INDUSTRIAL AND MANAGEMENT ENGINEERING, POSTECH

Ergonomic Design Technology Lab

Convergence of Ergonomics & ICT in Smart Healthcare Product Development

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Global Contributor to Eco-Techno-Humanopia

Contents

- ❑ **Profiles of EDT Lab** — 10 min
- ❑ **Ergonomics & Product Design** — 30 min
  - Helicopter Cockpit Design
  - Bus Passenger Seat Design
  - Vacuum Cleaner Handle Design
  - Earset Design
  - On-Going Research Topic: Design w/ Temporal Scan Data
- ❑ **Smart Healthcare Products: Ergonomics + ICT** — 40 min
  - Aria Fresca, Natural Dyeing Health Mask
  - Dr. Liver™ for Preoperative Liver Surgery Planning
  - Smart Harmony™ for Brain Fitness
  - SMAS™ (Swallow Monitoring & Assessment System) for Dysphasia
- ❑ **Q & A** — 10 min

Ergonomic Design Technology Lab

Global Contributor to

Eco-Techno-Humanopia

Developer and Provider

of Leading-Edge Ergonomic Solutions

in Designing Products and Systems

Personal Profile

You, Heecheon
유희천 (劉喜天)
Joyful Sky/Heaven

Education

- Ph.D., Industrial Engineering, May 1999, **Pennsylvania State Univ.**
- M.S., Industrial Engineering, Feb. 1990, **Seoul National Univ.**
- B.S., Industrial Engineering, Feb. 1988, **Seoul National Univ.**

Appointments

- **Visiting Prof.**, IME, **Pennsylvania State Univ.**, Aug. 2017 ~ present
- **Professor**, IME, **POSTECH**, Sept. 2013 ~ present
- Associate Prof., IME, POSTECH, Mar. 2007 ~ Aug. 2013
- **Visiting Associate Prof.**, ESD, **MIT**, 2009
- Assistant Prof., IME, POSTECH, July 2002 ~ Feb. 2007
- **Assistant Prof.**, IME, **Wichita State Univ.**, Jan. 1999 ~ June 2002
- Instructor, School of Technology & Commonwealth Engineering, Penn. State Univ., Aug. ~ Dec. 1998
- RA, IME, Penn. State Univ., Aug. 1994 ~ July 1998
- **Research Manager**, **High Touch**, Mar. ~ July 1994
- Instructor, IE, Seoul National Polytechnic Univ., Mar. ~ June 1994
- **Air Force Officer** (Fighter Controller, Pilot Aptitude Research Officer), **ROK Air Force**, Nov. 1990 ~ Mar. 1994

EDT Lab: Vision & Missions

Vision

Global Contributor to

Eco-Techno-Humanopia

Developer and Provider

of Leading-Edge Ergonomic Solutions

in Designing Products and Systems

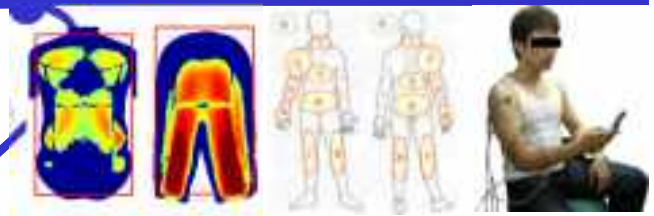
Missions

1. **Academic Contributions:** Develop effective methods and scientific findings
2. **High-Quality Services to Industry:** Provide practical and useful solutions for industry sponsors
3. **Fruitful Researchers:** Develop research capabilities and qualifications to produce meaningful and effective solutions to real-world problems

Research Areas

Digital Ergonomics

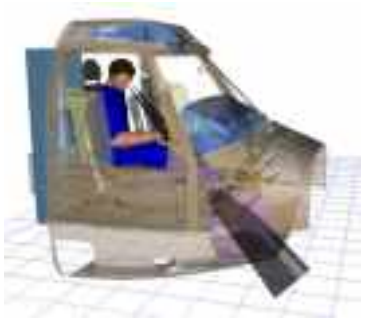
Human Performance & Workload Evaluation



Innovative Product Design & Development

Ergonomics & Product Design

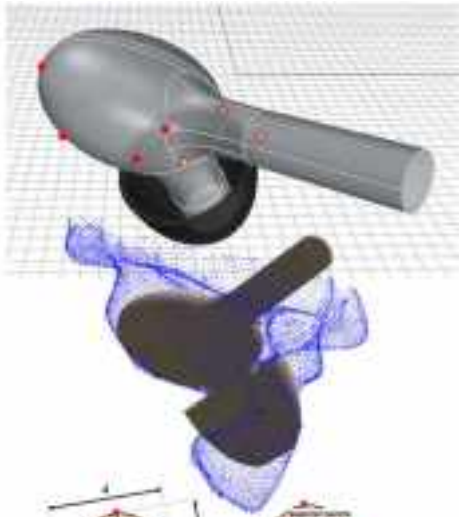
Cockpit Layout Design

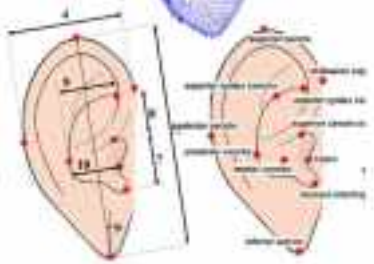


Bus Passenger Seat Design

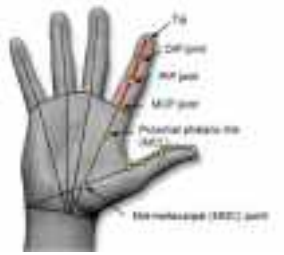
Vacuum Cleaner Handle Design

Earset Design





On-Going Research Topic



Ergonomics?

