

Development of a Generation Method of Digital Human Models with Various Sizes



Ergonomic Design Technology Lab

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Agenda

- ❑ Ergonomic Design with Digital Human Models
- ❑ Objectives of the Study
- ❑ Generation Method of Digital Human Models
- ❑ Web-Based Human Model Generation System
- ❑ Discussion

Ergonomic Design with Digital Human Models



JACK™



RAMSIS™



SAFEWORK™

❑ Benefits

- Concurrent design, evaluation, and revision
- Efficient prototyping and visualization

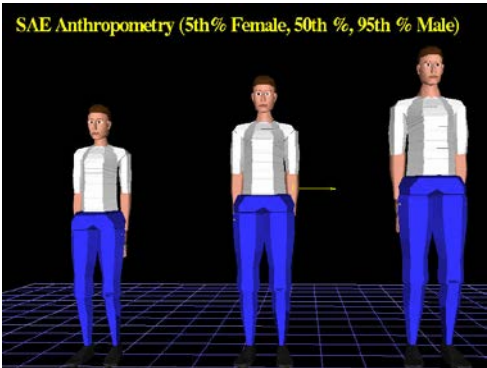
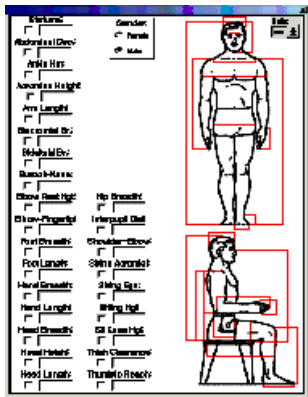
❑ Key Ergonomic Issues

Human Model Formation
(population accommodation)


Behavior Prediction
(posture & motion)

Ergonomic Design Diagnosis
(reach, visibility, clearance, etc.)

Human Model Generation Methods

Conventional Methods	Limitations	
<p>Typical human models (5th, 50th, 95th %ile) stored</p>		<ul style="list-style-type: none"> - Ambiguous in defining the sizes of percentile models in multivariate design context - Lacking representativeness of the population
<p>Customized human models</p>		<ul style="list-style-type: none"> - Inefficient to input the sizes of the body segments - Not indicate how to form a representative group of human models for the population
<p>Customization (stature, weight) + Body segment sizes estimated by regression models with stature and/or weight</p>	<ul style="list-style-type: none"> - Not indicate how to form a representative group of human models for the population 	

Objectives of study

- 
- ❑ Develop a method to **generate a group of human models** in various sizes which **statistically represents** the target population.

 - ❑ Develop a generation system of human models in a **fast and easy** manner.

Generation Procedure of Human Models

Accommodation
range (%)

Number of human
models (n)

S1: Generate pairs of stature and weight

$HM_1(\text{stature, weight})$

$HM_2(\text{stature, weight})$

...

$HM_n(\text{stature, weight})$

S2: Estimate the sizes of the body segments
by using hierarchical regression models

