8	50,0	50,0	50,0	50,0	50,0	50,0															
18	50,0	50,0	98,8	50,0	98,8																				
19	50,0	50,0	1,2	50,0	1,2																				
20	1,2	1,2	1,2	1,2	1,2																				
21	98,8	98,8	98,8	98,8	98,8																				

3 RESULTS

The hip point locations (M-1) obtained from simulation are shown in Figure 2. It can be seen that the BodyBuilder (A-1) family's hip points are gathered in three clusters, whereas the A-CADRE (A-2) family distribute the hip points more regularly. The current approach (A-3) positioned the hip-points as corner points representing an area. The two percentile approaches (A-4 and A-5) gave hip points basically on straight lines.

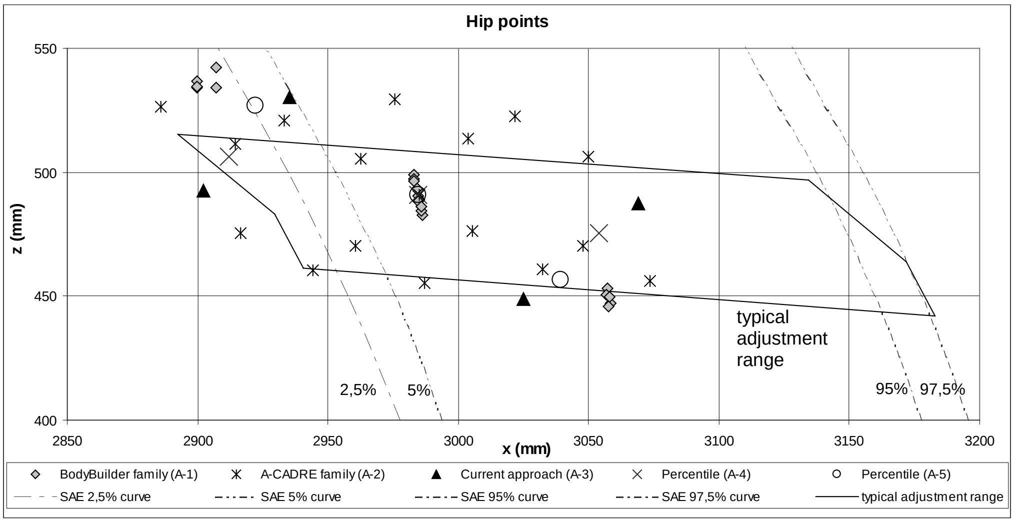

Figure 2. Hip point locations (M-1) for five different user representation approaches.

Grip point locations (M-2) obtained from RAMSIS for all user representation approaches were distributed over an area exceeding current steering wheel adjustment area. The BodyBuilder (A-1) family's grip points were distributed over a large area whereas the A-CADRE (A-2) family distribute the grip points more closely, representing a narrow rectangle quite close to the area obtained from the current approach (A-3). The percentile approaches (A-4 and A-5) gave grip points basically on a straight line, also quite similar to the current approach.

4 DISCUSSION

Results indicate that a wider and more comprehensive consideration of users can be achieved when using a manikin family approach for human accommodation compared to a percentile approach. This finding is in agreement with Roebuck et al., (1975); Robinette and McConville, (1981); Porter et al., (1993) who found that the percentile approach is not suitable for multivariate problems such as the design of car cockpits, i.e. where a range of body segment dimensions affects the design. In particular, the A-CADRE (A-2) approach seems promising and provided for an elaborate representation of different user configurations. The current approach (A-3) indicates good functionality by providing corner points on a suggested adjustment range area. The human simulation tool RAMSIS predicts posture fairly accurately (Loczi et al., 1999). However, the tool predicts a mean posture based on empirical data obtained from studying a number of people, and is not able to predict individually postures due to inter-subject variance. The simulation results for all approaches used in this study, except the percentile approach A-4, indicate that short drivers may experience difficulties in finding a suitable driving position. However, this result needs to be validated in a physical environment before firm conclusions can be drawn of the correctness of the simulation.

In the simulation performed there were no strict constraints for the location of manikins' hands (since this was to be measured), meaning that the manikins positioned their arms in the most comfortable position according to the posture prediction functionality in the software. However, experienced level of comfort is not very distinct and a small variance from an ideal posture is unlikely to result in major variations of comfort level, i.e. comfort level is not as firm constraint as for example reach or fit. This indicates that careful interpretation of simulation results is needed since the level of importance of following the results differs.

The use of human simulation to predict hip point and grip point locations seems to be a more careful user consideration approach compared with SAE (Society of Automotive Engineers) occupant packaging guidelines. The human simulation tool generates human pictures and might be considered as a more human centred approach compared to the more technical SAE method when performing adjustment range analysis. However, the human simulation and the SAE method complement each other.

The study was performed with German females between 18-70 years as the target population. This was considered as a relevant group for this initial work, without extreme bodily dimensions, but representing a user group not always considered.

More studies needs to be done on validation and comprehension of the results.

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