- **Origin**

  Ergonomics = Ergon (work) + Nomos (laws)

- **Definition**
  - **Understanding** the **physical, mental, and social characteristics of human** (anatomy, anthropometry, biomechanics, physiology, psychophysics, psychology, and sociology)
  - **Applying** the **scientific knowledge** of human beings to develop a **system** (including tasks, products, tools, machines, workplaces, and environments) which **better fits the needs, capabilities, and limitations of people** for **better safety, usability, comfort, and productivity.**

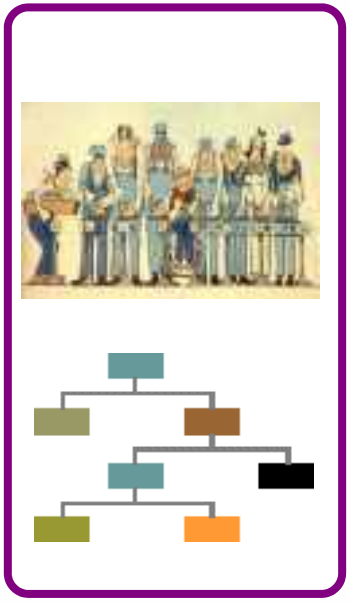
(Board of Certification for Professional Ergonomists, 1993; International Ergonomics Association, 2000)

Domains of Specialization

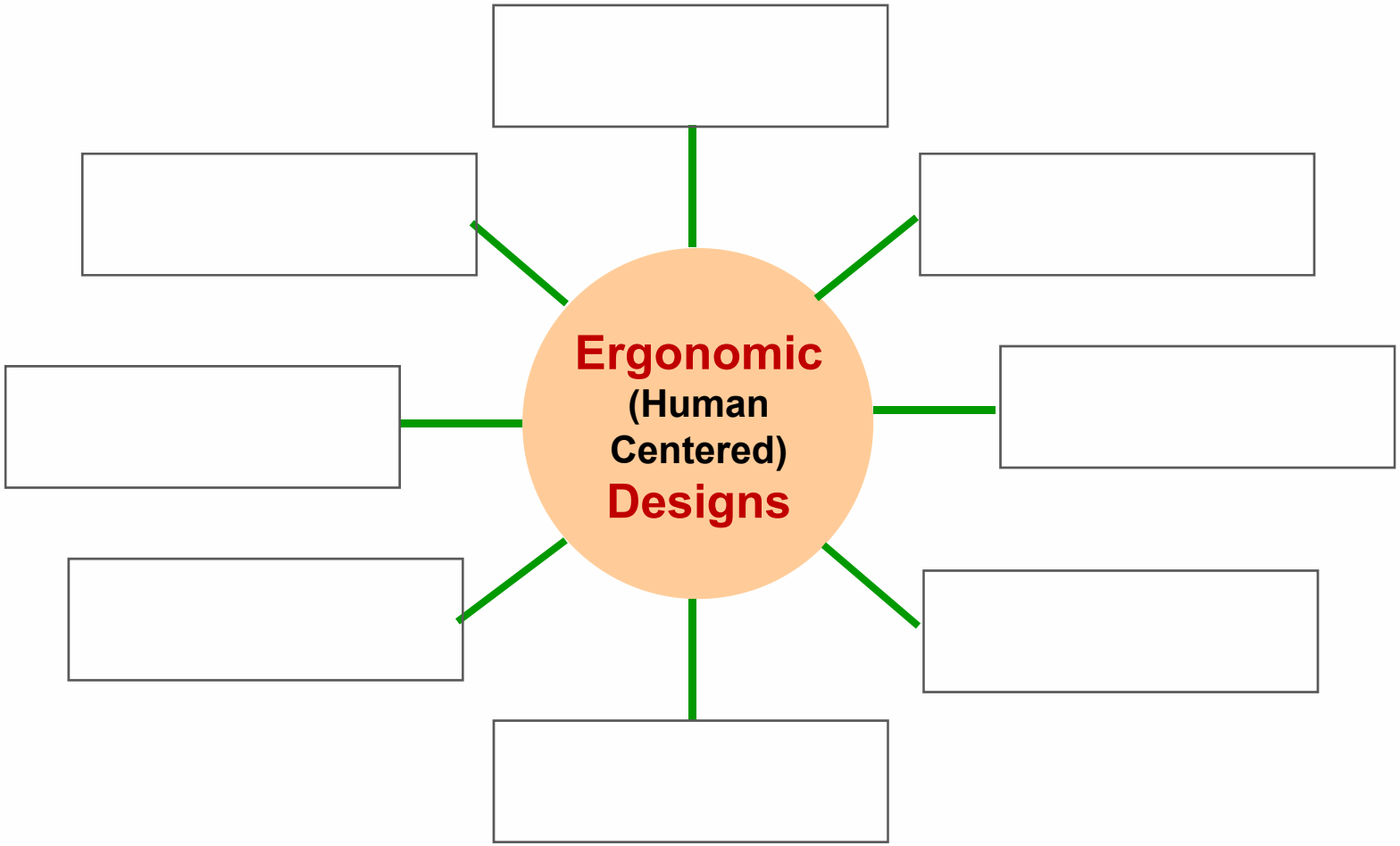
Physical Ergonomics

Cognitive Ergonomics

Organizational Ergonomics



Values of Ergonomic Designs



Benefits only?

Ergonomic Helicopter Cockpit Design

Technical Missions

- **Helicopter cockpit design (2006. 11 ~ 2008. 4)**
  - **Ergonomically appropriate**
  - **Customized to Korean pilots**
- Pilot workload assessment system for HMI design (08. 1 ~ 11)

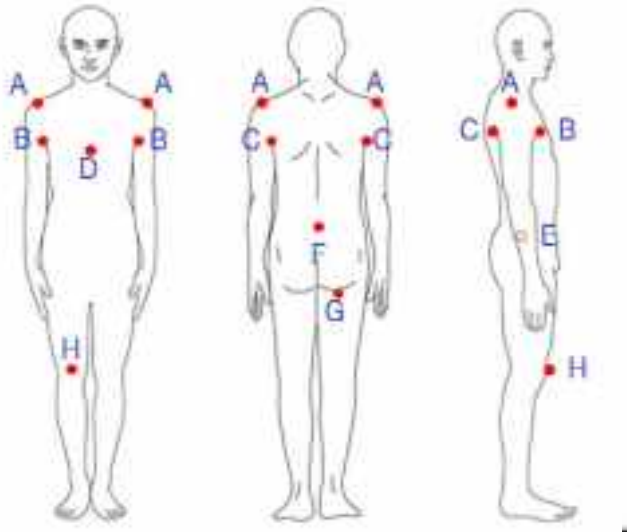
- T1. Anthropometric Survey& Analysis
- T2. Preliminary Cockpit Design Development
- T3. Virtual Mockup Simulation & Evaluation
- T4. Physical Mockup Evaluation

T1. Anthropometric Survey

- Sample size: 100 Korean Army helicopter pilots (average age = 34, S.D. = 6.7)

Age	Male	Female	Total
20s	27	6	33
30s	43	-	43
40s	24	-	24
Total	94	6	100

- Measurement protocol
  - ISO 15535: General requirements for establishing anthropometric databases
  - ISO 7250: Basic human body measurements for technological design