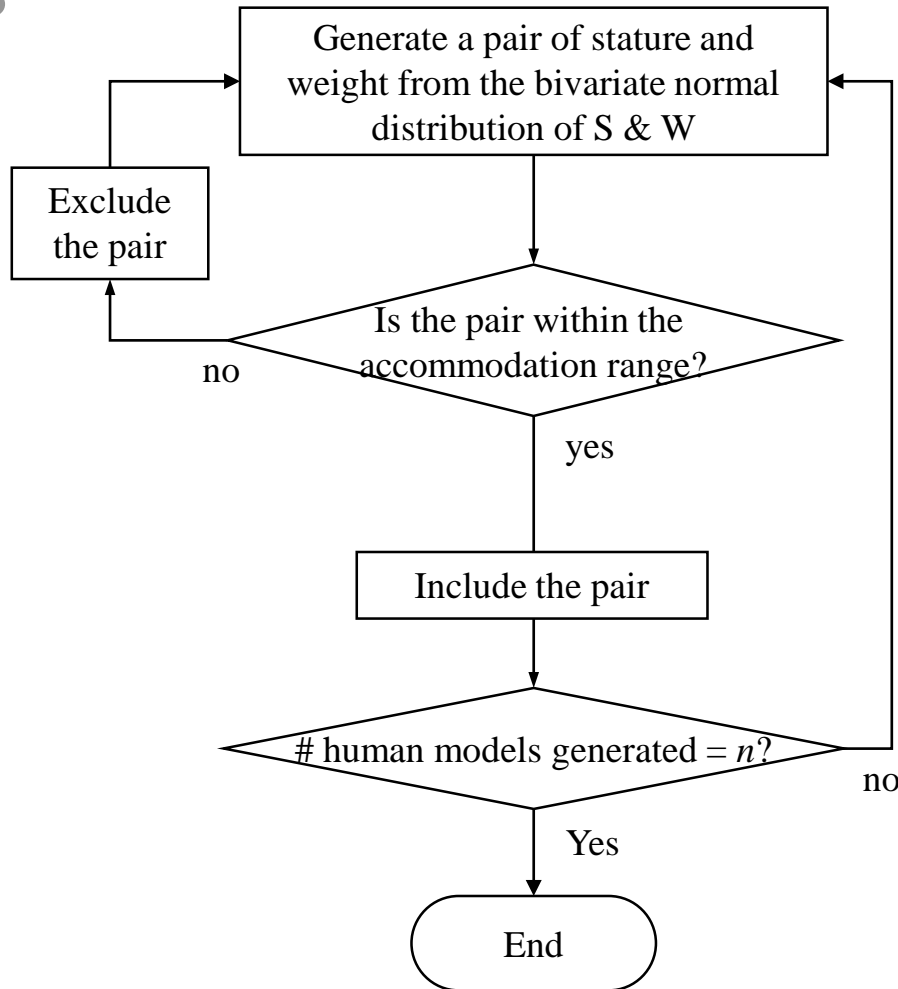
$HM_1(\text{acromial height, waist height, ... , sitting height})$

$HM_2(\text{acromial height, waist height, ... , sitting height})$

...

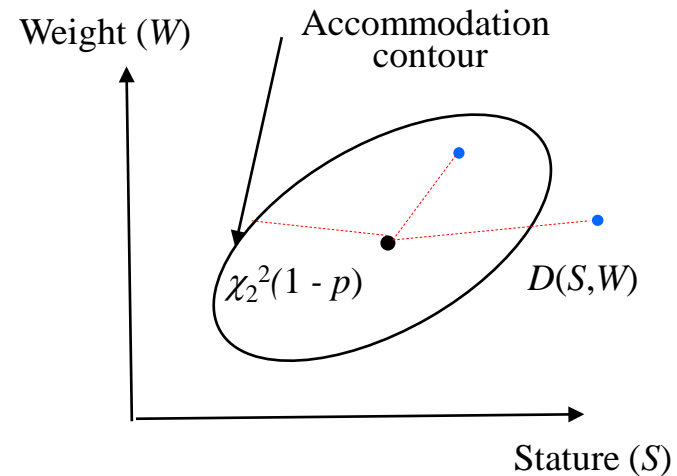
$HM_n(\text{acromial height, waist height, ... , sitting height})$

S1: Generation of Pairs of Stature and Weight



Normalized squared distance of (S, W)

$$D(S, W) = (S - \mu_s \quad W - \mu_w) \begin{pmatrix} \sigma_s^2 & \sigma_{sw} \\ \sigma_{sw} & \sigma_w^2 \end{pmatrix}^{-1} \begin{pmatrix} S - \mu_s \\ W - \mu_w \end{pmatrix}$$



