

# 다중치수제품 설계를 위한 산포대표인체모델 생성 및 분석 시스템 개발

Development of a Distributed Representative Human Model  
Generation and Analysis System for Multiple-Size Product Design

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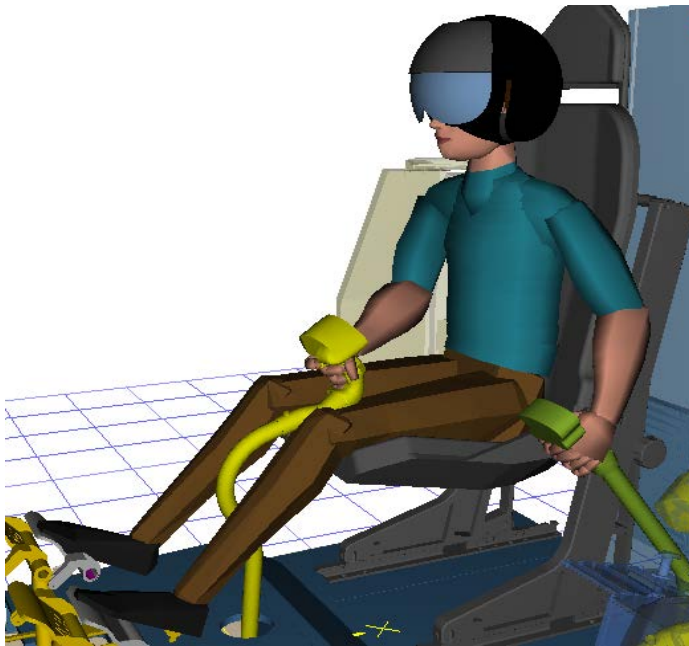
# AGENDA

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- Background
- Research Objectives
- Literature Review
- System Development
- Discussion

# Digital Human Model Simulation System

- Digital human model simulation (DHMS) system: 가상환경상에서 대표인체모델을 생성하여 인간공학적 제품과 작업공간의 설계 및 평가를 위한 효율적인 도구로 사용(Jung et al., 2009)



한국형 헬리콥터 조종실 설계  
(박장운 외, 2008)

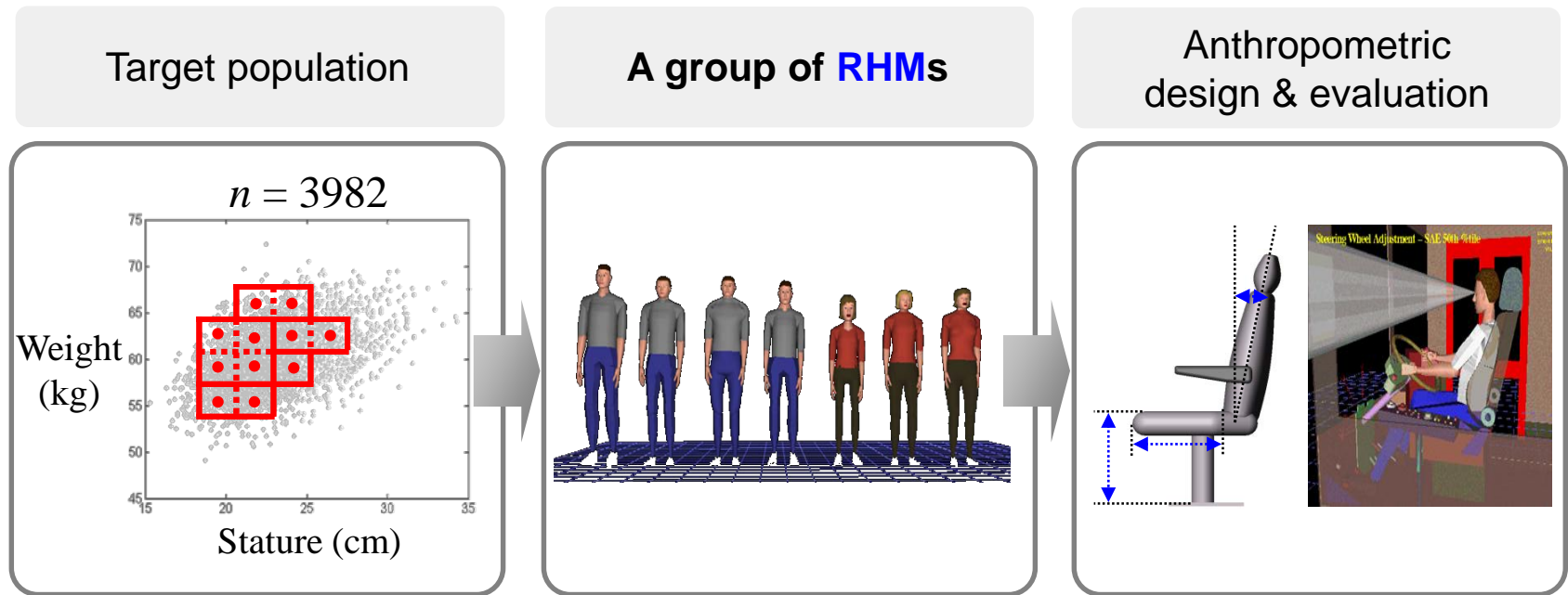


방사성폐기물처리장 주제어실 평가  
(이백희 외, 2010)

⇒ 인간공학적 평가 기준(예: reach, visibility) 적용을 위한 human-workstation interaction 평가 및 시각화에 유용하게 활용되고 있음

# Representative Human Model

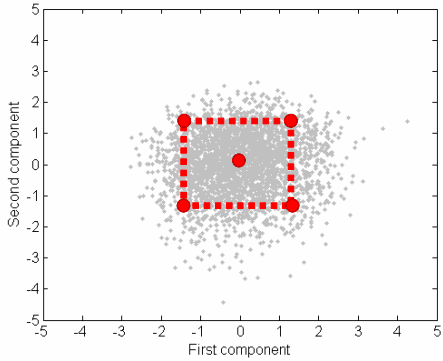
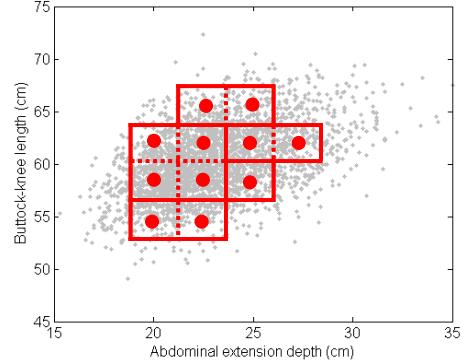
- 대표인체모델(representative human model; RHM): 제품 설계대상인구(target population)의 인체크기를 통계적으로 적합하게 대표하는 소수의 인체모델(Jung and You, 2005)