T1. Representative Human Models

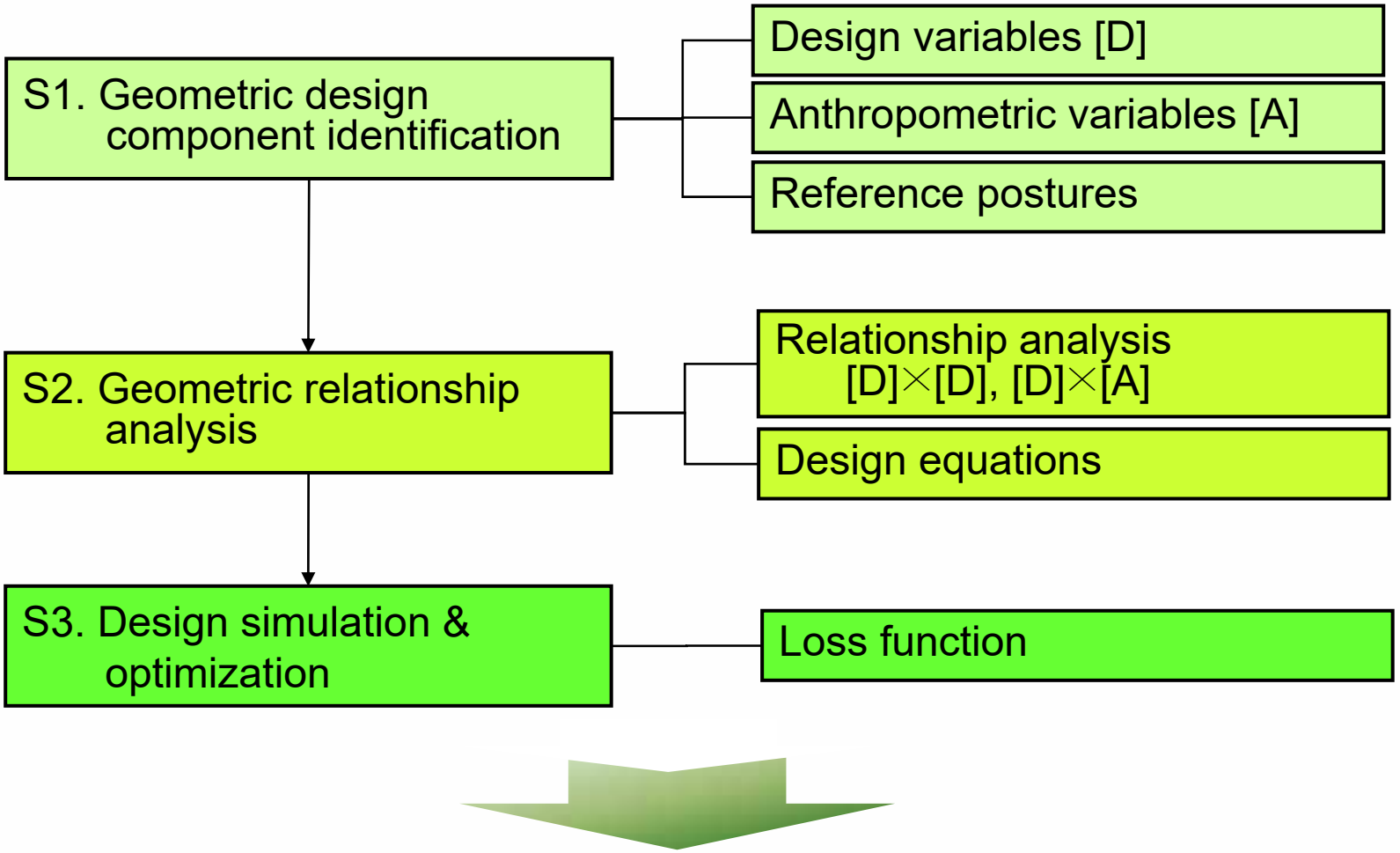
- Determined the body sizes of 3 RHMs based on the anthropometric data of Korean helicopter pilots & US Army personnel
  - 5th %ile: min. of 5%iles of the two populations
  - 50th %ile: average of 50%iles of the two populations
  - 95th %ile: max. of 95%iles of the two populations

⇒ Accommodating the 5th %ile ~ 95th %ile of each population

No	Anthropometric Dimensions	Impor-tance	US Army Personnel			Korean Helicopter Pilots			Percentile RHMs		
			5%ile	50%ile	95%ile	5%ile	50%ile	95%ile	5%ile	50%ile	95%ile
1	Acromial height	H	54.1	59.6	64.5	56.3	60.7	65.8	54.1	60.2	65.8
2	Biacromial breadth	M	36.1	39.6	42.7	35.0	40.2	42.6	35.0	39.9	42.7
3	Buttock-knee length	H	56.5	61.4	66.8	53.4	57.7	61.0	53.4	59.6	66.8
4	Buttock-popliteal length	H	45.6	49.9	54.7	43.8	47.7	50.4	43.8	48.8	54.7
5	Chest circumference	L	89.1	101.9	113.6	88.1	100.0	109.9	88.1	101.0	113.6
6	Chest depth	L	21.0	24.3	28.2	-	-	-	21.0	24.3	28.2
7	Eye height	H	72.4	78.9	84.7	76.4	80.8	86.7	72.4	79.8	86.7
8	Foot length	L	24.2	26.8	29.2	23.3	25.1	26.8	23.3	26.0	29.2
9	Forearm to forearm breadth	M	46.4	54.3	62.1	41.0	48.2	55.8	41.0	51.3	62.1
10	Elbow to fingertip length	H	44.0	48.2	52.3	42.8	46.0	48.6	42.8	47.1	52.3
11	Hip breadth	H	33.1	36.7	41.4	35.1	37.6	40.8	33.1	37.2	41.4

Min. Avg. Max.