Generated Pairs of Stature and Weight

- 1988 US Army Anthropometric Survey: 1773 males

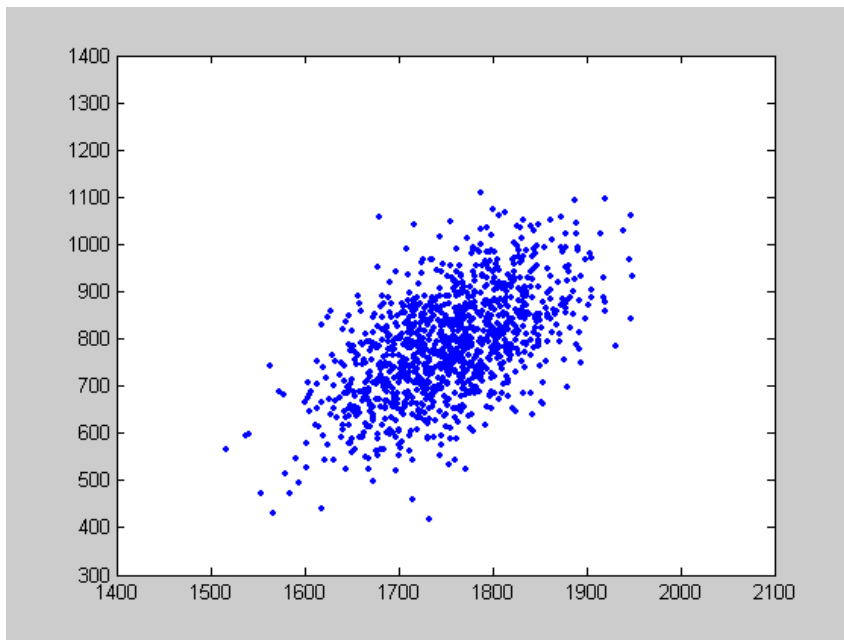
S & W ~ bivariate normal distribution

$$(\chi^2 = 9.66, p = 0.379)$$

$$\begin{aligned} \mu_S &= 175.6 \text{ cm} & \mu_W &= 78.5 \text{ kg} & r_{S,W} &= 0.5 \\ \sigma_S^2 &= 6.7^2 & \sigma_W^2 &= 3.5^2 \end{aligned}$$

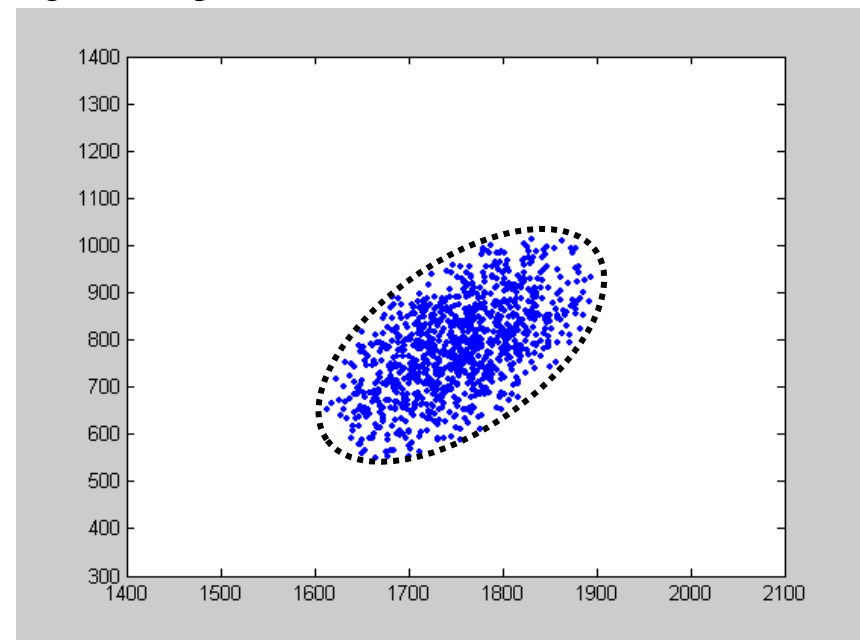
(e.g.) 1000 pairs of S & W within 90% of accommodation range

Weight (10^{-1} kg)



Stature (mm)

Weight (10^{-1} kg)



Stature (mm)