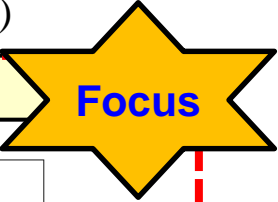


⇒ 소수의 RHM을 활용하는 방법은 효율적인 제품 설계 및 개발을 위한 필수적 기법

# Taxonomy of RHM Generation Method

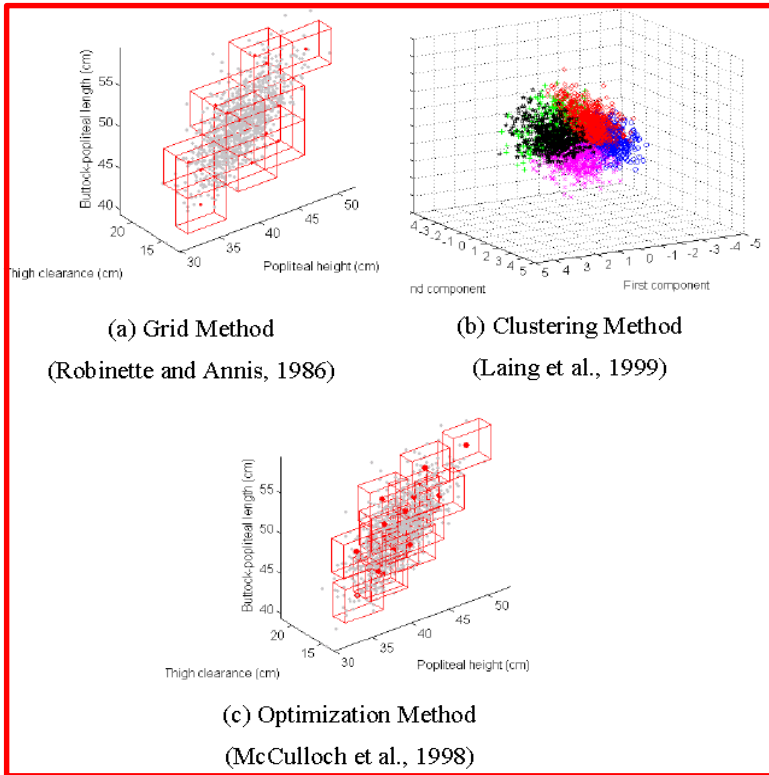
- RHM은 제품 설계 적용 분야에 따라 2가지 방법으로 생성될 수 있음(Jung, 2009)

	Boundary method	Distributed method
Illustration	 <p>A scatter plot with 'First component' on the x-axis and 'Second component' on the y-axis, both ranging from -5 to 5. A dense cloud of grey points is centered around (0,0). A red dashed rectangle is drawn around a smaller, denser cluster of points within the main cloud.</p>	 <p>A scatter plot with 'Abdominal extension depth (cm)' on the x-axis (15 to 35) and 'Buttock-knee length (cm)' on the y-axis (45 to 75). A dense cloud of grey points is centered around (25, 60). Several overlapping red dashed rectangles are drawn around different sub-clusters of points within the main cloud.</p>
Application	<ul style="list-style-type: none"> <li>• 단일치수제품(one-size product) 설계</li> <li>• 예: 비행기 조종석, 자동차 운전석</li> </ul>	<ul style="list-style-type: none"> <li>• 다중치수제품(multiple-size product) 설계</li> <li>• 예: 의복, 장갑</li> </ul>
Methods	<ul style="list-style-type: none"> <li>• Square method (Bittner, 2000)</li> <li>• Circular method (Meindl et al., 1993)</li> <li>• Rectangular method (Kim and Whang et al., 1997)</li> <li>• Boundary zone method (Jung, 2009)</li> </ul>	<ul style="list-style-type: none"> <li>• Grid method (Robinette and Annis, 1986)</li> <li>• Cluster method (Laing et al., 1999)</li> <li>• Optimization method (McCulloch et al., 1998)</li> </ul>



# Distributed Representative Human Model

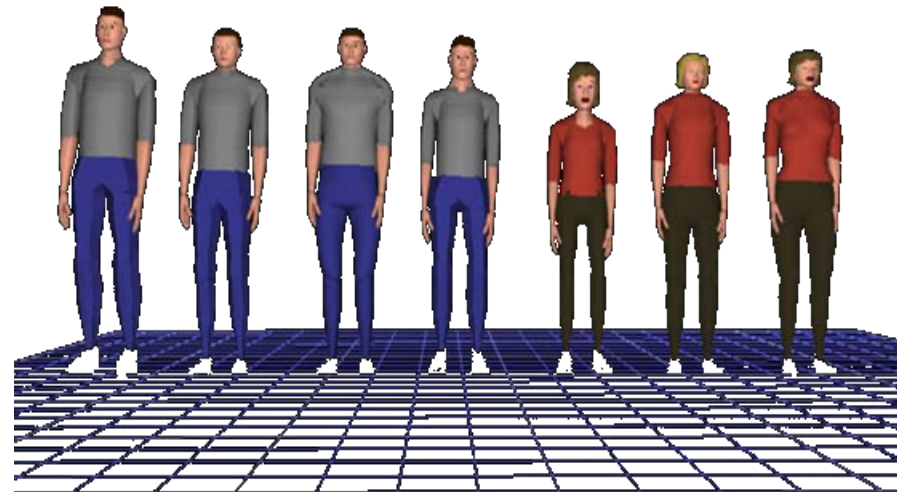
- 산포대표인체모델(distributed RHM)의 생성은 의복과 같은 다중치수제품(multiple-size product) 및 대량맞춤생산(mass customization)을 위한 치수체계(sizing system) 개발에 활용되고 있어 이에 특화된 시스템이 필요함



3가지 DRHM 생성 방법



↑ 인체크기 = 치수



생성된 distributed RHMs



# RHM Generation Method in DHMS System

❑ DHMS system의 RHM 생성은 percentile 방법과 custom-built 방법으로 구분

❑ **Limitations** (Jung et al., 2009)

1) Percentile 방법: 설계 대상 인구(target population)에 대한 RHM의 대표성(representativeness) ↓

2) Custom-built 방법: RHM 생성 효율성(generation efficiency) ↓

1) **Few RHMs**: Mostly 3 (5<sup>th</sup>, 50<sup>th</sup>, 95<sup>th</sup> percentiles)  
 2) **Multivariate accommodation percentage** ↓  
 (HFES 300, 2004; Meunier, 1998)

Very Short Short Medium Tall Very Tall Reference Year: 2010  
 Corpulence (Key Dimension : Waist Circumference): Slim Waist Medium Waist Large Waist  
 Proportion (Key Dimension : Sitting Height): Short Torso Medium Torso Long Torso Age Group: 18 - 70  
 Hand Model: Mitten-like 5-Finger Hand Foot Model: Naked GIND DIN / SAE

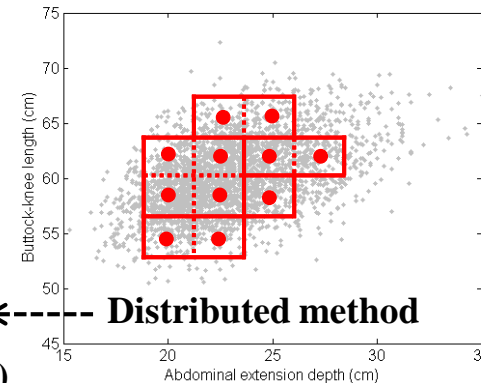
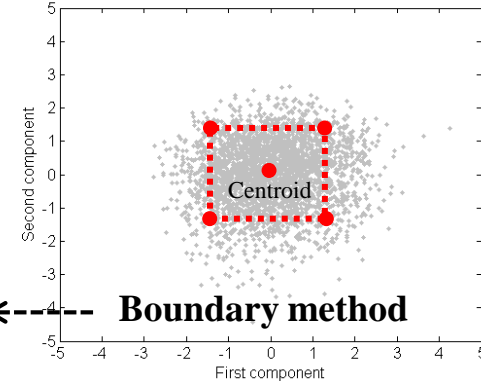
**Percentile method UI (RAMSIS®)**