T2. Anthropometric Cockpit Design Process

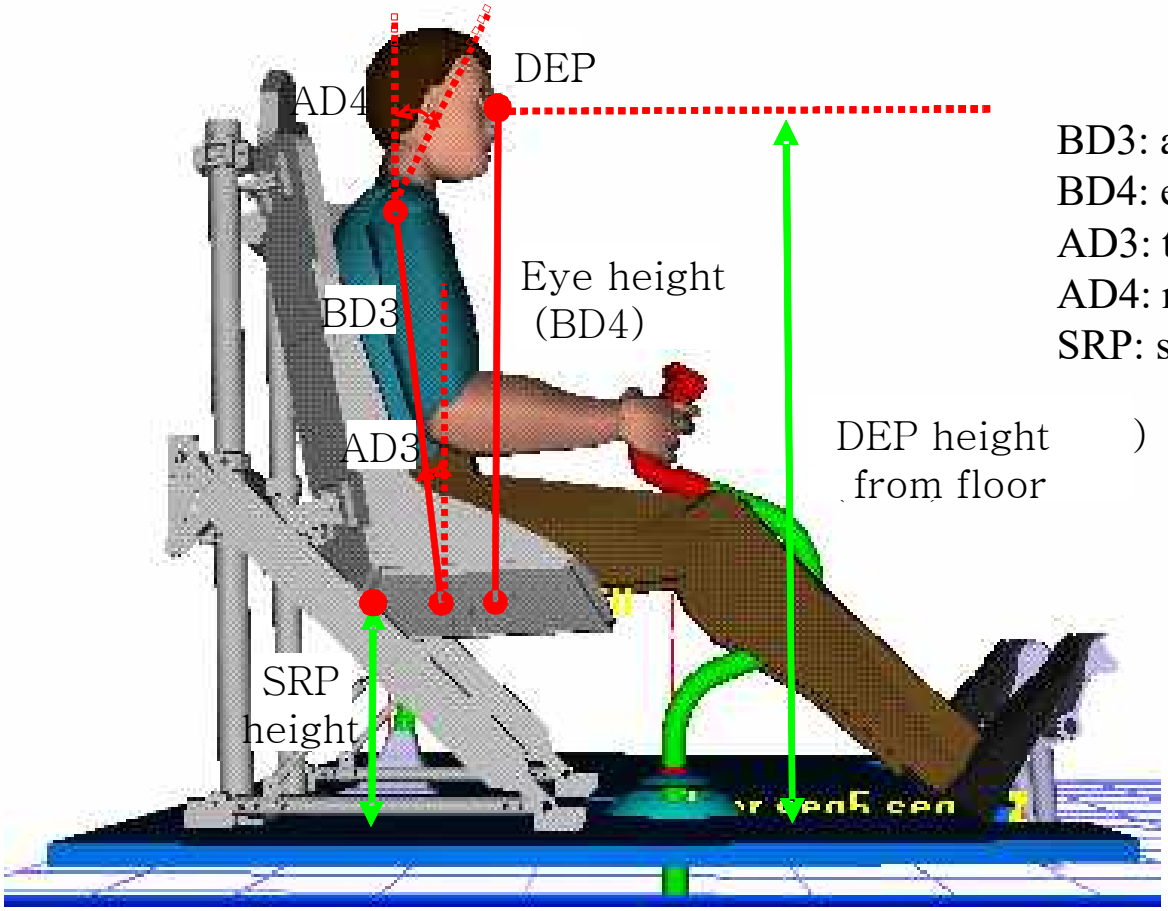


Size, Orientation, Location, Adjustment Range

T2. Geometric Relationship Analysis

trunk　　head & neck

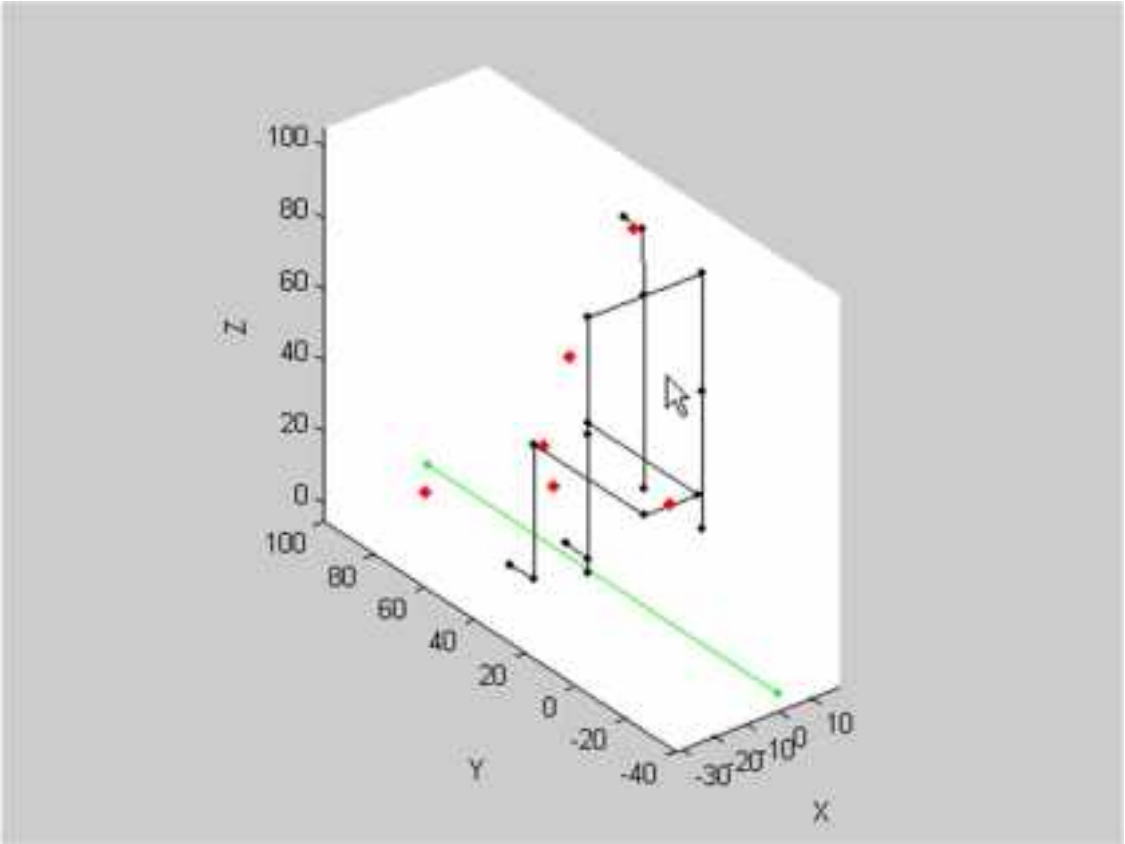
DEP height (DD3) = Seat height (DD6) + BD3 * cos (AD3) + (BD4 - BD3) * cos (AD4)