Flat vs. Hierarchical Estimation Methods

Flat estimation

trochanterion height = $f_1(\text{stature})$

upper leg length = $f_2(\text{stature})$

knee height at midpatella = $f_3(\text{stature})$

shank length = $f_4(\text{stature})$

lateral malleolus height = $f_5(\text{stature})$

Hierarchical estimation

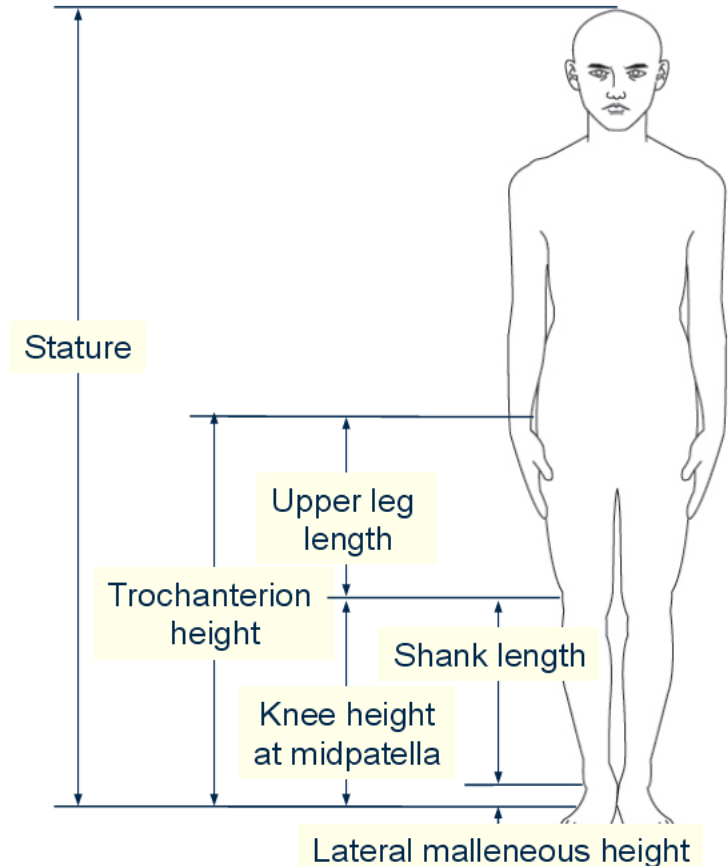
trochanterion height = $g_1(\text{stature})$

upper leg length = $g_2(\text{trochanterion height})$

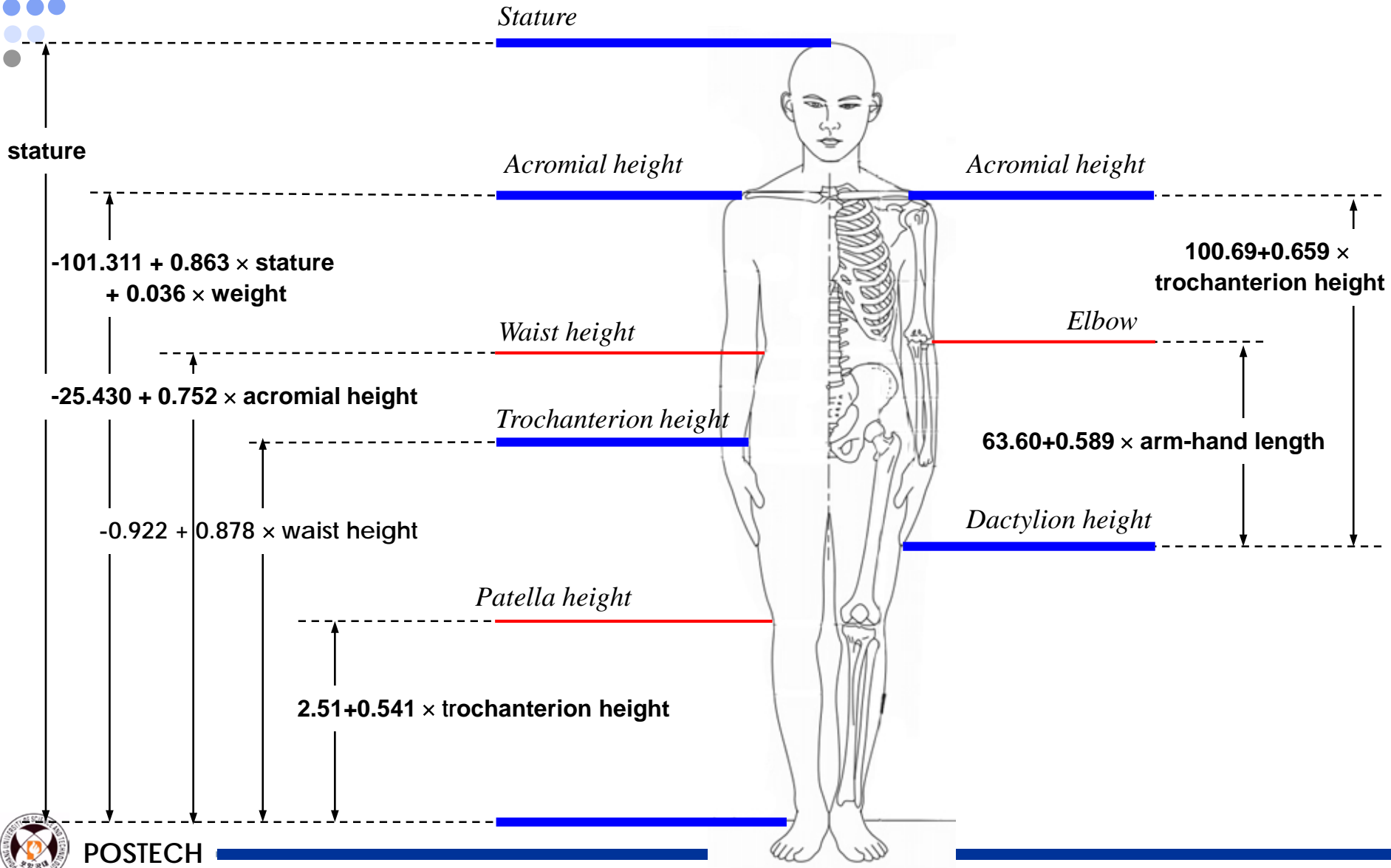
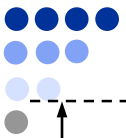
knee height = $g_3(\text{trochanterion height})$