**Boundary와 distributed RHM 생성 시스템  
 및 생성된 RHM에 대한 분석 기능 필요**

Build Human... Gender: Female Male Units: cm  
 Stature: Abdominal Dep.: Ankle Hgt: Acromion Height: Arm Length: Biacromial Br.: Bideltoid Br.: Buttock-Knee:  
 Hand Length: Sitting Hgt: Head Breadth: Sit Knee Hgt: Head Height: Thigh Clearance: Head Length: Thumbtip Reach:  
 Save as: Name: Edit Existing: Human Usage Clear Dismiss

1) **Calculation &**  
 2) **Inputting**  
 body sizes of RHMs  
 ⇒ **Time demanding** ↑

**Custom-built method UI (Jack®)**



# Research Objective

## 다중치수제품 설계를 위한 산포대표인체모델 생성 및 분석 시스템 개발

### ❑ Distributed RHM 생성 기법 및 DHMS system 특성 파악

- ✓ Distributed RHM 생성 방법(grid, cluster, and optimization method) 및 생성 절차(중요 변수 선정, 대표격자 형성, 대표인체모델 치수 추정) 관련 문헌 조사
- ✓ DHMS system (Jack, RAMSIS, and CATIA Human)의 RHM 생성 인터페이스 파악

### ❑ Distributed RHM 생성 및 분석에 특화된 시스템 개발

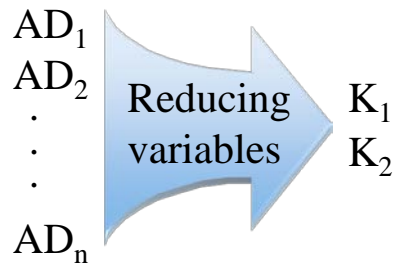
- ✓ 설계 대상 인구 및 설계 대상 인체변수 선정에 용이한 인터페이스 개발
- ✓ Distributed RHM 생성간 적용되는 통계적 기법의 총체적 제공
- ✓ 생성된 Distributed RHM의 분석 기능 구현 및 3차원 시각화



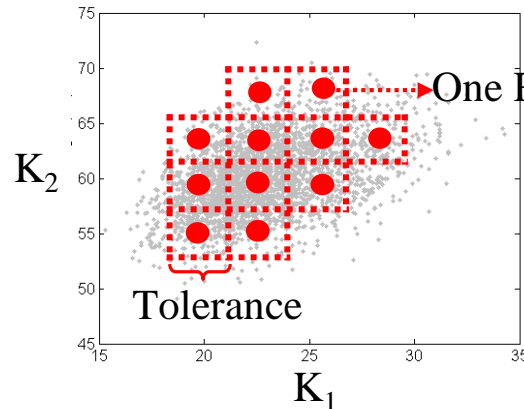
# Distributed RHM Generation Process

## □ Distributed RHM 생성 절차(Jung, 2009)

**Step 1:** Extraction of key dimensions



**Step 2:** Determination of distributed method



**Step 3:** Determination of body sizes of RHMs

$$\begin{cases}
 AD_1 = f_1(K_1, K_2) \\
 AD_2 = f_2(K_1, K_2) \\
 \vdots \\
 AD_n = f_n(K_1, K_2)
 \end{cases}$$

Factor analysis  
Principal component analysis  
Regression analysis

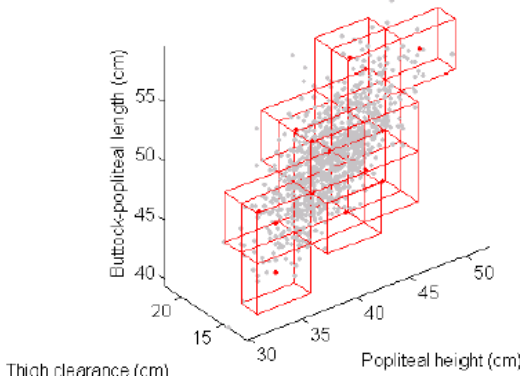
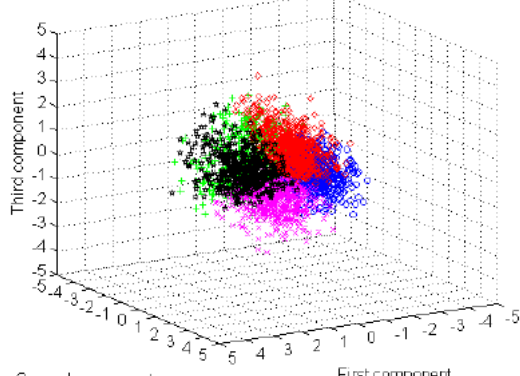
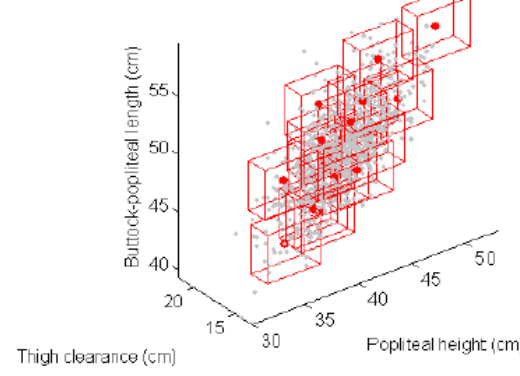
Grid method  
Cluster method  
Optimization method

Estimation  
Real case

Used statistical method

Note: AD = anthropometric dimension, K = key dimension

# Distributed Methods

	<i>Grid method</i>	<i>Cluster method</i>	<i>Optimization method</i>
Illustration	 <p>Thigh clearance (cm)</p> <p>Popliteal height (cm)</p> <p>Buttock-popliteal length (cm)</p>	 <p>Third component</p> <p>Second component</p> <p>First component</p>	 <p>Thigh clearance (cm)</p> <p>Popliteal height (cm)</p> <p>Buttock-popliteal length (cm)</p>
Study	<ul style="list-style-type: none"> <li>• Robinette and Annis (1986)</li> <li>• Rosenblad-Wallin (1987)</li> <li>• Moon (2002)</li> <li>• Kwon et al. (2004)</li> <li>• Zheng et al. (2007)</li> </ul>	<ul style="list-style-type: none"> <li>• Laing et al. (1999)</li> </ul>	<ul style="list-style-type: none"> <li>• McCulloch et al. (1998)</li> </ul>
Determination of grid	<ul style="list-style-type: none"> <li>• Determined as the centroids of the grids formed to accommodation rate of the target population <b>by grading system</b></li> <li>• Size of the grid was determined with a <b>design fitting tolerance value</b></li> </ul>	<ul style="list-style-type: none"> <li>• Determined as the centroids of the clusters generated <b>by K-means cluster analysis</b> in the space of the factors</li> <li>• Number of clusters was determined by the trend of <b>within-cluster average distances</b></li> </ul>	<ul style="list-style-type: none"> <li>• Determined as the centroids of the grids formed in the space of the key dimensions <b>by applying the Nelder-Mead optimization algorithm</b></li> <li>• Optimal location was determined by the <b>loss score</b></li> </ul>