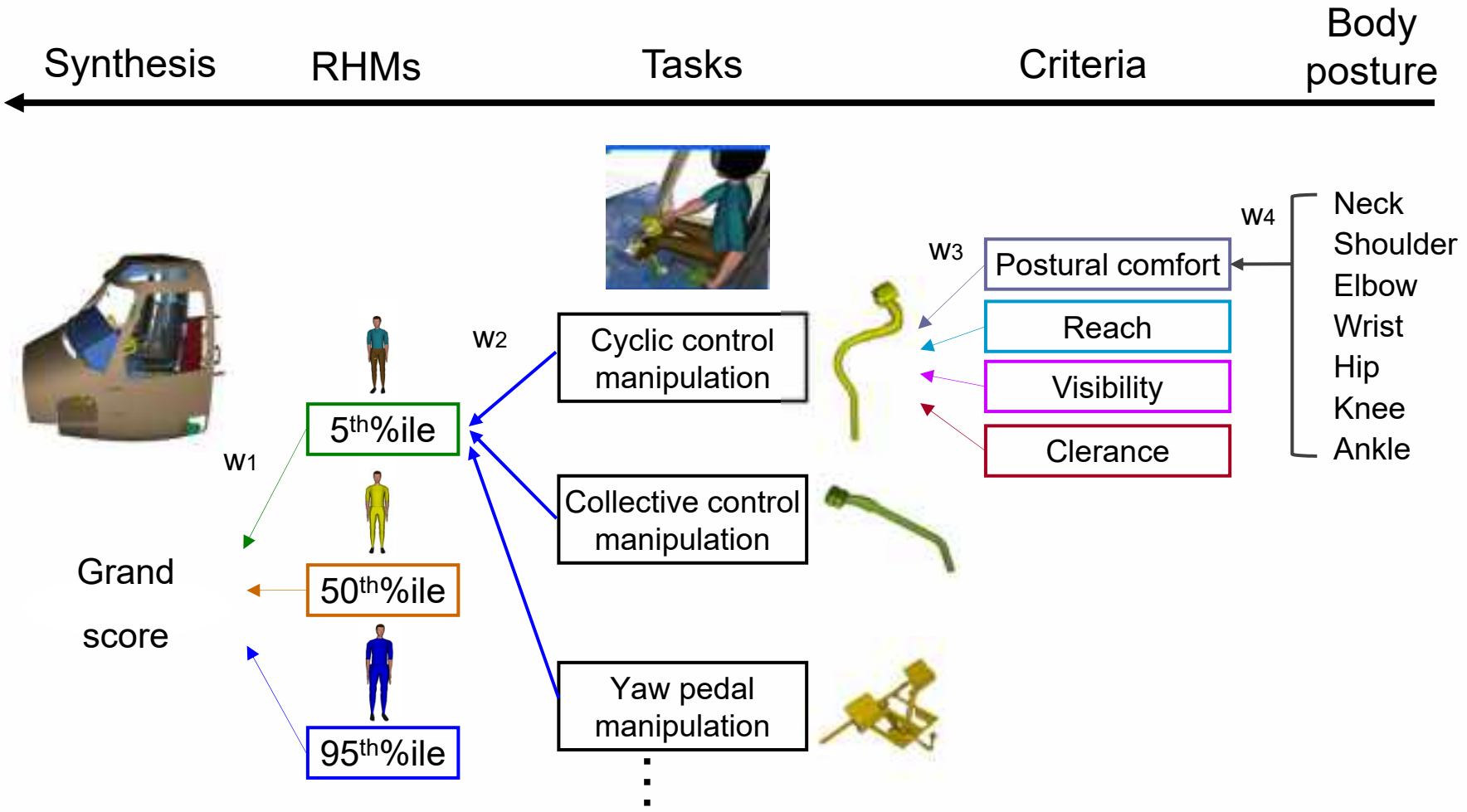
BD3: acromial height
BD4: eye height
AD3: trunk extension
AD4: neck flexion
SRP: seat reference point

T2. Posture Simulation

- Estimate a posture of a selected anthropometric case which minimizes a defined loss function for a particular cockpit layout.



T3. Virtual Mockup Simulation & Evaluation



T3. Pilot Tasks

- Identified 57 tasks of 4 categories by referring to the UH-60 pilot training manual and considering KHP design characteristics.

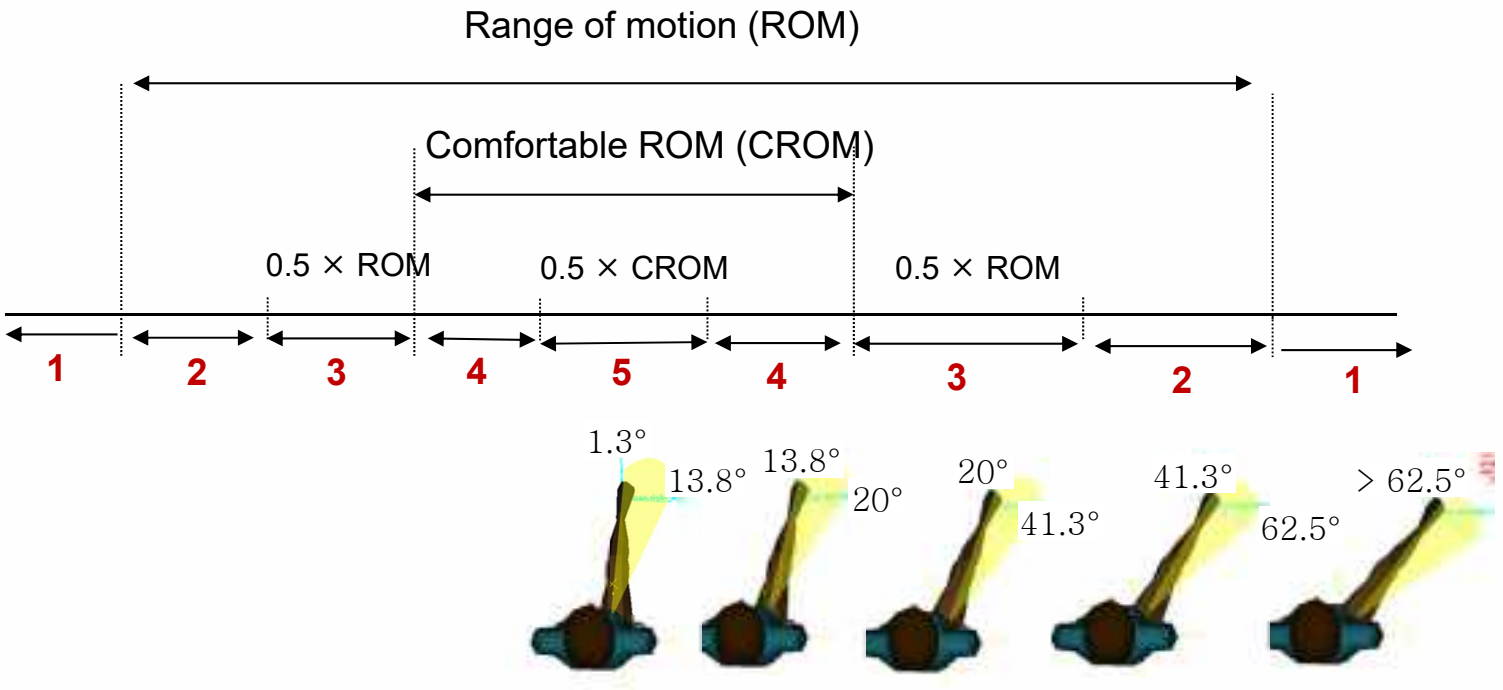
Pre-flight	In-flight	Emergency	Post-flight
▪ Ingress ▪ Seat adjustment ▪ Yaw pedal adjustment ▪ Armor plate locking ▪ Safety belt fastening ▪ Check switches & controls ▪ Rotor brake release ▪ Parking brake release	▪ Cyclic manipulation ▪ Collective control manipulation ▪ Yaw pedal manipulation ▪ Instrument panel operation ▪ Center console operation ▪ Upper console operation ▪ Vigilance: forward, side, and downward ▪ NVG	▪ Safety belt release ▪ Pilot evacuation	▪ Parking brake engagement ▪ Rotor brake engagement ▪ Check switches & controls ▪ Armor plate release ▪ Safety belt release ▪ Seat adjustment ▪ Egress