shank length = $g_4(\text{knee height})$

lateral malleolus height = $g_5(\text{knee height})$

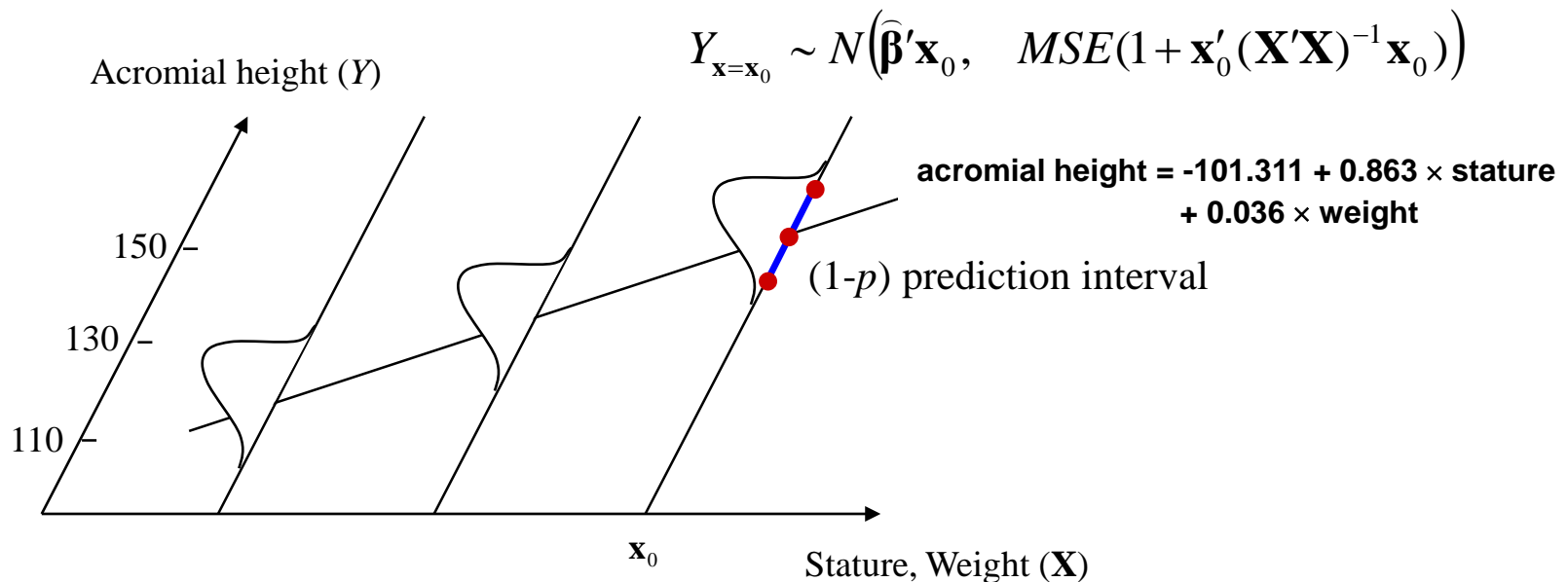


Hierarchical Regression Models (examples)