# RHM Generation in DHMS System

□ 대표적으로 사용되는 3가지 DHMS system의 RHM 생성 인터페이스 특징 파악

	Jack	RAMSIS	CATIA Human
Developer	SIMENS, Germany	Human Solutions, Germany	Dassault Systemes, France
Latest release ver.	Ver. 5.1	Ver. 3.8.30	Ver. 5
Database / Nation (Reference year)	US Army (1988)	Germany etc., 17 nations (1984 - 2020)	American, canadian, French, Japanese, Korean (*N.S.)
Gender	Female, Male, (Child)	Female, Male, (Child)	Female, Male
Age groups	**N.F.	Fixed 4 groups (18-70, 18-29, 30-49, 50-70)	N.F.
Number of anthropometric variables (in custom-built RHM)	26	24	N.F.
RHM-generation method	Percentile method Custom-built method	Percentile method Custom-built method	Percentile method

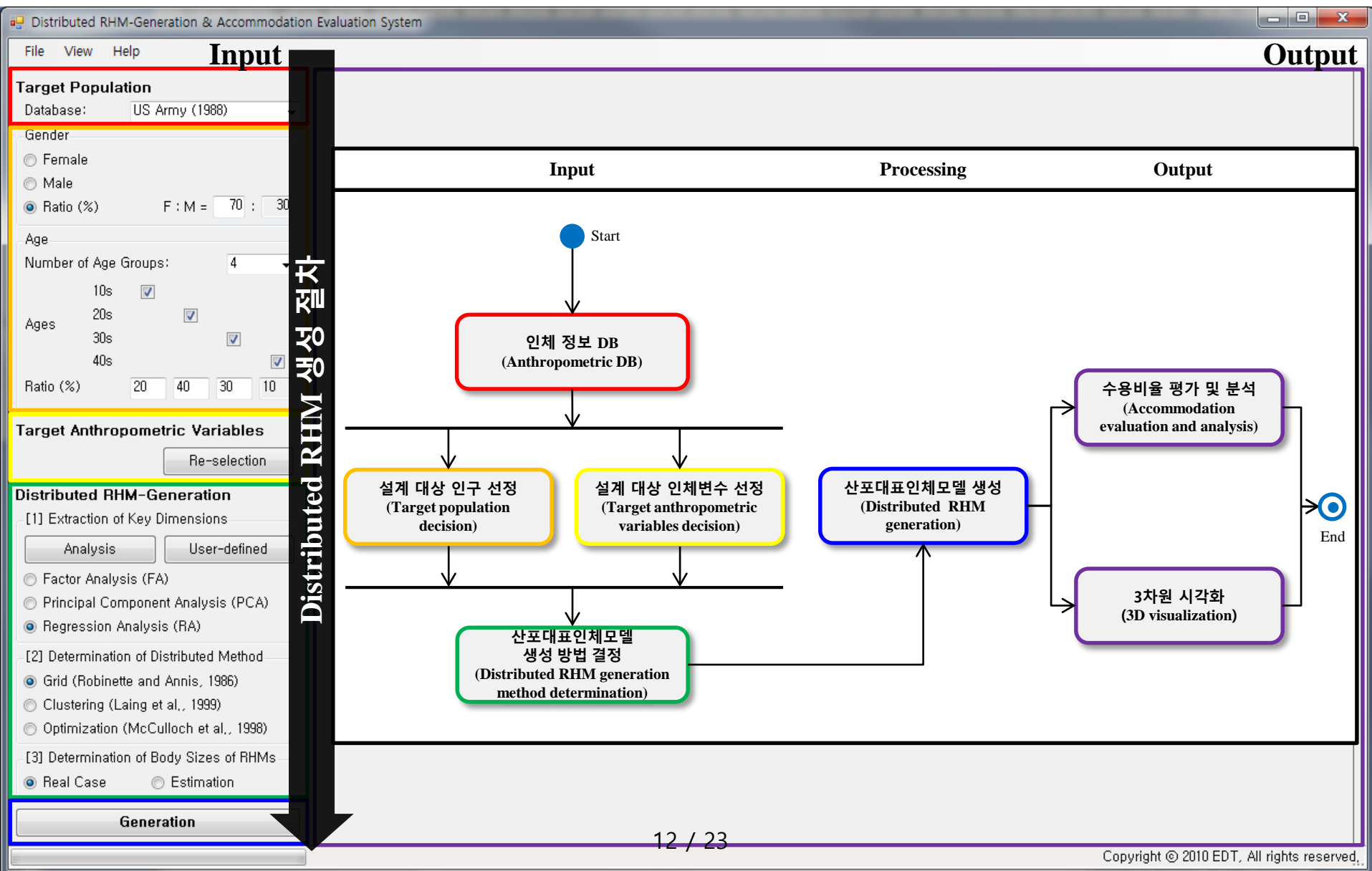
## Limitations

\*N.S.: not specified

\*\*N.F.: no function

- ⇒ **Gender: 혼성 인구가 고려되지 않음**
- ⇒ **Age groups: 다양한 연령대의 인구가 고려되지 않음**
- ⇒ **Number of anthropometric variables: 대표적인 소수의 인체변수만 제공**
- ⇒ **RHM generation method: distributed (or boundary) method와 연동되지 않음**

# System Overview & Activity Diagram



# User Interface: Target Population

- 3가지 인체측정 DB로부터 다양한 성별과 연령집단을 선택 가능하도록 개발됨

**Target Population**

Database: US Army (1988)

Gender

Female

Male

Composite (%) F : M =  :

Age

Number of Age Groups: 2 (1, 2, 3, 4)

Ages	10s	<input type="checkbox"/>	<input type="checkbox"/>
	20s	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	30s	<input type="checkbox"/>	<input checked="" type="checkbox"/>
	40s	<input type="checkbox"/>	<input type="checkbox"/>

Ratio (%)



3 Anthropometric Databases		US Army	US Army Pilot	Korean Pilot
Year measured		1988	1988	2007
Sample size (n)	Female	2,208	334	-
	Male	1,774	487	1,237
	Total	3,982	821	1,237
Range of ages		10s ~ 40s	20s ~ 40s	20s ~ 40s

$$\text{Maximize } Z = \sum_i \sum_j x_{ij}$$

Gender와 age group 각각의 비율을 만족하는 최대의 인구 수 추출

subject to

$$x_{ij} \leq y_{ij} \text{ for all } i, j$$

$$R_F : R_M = \sum_j x_{Fj} : \sum_j x_{Mj}$$

$$R_{10} : R_{20} : R_{30} : R_{40} = \sum_i x_{i10} : \sum_i x_{i20} : \sum_i x_{i30} : \sum_i x_{i40}$$

$$x_{ij} > 0 \text{ for all } i, j$$

## < Algorithm for extraction of target population >

Let  $x_{ij}$  = # [will be selected] of  $i$ (gender) aged  $j$ 's

$y_{ij}$  = # [in database] of  $i$ (gender) aged  $j$ 's

$R_k$  = # in  $k$ \_ratio cell

$i = F, M, j = 10, 20, 30, 40, k = F, M, 10, 20, 30, 40$

# Target Anthropometric Variables

- 인체변수를 대분류, 소분류, 치수유형으로 분류(You et al., 2004) 하여 용이한 선택이 가능하도록 인터페이스 구현

예: 가슴둘레(Chest circumference)를 선택하는 경우

Target Anthropometric Variables

Selection

Selected Anthropometric Variables

Anthropometric Variable	Measureme...	Sub Class	Major Class
<input checked="" type="checkbox"/> Chest Circumference	Circumfer...	Chest	Trunk

