A Generation Method of Representative Human Models at the Boundary Zone of a Designated Accommodation Percentage

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Representative human models

A group of representative human models (RHMs) selected from the target population is utilized for efficient ergonomic design and evaluation.

Target population → Representative human models → Anthropometric design & evaluation
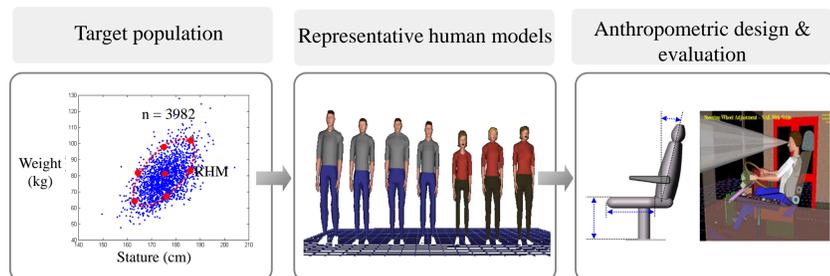
Generation process of RHM

The existing RHM generation method generates RHMs at the corners and centroid of a boundary formed in the space of factors identified by factor analysis on anthropometric dimensions.

⇒ **Factor analysis greatly simplifies the generation process of RHMs, resulting in loss in reflecting the body size variability (e.g., 20% of the total variability) and error in estimating the body sizes of RHMs.**

Data reduction | Boundary determination | RHMs generation

Variability loss (20%)   Estimation error

Notes: F = factor
L = factor loading matrix
C = coefficient matrix encompassing the designated percentage (e.g., 95%ile = 1.645)
AD = anthropometric dimension
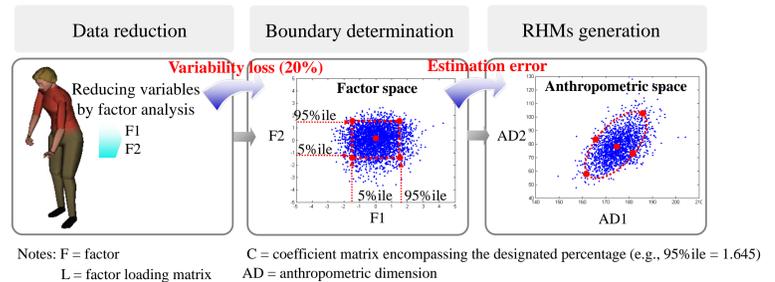
New approach: Boundary-zone

The present study proposed a two-step generation method of RHMs at the boundary zone which accommodates a designated percentage of the target population.

Identification of the boundary zone

- Forming the boundary zone (e.g., 89 and 91%) which statistically accommodates the designated percentage (e.g., 90%)
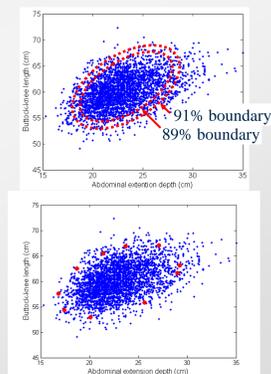
Clustering analysis for the cases within the boundary zone

- Clustering the cases in the boundary zone by K-mean clustering analysis
- Generating RHMs at the centroid of each cluster

To determine a boundary for the designated accommodation percentage, the values of anthropometric dimensions are converted into normalized square distances from the centroid. Then, the boundary zone are formed for the designated accommodation percentage ± tolerance (e.g., 90% ± 1%).

$$D(S,W) = (S - \mu_s \quad W - \mu_w)\Sigma^{-1}\begin{pmatrix} S - \mu_s \\ W - \mu_w \end{pmatrix}$$

where: D = normalized squared distance
S = stature
W = weight
μ_s = average of stature
μ_w = average of weight
Σ = variance-covariance matrix of stature and weight
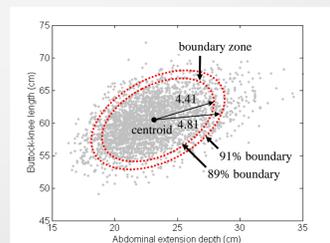
Performance comparison

Evaluation method

The 1988 US Army anthropometric data and 10 anthropometric dimensions related to the design of computer workstation were used to generate RHMs .

Anthropometric database

- The anthropometric database (males = 1,774; females = 2,213) of the US Army was used in the study. The anthropometric data were divided into two subsets (training set: 2,982; testing set: 1,000) for cross validation.

Anthropometric dimensions

- The anthropometric dimensions for the design of computer workstation were selected by referring to BSR/HFES 100 (2002) - Human factors engineering of computer workstations

Results

The accommodation percentage of the boundary zone method was 91% which is close to the target percentage (90%) and all the generated RHMs were within the size ranges of the target population

	Proposed	Bittner et al. (1987)	Kim & Whang (1997)	Meindl et al. (1993)
Image				
# of RHM	34	9	9	20
Accommodation %	**91%**	41%	**92%**	66%
Outlier	-	-	Possible	-

Note: Red: RHM, Green: accommodated cases, Blue: unaccommodated cases