S2: Estimation of Body Segment Sizes

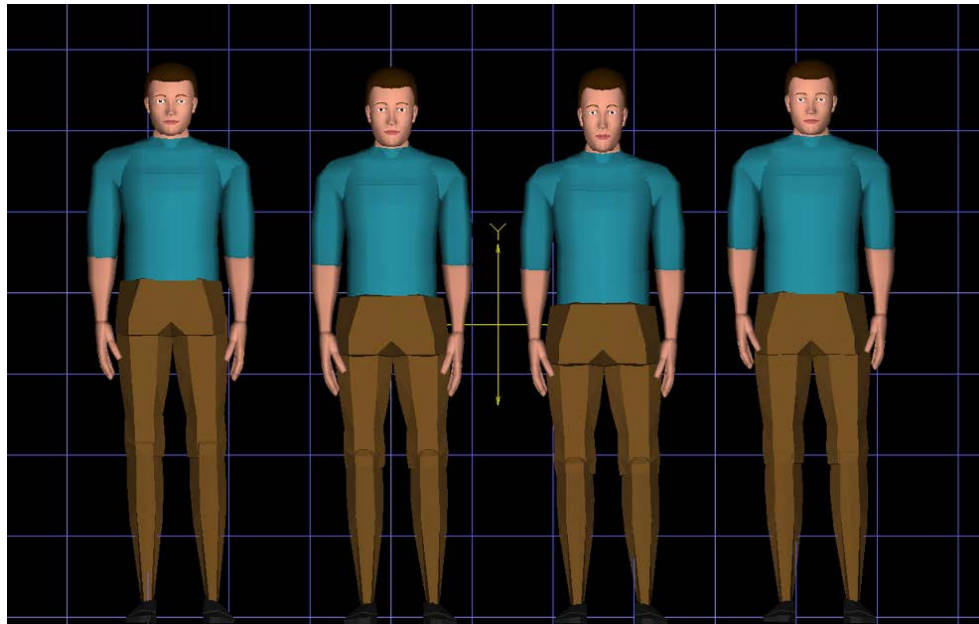
- By using the sampling distribution of an individual observation for an anthropometric variable (Y) given a value of regressor(s) ($\mathbf{x} = \mathbf{x}_0$), establish a $(1-p)$ prediction interval of $Y_{\mathbf{x} = \mathbf{x}_0}$.
- Select a value for Y in the prediction interval at random.



Generation of Human Models (example)

- Human models of the same stature and weight with various proportions of body segments could be defined.

(e.g.) human models of $S = 175.6$ cm and $W = 78.5$ kg, having different sizes of body segments



Development of a Human Model Generation System

Web-based user interface (HTML)

59 AVs
(selected to design an occupant packaging layout)

1988 US Army anthropometric survey data

Generation of pairs of S & W within a designated accommodation range from the bivariate normal distribution of S & H (Matlab[®])

Estimation of the sizes of body segments by using hierarchical regression models (Matlab[®])

Visualization of human models in various sizes (VRML)