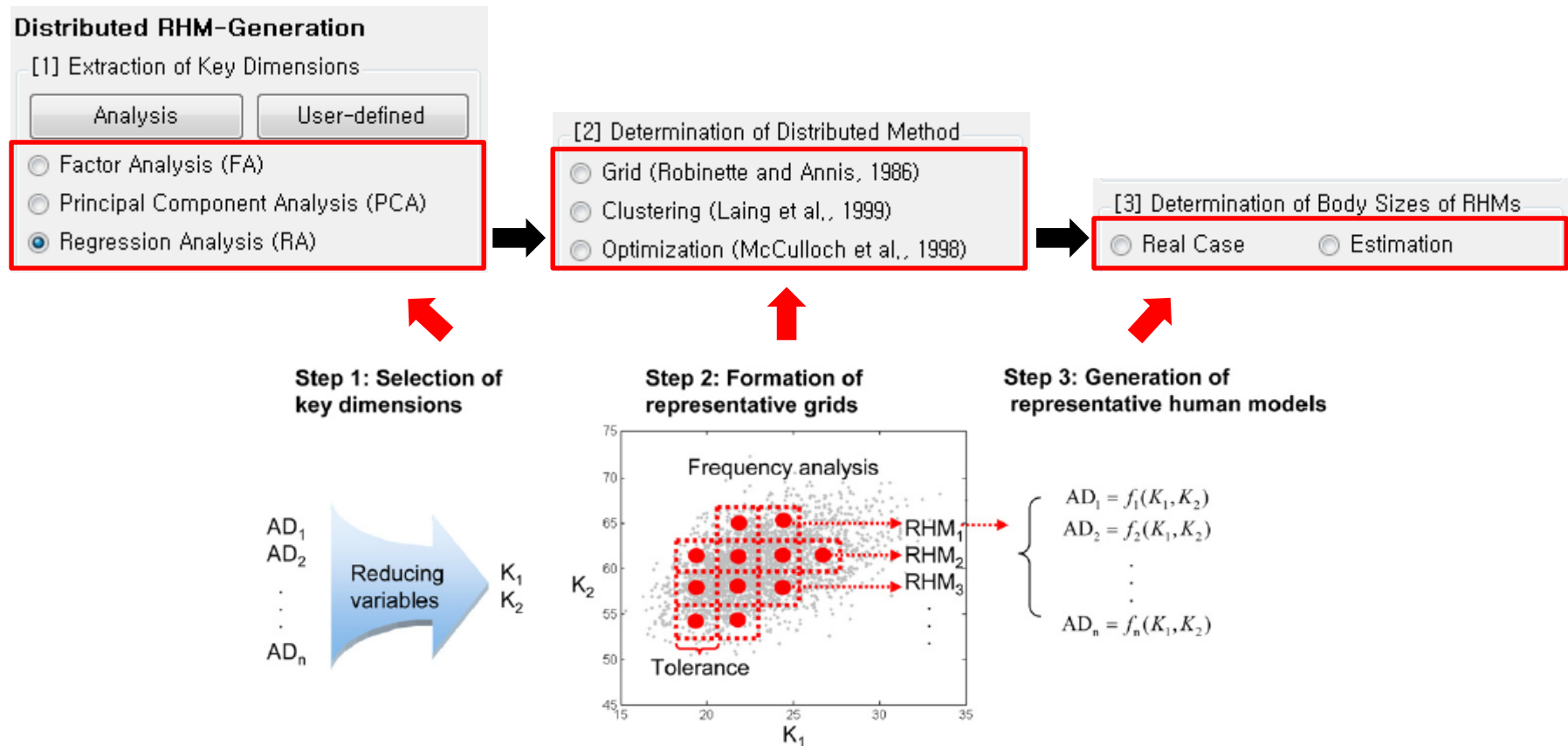
**인체측정변수 분류 체계(You et al., 2004)**

대분류	소분류	치수유형	인체측정변수 명칭	
			영어	한글
몸통	가슴	높이	Axilla height	겨드랑높이
			Biacromial breadth	어깨너비
		Bideltoid breadth	몸통너비	
		Chest breadth	윗가슴너비	
	배	높이	Chest depth	가슴두께
			Chest circumference	가슴둘레
		너비	Waist height	허리높이
			Waist height, sitting	앉은허리높이
너비	Waist breadth	허리너비		
	Waist depth	허리두께		
	둘레	Waist circumference	허리둘레	



# Distributed RHM Generation

- 3단계 distributed RHM 생성 절차(Jung et al., 2010)를 따라 각 절차에서 적용되는 통계적 기법을 제공



RHM generation process of the grid method (Jung et al., 2010)

# Step 1: Extraction of Key Dimensions

- 대표적으로 사용되는 3가지 통계적 분석방법(factor analysis, principal component analysis, regression analysis)을 적용할 수 있는 각각의 인터페이스를 제공

**Method of extraction:** principal components  
**Plot of eigenvalue**      **Plot of cumulative % variability**

**Method of extraction:** principal components  
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**Method of extraction:** principal components  
**Plot of eigenvalue**      **Plot of cumulative % variability**

**Trend of average adjusted R<sup>2</sup>**

Number of key dimensions	Adjusted R <sup>2</sup> (Maximum)	Adjusted R <sup>2</sup> (Minimum)
1	0.712	0.350
2	0.876	0.350
3	0.883	0.337
4	0.921	0.337
5	0.949	0.337

**Possible pairs of key dimensions**

Candidate for key dimension	Adjusted R <sup>2</sup>		
	Average	Minimum	Maximum
<input checked="" type="checkbox"/> Acromion Height-Sitting; Overhead Reach	0,876	0,741	0,973
<input type="checkbox"/> Overhead Reach; Sitting Height	0,874	0,724	0,973
<input type="checkbox"/> Acromion Height-Sitting; Overhead Reach-Extended	0,873	0,742	0,973
<input type="checkbox"/> Overhead Reach-Extended; Sitting Height	0,870	0,724	0,973
<input type="checkbox"/> Acromion Height-Sitting; Stature	0,843	0,741	0,930
<input type="checkbox"/> Sitting Height; Stature	0,839	0,722	0,935
<input type="checkbox"/> Acromion Height; Sitting Height	0,831	0,732	0,948
<input type="checkbox"/> Acromion Height; Acromion Height-Sitting	0,825	0,708	0,926
<input type="checkbox"/> Acromion Height-Sitting; Overhead Reach Sitting	0,770	0,723	0,817
<input type="checkbox"/> Overhead Reach Sitting; Sitting Height	0,765	0,704	0,816
<input type="checkbox"/> Overhead Reach; Stature	0,751	0,421	0,973
<input type="checkbox"/> Overhead Reach-Extended; Stature	0,749	0,420	0,975
<input type="checkbox"/> Overhead Reach; Stature	0,732	0,402	0,927
<input type="checkbox"/> Overhead Reach; Stature	0,727	0,427	0,934
<input type="checkbox"/> Overhead Reach; Stature	0,717	0,379	0,973
<input type="checkbox"/> Overhead Reach; Stature	0,716	0,378	0,975
<input type="checkbox"/> Overhead Reach; Stature	0,712	0,391	0,974
<input type="checkbox"/> Overhead Reach; Stature	0,709	0,394	0,974
<input type="checkbox"/> Acromion Height; Stature	0,693	0,407	0,890
<input type="checkbox"/> Overhead Reach; Overhead Reach-Extended	0,620	0,243	0,879