T3. Physical Workload Evaluation Criteria

Criteria	Definition
Postural comfort	The level of maintaining a comfort posture to operate a component
Ease of reach	The level of ease of access to a component
Visibility	The level of visibility to acquire visual information
Clearance	The level of clearance between the body and component

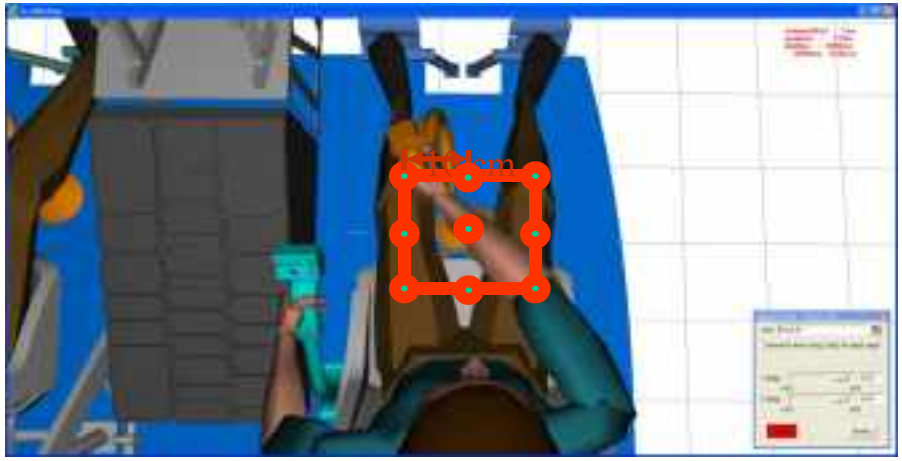
T3. Evaluation Scale: Postural Comfort

- 5-point scale for each joint motion: ROM & comfortable ROM



References: Kroemer et al. (1994), Diffrient et al. (1981)

T3. Evaluation: Cyclic Control Manipulation



Task	
Criteria	Comfort
	Reach
	Visibility
	Clearance
Remarks	Evaluated 9 CC locations

Task		Physical workload		Anthropometric dimension				Score			
Title	Weight	Item	Weight for item	Body joint	Weight for body	Motion	Weight for motion	Score for right	Score for body	Score for item	Total score
Cyclic control 조작	1	자세 (Posture)	0.3	Neck	0.143	dorsal(-)/ventral(+) flexion	0.3	5	5.0	4.3	4.4
						left(-)/right(+) tilt	0.3	5			
						left(-)/right(+) rotation	0.3	5			
				Shoulder	0.143	extension(-)/flexion(+)	0.3	4	3.8		
						adduction(-)/abduction(+)	0.3	4			
						medial(-)/lateral(+) rotation	0.3	3			
				Elbow-Forearm	0.143	flexion(+)	0.5	5	3.8		
						supination(-)/pronation(+)	0.5	3			
				Wrist-Hand	0.143	extension(-)/flexion(+)	0.5	5	4.4		
						adduction(-)/abduction(+)	0.5	4			
				Hip	0.143	flexion(+)	0.3	5	4.7		
						adduction(-)/abduction(+)	0.3	4			
						medial(-)/lateral(+) rotation (shifting)	0.3	5			
				Knee	0.143	flexion(+)	1.0	5	5.0		
				Ankle	0.143	flexion(-)/extension(+)	0.5	3	3.5		
						adduction(-)/abduction(+)	0.5	4			
		도달성 (Reach)	0.3					4		4.0	
		여유공간 (Clearance)	0.3							5.0	

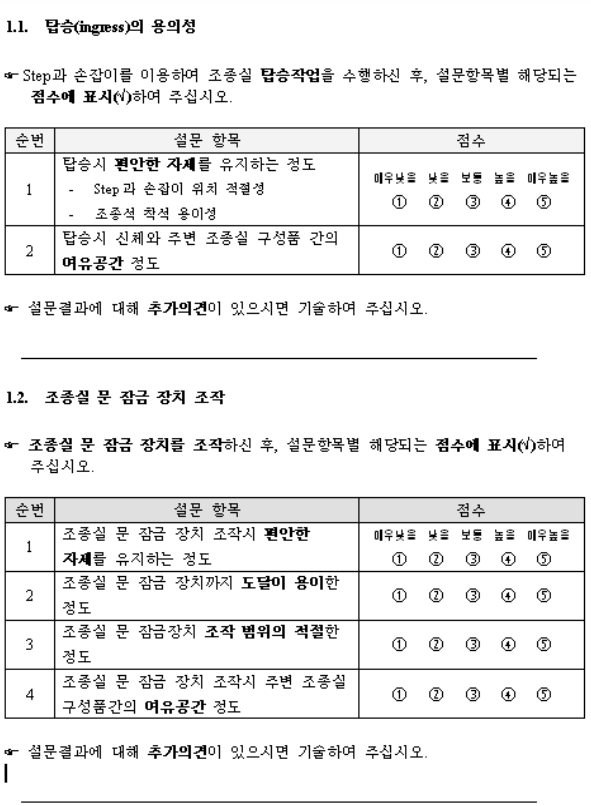
Individual Score

Composite Score

T4. Physical Cockpit Mockup Evaluation

T4. Prototype Testing Protocol

- ❑ Questionnaire: 3 parts (introduction, demographics, assessment)
- ❑ Tasks simulated: 63 tasks (233 assessment questions)
- ❑ Participants: 29 (12 warrant officers, 6 captains, 11 majors)



1.1. 탑승(ingress)의 용의성

☞ Step과 손잡이를 이용하여 조종실 **탑승작업**을 수행하신 후, 설문항목별 해당되는 **점수에 표시(√)**하여 주십시오.

순번	설문 항목	점수
1	탑승시 **편안한 자세**를 유지하는 정도 - Step과 손잡이 위치 적절성 - 조종석 착석 용이성	매우낮음 ① 낮음 ② 보통 ③ 높음 ④ 매우높음 ⑤
2	탑승시 신체와 주변 조종실 구성품 간의 **여유공간** 정도	① ② ③ ④ ⑤

☞ 설문결과에 대해 **추가의견**이 있으시면 기술하여 주십시오.