Web-Based Human Model Generation System

Simple inputs

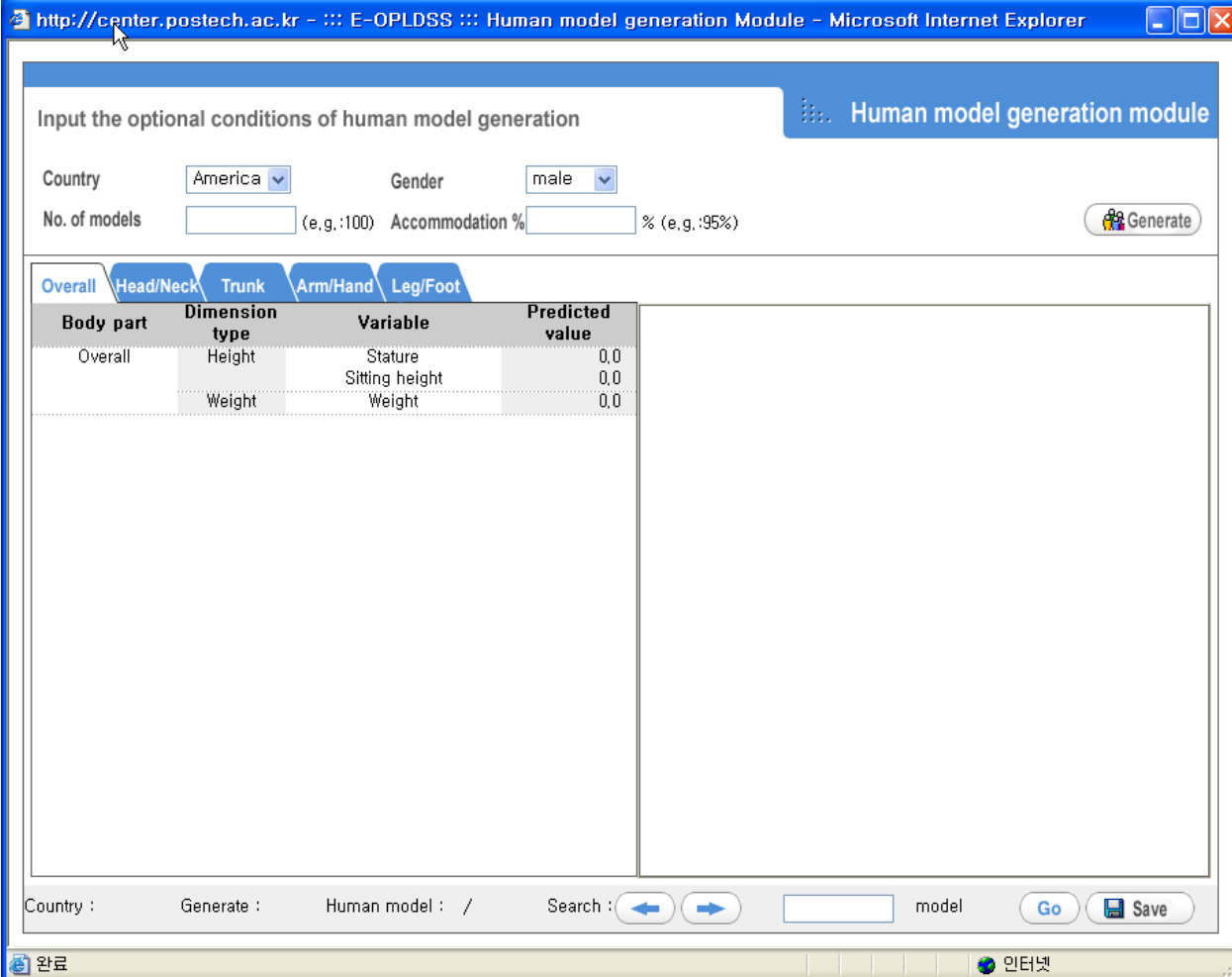
- ✓ Nationality
- ✓ Gender
- ✓ # human models
- ✓ Accommodation %

Generating human models in a short time

Easy access to body segment size information

Visualizing human models


Saving data in Excel file format for other applications



The screenshot shows a web browser window titled "http://center.postech.ac.kr - :: E-OPLDSS :: Human model generation Module - Microsoft Internet Explorer". The page content includes a header "Human model generation module" and a form titled "Input the optional conditions of human model generation". The form contains dropdown menus for "Country" (set to "America") and "Gender" (set to "male"), and input fields for "No. of models" (with a hint "(e.g.:100)") and "Accommodation %" (with a hint "% (e.g.:95%)"). A "Generate" button is located to the right of the form. Below the form is a table with tabs for "Overall", "Head/Neck", "Trunk", "Arm/Hand", and "Leg/Foot". The "Overall" tab is active, showing a table with columns "Body part", "Dimension type", "Variable", and "Predicted value". The table contains three rows of data for "Overall" body part: "Height" with variables "Stature" and "Sitting height", and "Weight" with variable "Weight". All predicted values are 0.0. At the bottom of the page, there is a status bar with "Country :", "Generate :", "Human model : /", "Search :", and "Go" and "Save" buttons.

Body part	Dimension type	Variable	Predicted value
Overall	Height	Stature	0.0
		Sitting height	0.0
	Weight	Weight	0.0

Discussion

- 
- ❑ Developed a method which generates human models having
 - Heights and weights within a designated accommodation range from the corresponding bivariate normal distribution
 - Different proportions of the body segments for the same height and weight by using hierarchical regression models and the corresponding sampling distributions of individual observations

 - ❑ Developed a web-based system which generates a group of human models which represents the population in terms of height and weight with simple inputs of nationality, gender, accommodation range, and # human models.

 - ❑ The human model generation system can be of use for ergonomic design and evaluation with digital human models in various sizes to properly accommodate the designated level of the body size variability of the user population.

Q & A

Thank you for your attention...