**Number of key dimensions:** 2

**Selection**

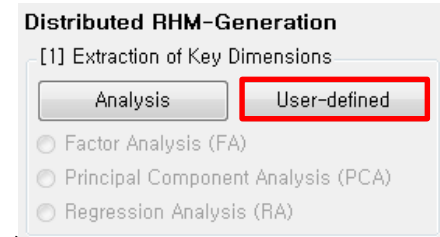
수정회귀계수의 increase가 감소하는 곳을 참고하여 key dimension의 개수를 선택 가능

Key dimensions과 other dimensions간의 평균 수정회귀계수가 내림차순으로 정렬되어 사용자가 원하는 key dimensions 선택 가능

# Step 1: Extraction of Key Dimensions

- 사용자가 중요변수를 알고 있는 경우 직접 선택할 수 있도록 인터페이스 구현

예: Kwon et al. (2009)는 기존 문헌 조사를 통해 3가지 중요변수 선정 (hand length, hand circumference, hand breadth)



Anthropometric Variable	Measurement T...	Sub Class	Major Class
<input checked="" type="checkbox"/> Ankle Circumference	Circumference	Foot/Ankle	Leg/Foot
<input checked="" type="checkbox"/> Buttock Circumference	Circumference	Upper Leg/Hip	Leg/Foot
<input type="checkbox"/> Buttock Height	Length	Combined_L...	Leg/Foot
<input type="checkbox"/> Buttock-Knee Length	Length	Combined_L...	Leg/Foot
<input type="checkbox"/> Calf Circumference	Circumference	Lower Leg/K...	Leg/Foot
<input type="checkbox"/> Knee Circumference	Circumference	Lower Leg/K...	Leg/Foot
<input type="checkbox"/> Thigh Circumference-Distal	Circumference	Upper Leg/Hip	Leg/Foot
<input type="checkbox"/> Waist Circumference-Natural	Circumference	Abdomen	Trunk
<input type="checkbox"/> Waist Hip Length	Length	Upper Leg/Hip	Leg/Foot

Anthropometric Variable	Measurement T...	Sub Class	Major Class
<input checked="" type="checkbox"/> Ankle Circumference	Circumference	Foot/Ankle	Leg/Foot
<input checked="" type="checkbox"/> Buttock Circumference	Circumference	Upper Leg/Hip	Leg/Foot

Target anthropometric variables 중에서 직접 선택

Buttons: Add, Clear All, Delete Checked Variables, Save, Load, OK

# Step 2: Determination of Distributed Method

- 3가지 distributed RHM 생성 방법(grid, cluster, optimization method) 적용을 위한 각각의 인터페이스 제공

Key dimensions

Descriptive statistics	Acro...	Over...
Mean	557,2	2157,5
S.D.	28,1	102,3
Minimum	464,0	1868,0
Maximum	624,0	2428,0
Range (Max - Min)	160,0	560,0
1st percentile	465,6	1873,6
99th percentile	622,4	2422,4
1 - 99 percentile range	156,8	548,8

Fitting tolerance (unit: mm)

Single value:   
 Multiple values:

Accommodation rate (unit: %)

Target accommodation rate:   
 Minimum population coverage rate:

OK

[2] Determination of Distributed Method

Grid (Robinette and Annis, 1986)

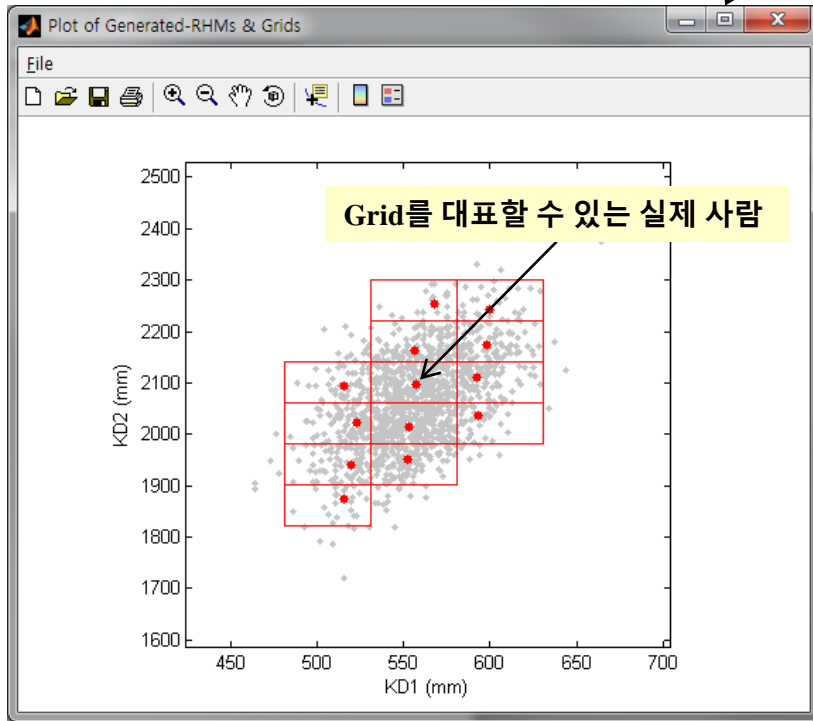
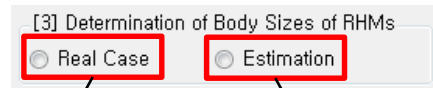
Clustering (Laing et al., 1999)

Optimization (McCulloch et al., 1998)