1.2. 조종실 문 잠금 장치 조작

☞ **조종실 문 잠금 장치를 조작**하신 후, 설문항목별 해당되는 **점수에 표시(√)**하여 주십시오.

순번	설문 항목	점수
1	조종실 문 잠금 장치 조작시 **편안한 자세**를 유지하는 정도	매우낮음 ① 낮음 ② 보통 ③ 높음 ④ 매우높음 ⑤
2	조종실 문 잠금 장치까지 **도달이 용이**한 정도	① ② ③ ④ ⑤
3	조종실 문 잠금장치 **조작 범위의 적절**한 정도	① ② ③ ④ ⑤
4	조종실 문 잠금 장치 조작시 주변 조종실 구성품간의 **여유공간** 정도	① ② ③ ④ ⑤

☞ 설문결과에 대해 **추가의견**이 있으시면 기술하여 주십시오.

Flights	# Participants	Flight Hours			
		Mean	SD	Min	Max
UH-1H	27	1240	1781	11	5600
UH-60	11	1216	1346	20	3300
500MD	21	439	442	15	2800
AH-1S	9	175	143	20	1500
OH-23	9	43	17	20	80
Total	29	1946	1635	350	5100

T4. KHP Full Mockup @ Seoul Airshow

Former Korean President Roh rode the KHP mockup at the 2007 Seoul airshow

Development of an **Ergonomic Bus Passenger Seat** Based on **3D Seat Profile and Seat Comfort Analyses**

HYUNDAI | NEW THINKING. NEW POSSIBILITIES.

HANIL INTERIOR

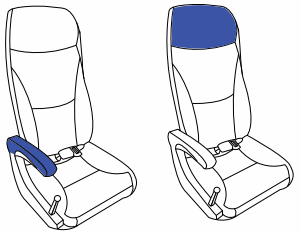
POSTECH
POHANG UNIVERSITY OF SCIENCE AND TECHNOLOGY

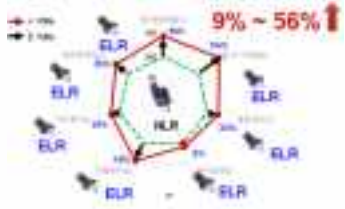
Ergonomic Design Technology Lab

Approach


S1. Development of Seat Comfort Evaluation Protocol


S2. Evaluation of Seat Designs





S3. Identification of Preferred Designs

S4. Analysis of 3D Seat Profiles

S5. Development & Validation of Ergonomic Seat Design

Project Progress

2012. 5 — 8 — 9 — 10 — 11 — 12 — 2013. 1 — 2 — 3 — 4 — 2013. 4. 17

Final

Kick-off Meeting

Establishment of Evaluation Protocol

Seat Comfort Evaluation

Material Property Evaluation

Seat Profile Analysis

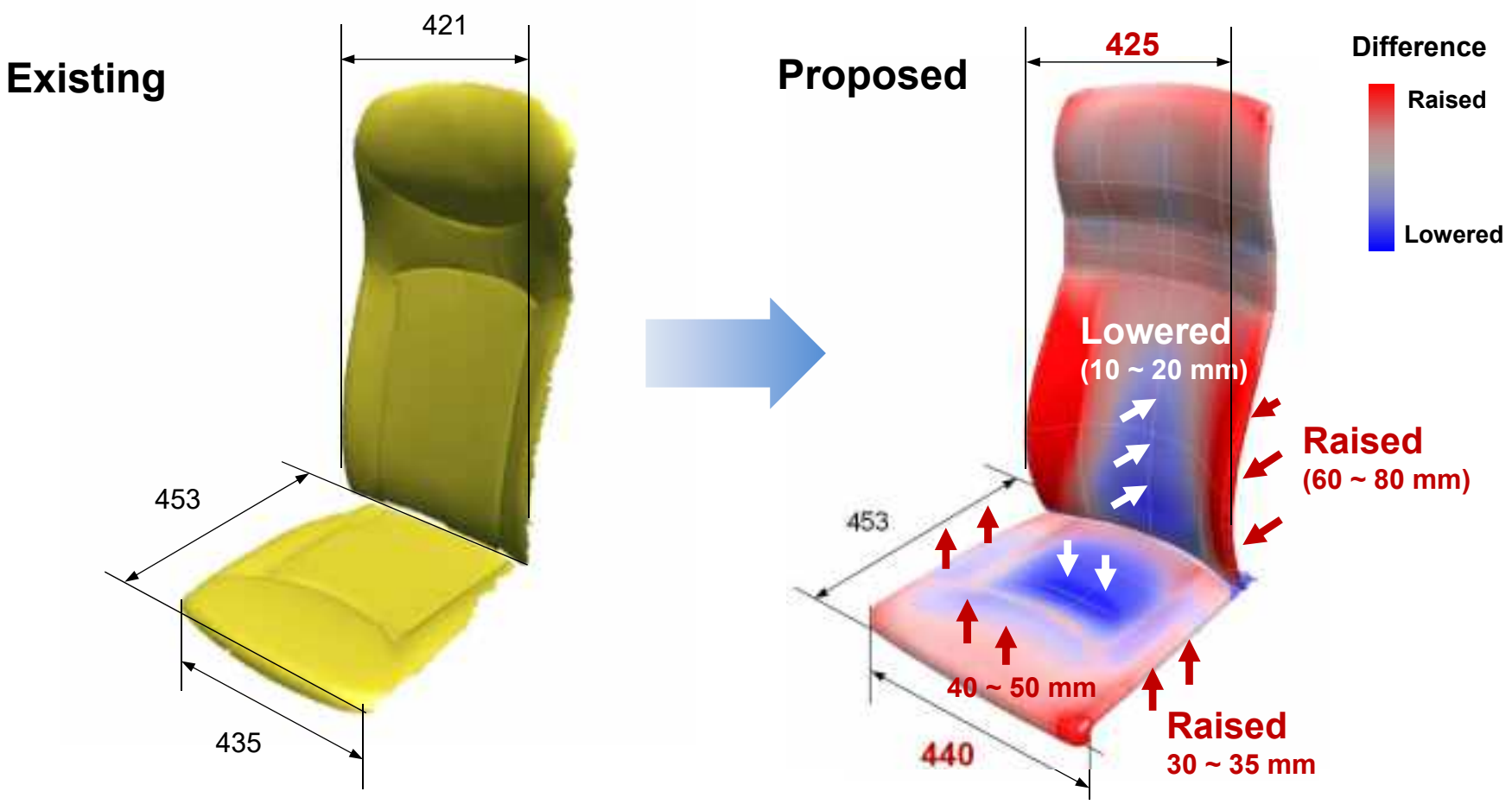
Interim Review

3D Seat Profile Design

Mock-up Fabrication

Validation

Profile Comparison: Existing vs. Proposed



Validation

❑ Lab Testing

- ✓ *n* = 125 (male = 59, female = 66)
- ✓ Age: *M* = 41.6, *SD* = 13.2, *R* = 15 ~ 77