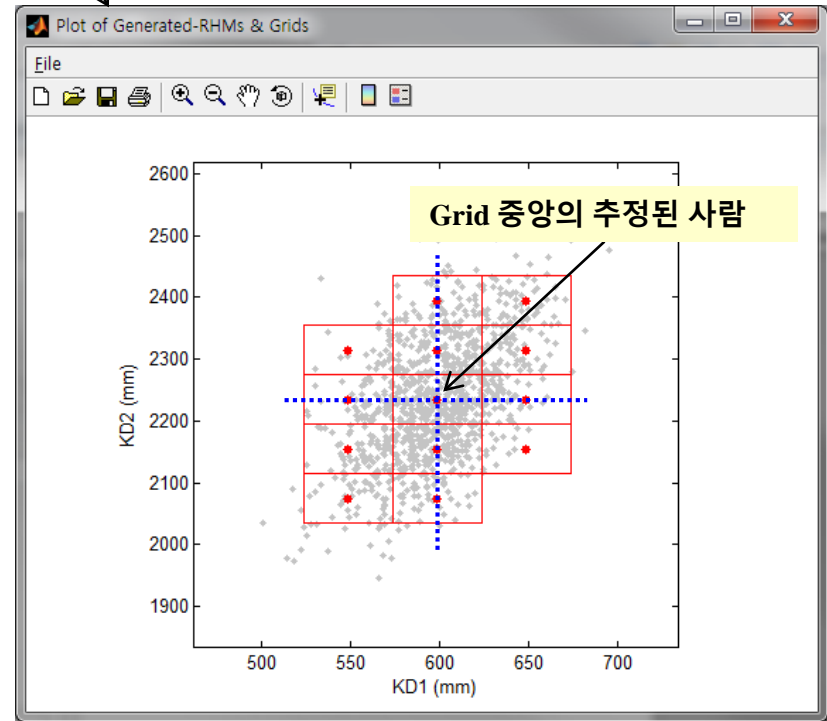
**Sum of coverage rates of grids > 95%**  
 (Jung et al., 2010)  
**A grid of coverage rate > 2%**  
 (Kwon et al., 2009)

# Step 3: Determination of Body Sizes of RHM

- 2가지 인체크기 추정방법(real case or estimation)을 제공



**Medoid:** Finding an object  $i$   
whose average distance is the smallest in a grid



**Centroid:** Finding an object  $i$   
located geometric center in a grid

# Result View *(under development)*

**Target Population**

Database: US Army (1988)

Gender

Female

Male

Ratio (%) F : M = 70 : 30

**Visualization part** →

10s

20s

30s

40s

Ratio (%) 20 40 30 10

**Target Anthropometric Variables**

Re-selection

**Distributed RHM-Generation**

[1] Extraction of Key Dimensions

Analysis User-defined

Factor Analysis (FA)

**Analysis part** (PCA) →

Regression Analysis (RMA)

[2] Determination of Distributed Method

Grid (Robinette and Annis, 1986)

Clustering (Laing et al., 1999)

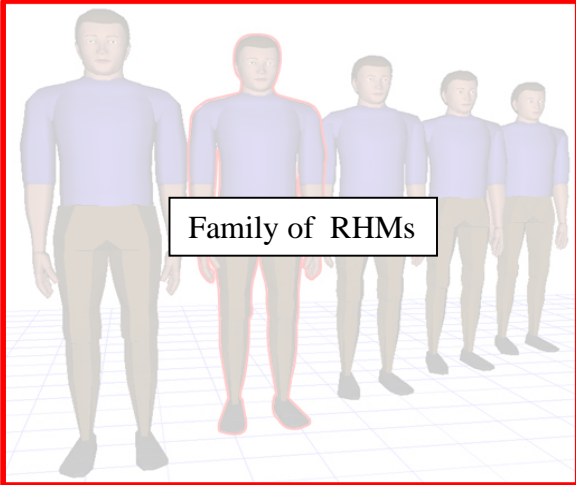
Optimization (McCulloch et al., 1998)

[3] Determination of Body Sizes of RHMs

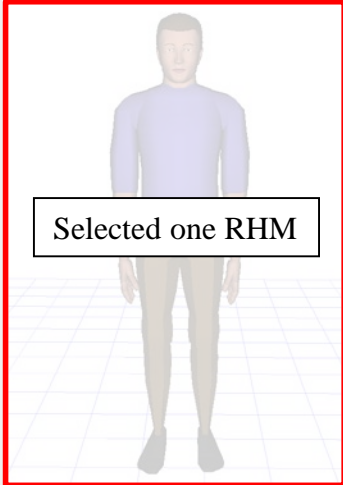
Real Case

Estimation

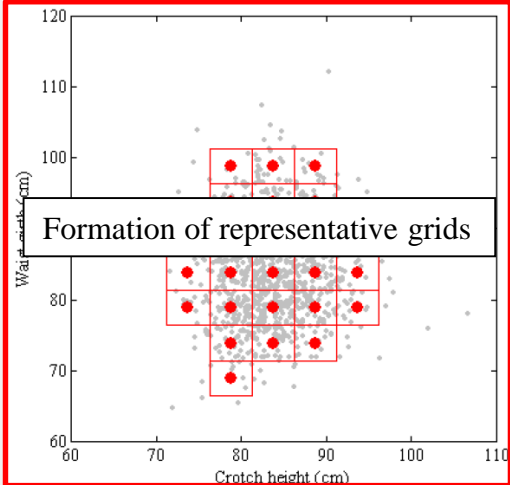
**Addition part** →



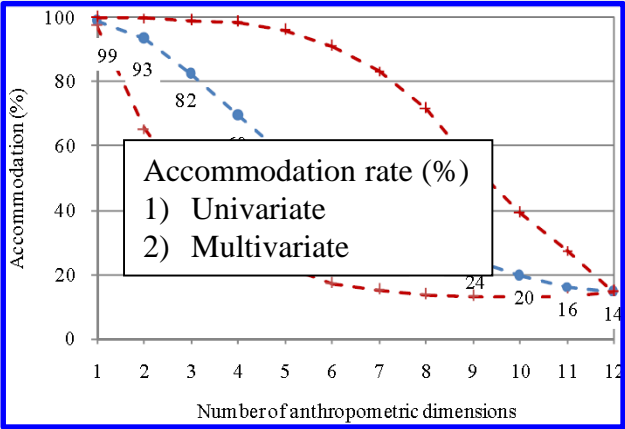
Family of RHMs



Selected one RHM



Formation of representative grids



Accommodation rate (%)

1) Univariate

2) Multivariate

No	Key dimensions				Non-key anthropometric dimension <sup>1</sup>							
	Crotch height (AD5)	Waist girth (AD7)	Waist height (AD1)	Waist-to-ankle length (AD2)	Waist-to-knee length (AD3)	Outside leg length (AD4)	Crotch length (AD6)	Hip girth (AD8)	Thigh girth (AD9)	Knee girth (AD10)	Calf girth (AD11)	Ankle girth (AD12)
1	73.8 (2)	74.1 (9)	101.0 (1)	94.8 (1)	51.3 (2)	96.8 (1)	69.9 (11)	89.5 (8)	53.5 (11)	33.5 (8)	34.9 (13)	20.7 (14)
2	73.8 (2)	79.1 (25)	101.9 (2)	95.6 (2)	51.8 (3)	97.6 (2)	72.9 (25)	93.0 (19)	56.1 (24)	36.5 (17)	36.0 (24)	21.2 (22)
3	73.8 (2)	84.1 (50)	102.8 (3)	96.4 (3)	52.3 (5)	98.4 (3)	75.8 (44)	96.4 (38)	58.7 (42)	37.5 (31)	37.1 (39)	21.6 (34)
4	78.8 (15)	69.1 (2)	105.2 (7)	98.8 (4)	53.8 (6)	99.8 (4)	78.8 (44)	96.4 (38)	61.4 (5)	35.0 (5)	34.2 (8)	20.6 (11)
5	78.8 (15)	74.1 (9)	106.0 (10)	99.8 (5)	54.8 (7)	100.8 (5)	80.8 (19)	96.4 (38)	61.4 (5)	35.0 (5)	34.2 (8)	20.6 (11)
6	78.8 (15)	79.1 (25)	106.9 (13)	101.3 (17)	54.6 (21)	103.4 (17)	76.3 (47)	97.4 (44)	59.2 (46)	38.1 (40)	37.5 (45)	21.9 (42)
7	78.8 (15)	84.1 (50)	107.8 (17)	101.3 (17)	54.6 (21)	103.4 (17)	76.3 (47)	97.4 (44)	59.2 (46)	38.1 (40)	37.5 (45)	21.9 (42)
8	78.8 (15)	80.1 (75)	108.7 (22)	102.1 (22)	55.0 (26)	104.2 (22)	79.2 (68)	100.9 (66)	61.8 (67)	39.1 (59)	38.6 (62)	22.3 (55)
9	78.8 (15)	94.1 (91)	109.6 (27)	102.9 (27)	55.5 (31)	105.1 (27)	81.2 (84)	104.4 (83)	64.4 (83)	40.2 (75)	39.7 (77)	22.8 (68)
10	83.8 (51)	69.1 (2)	110.2 (31)	103.7 (32)	55.5 (32)	105.8 (32)	67.8 (6)	88.0 (5)	51.9 (6)	35.6 (8)	34.6 (10)	20.9 (15)
11	83.8 (51)	74.1 (9)	111.1 (38)	104.5 (38)	56.0 (38)	106.7 (38)	70.8 (14)	91.5 (13)	54.5 (15)	36.6 (18)	35.6 (20)	21.3 (25)
12	83.8 (51)	79.1 (25)	112.0 (44)	105.3 (45)	56.4 (44)	107.5 (45)	73.7 (30)	95.0 (29)	57.1 (30)	37.6 (33)	36.7 (34)	21.7 (37)
13	83.8 (51)	84.1 (50)	112.9 (51)	106.1 (51)	56.9 (51)	108.4 (51)	76.7 (50)	98.4 (50)	59.7 (50)	38.7 (50)	37.8 (50)	22.2 (50)
14	83.8 (51)	89.1 (75)	113.7 (58)	106.9 (57)	57.4 (58)	109.2 (58)	79.7 (71)	101.9 (72)	62.3 (70)	39.7 (68)	38.9 (67)	22.6 (64)
15	83.8 (51)	94.1 (91)	114.6 (64)	107.8 (64)	57.8 (64)	110.0 (64)	82.6 (86)	105.4 (87)	64.9 (86)	40.7 (83)	40.0 (81)	23.1 (75)

**Body sizes of RHMs**

Example:

Information of grids button

Regression equation button

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# Discussion

- 대표적인 digital human model simulation (DHMS) system의 대표인체모델 생성 인터페이스 특성 종합 및 한계 파악
  - ⇒ 기존 DHMS System의 한계점을 보완하여 시스템 개발에 반영
  
- 다중치수제품 설계를 위한 산포대표인체모델 생성 및 분석 시스템 개발
  - ✓ Distributed RHM 생성 절차 및 기법에 적용되는 통계적 기법을 총체적 제공: 시간 ↓
  - ✓ 생성된 distribute RHM의 고급 분석기능(예: accommodation rate 등) 제공
  - ⇒ 인간공학적 제품의 치수체계(sizing system) 개발 시 유용하게 활용될 수 있음
  
- 다양한 인체측정 DB와 연동한 시스템 확장
  - ⇒ 다양한 제품 설계대상인구(target population)에 대하여 치수체계 설계 가능

# Follow-Up Study

1. 주변부대표인체모델(boundary representative human model) 생성 및 분석 시스템 개발
2. DHMS system (예: Jack®, RAMSIS®) RHM 생성 인터페이스와 연동

Key dimension	Navy anthropometric dataset												
	Waist girth	Waist	Waist-circumference	Waist-circumference	Waist-circumference	Waist-circumference	Waist-circumference	Waist-circumference	Waist-circumference	Waist-circumference	Waist-circumference	Waist-circumference	Waist-circumference
30	length	height	length	length	length	length	length	length	length	length	length	length	length
1	713.0	171.0	101.0	94.0	53.0	94.0	89.0	81.0	53.0	35.0	34.0	34.0	27.0
2	713.0	171.0	101.0	94.0	53.0	94.0	89.0	81.0	53.0	35.0	34.0	34.0	27.0
3	713.0	171.0	101.0	94.0	53.0	94.0	89.0	81.0	53.0	35.0	34.0	34.0	27.0
4	713.0	171.0	101.0	94.0	53.0	94.0	89.0	81.0	53.0	35.0	34.0	34.0	27.0
5	713.0	171.0	101.0	94.0	53.0	94.0	89.0	81.0	53.0	35.0	34.0	34.0	27.0

**Distributed RHM**  
Body sizes

**Automatic inputting**

**Boundary RHM**  
Body sizes

Statistics | Dependent Measurements

Control Measurements

Measurement Name	Value (mm)
body-height	1710.0
sitting-height	932.0
waist-circumference	865.0

Dependent Measurements

Measurement Name	Value (mm)
head-height	239.0
head-width	167.9
head-depth	185.0
stature	170.1
buttock-knee-length	574.9
knee-height-sitting	505.5
foot-height	82.2
foot-length	254.6
foot-width	100.5
upperarm-circumference	302.5
forearm-circumference	266.0
thigh-circumference	563.0
calf-circumference	405.5

Modify Selected Measurement...

Build Human...

Stature:  Units: cm

Gender:  Female  Male

Abdominal Dep.:

Ankle Hgt:

Acromion Height:

Arm Length:

Biacromial Br.:

Bideltoid Br.:

Buttock-Knee:

Elbow Rest Hgt:

Elbow-FingerTip:

Foot Breadth:

Foot Length:

Hand Breadth:

Hand Length:

Head Breadth:

Head Height:

Head Length:

Hip Breadth:

Interpupil Dist:

Shoulder-Elbow:

Sitting Acromial:

Sitting Eye:

Sitting Hgt:

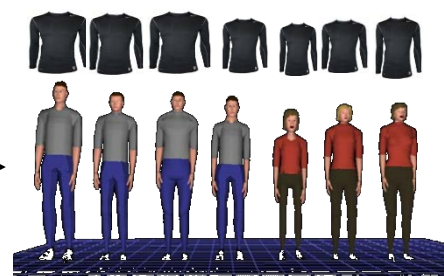
Sit Knee Hgt:

Thigh Clearance:

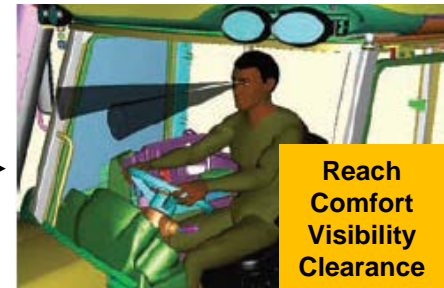
Thumbtip Reach:

Save as: Name: Edit Existing: Human

Basic Scaling Body Part Scaling Usage Clear Dismiss



**다중치수제품 설계에 활용**  
(예: 의복, 장갑 등)



**단일치수제품 설계에 활용**  
(예: 자동차, 헬리콥터 등)

**RAMSIS**

**Jack**

# Q & A

Thank You 😊