설계 부위	평가 결과: 평균 ± 표준편차		
	기존	신규	개선율(%)
머리지지부	4.4 ± 1.2	4.6 ± 1.2	4.5
흉부 지지부	4.3 ± 1.1	4.6 ± 1.2	7.0
요추 지지부	4.3 ± 1.0	4.7 ± 1.2	4.5 % ~
측면 지지부	4.1 ± 1.1	5.0 ± 1.3	23.0% ⇑
등받이 전반	4.3 ± 1.1	4.9 ± 1.2	
엉덩이 지지부	4.4 ± 1.0	4.8 ± 1.0	9.1
허벅지 지지부	4.4 ± 1.1	4.8 ± 1.0	9.1
측면 지지부	4.3 ± 1.1	4.8 ± 1.2	11.6
좌면 전반	4.3 ± 1.1	4.8 ±1.1	11.6

❑ Test-Track Testing

- ✓ *n* = 17 (seat design experts, engineers, test drivers)

Commercialization in 2015

Hyundai Motors

Universe Express Noble

KIA Motors

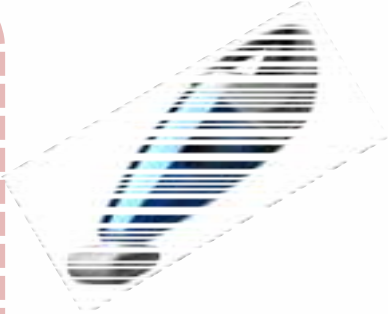
New Grandbird Silkroad

Ergonomic Vacuum Cleaner Handle Design

- Canister vacuum cleaners are commonly used for cleaning on hardwood, tile, vinyl, or laminate floors

Upright

Canister



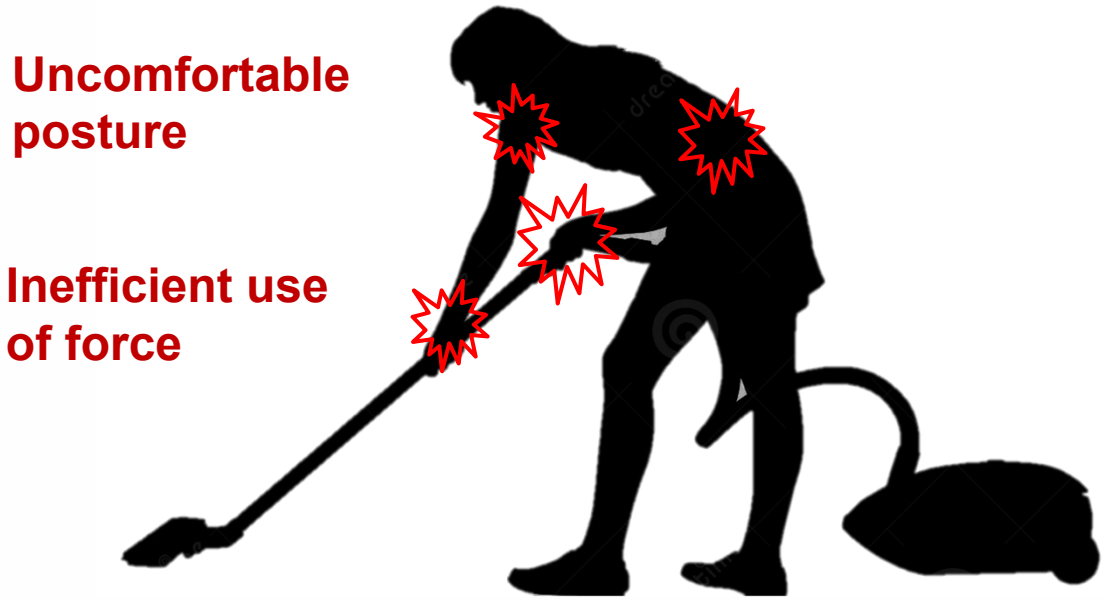
Handheld

Backpack

Robot

Needs of Ergonomic Vacuum Cleaner Handle

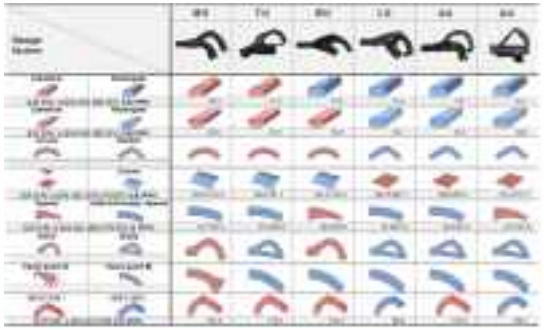
- A prolonged use of a vacuum cleaner with an improperly designed handle can result in discomfort at the shoulder, wrist, and low back (Hu et al., 2013).
- An ergonomically designed handle can contribute to improving convenience, muscular efficiency, performance, and satisfaction (Eksioglu, 2004; Harih and Dolsak, 2014; Bohlemann et al., 1994).



Objectives of the Study

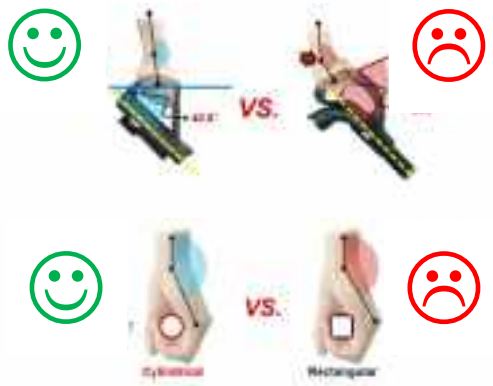
Ergonomic Evaluation on Handle Designs of Canister Vacuum Cleaner

G1. Identify key design factors of vacuum cleaner handle



G2. Evaluate vacuum cleaner handles with various design features

G3. Identify preferred handle design features

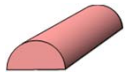
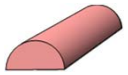
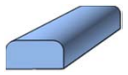
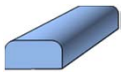
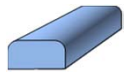
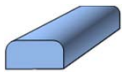
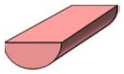
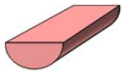
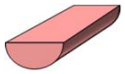
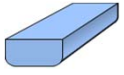
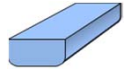
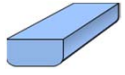
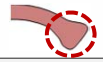


S1. Selection of VC Handles

- Selected vacuum cleaner handles different in shape and size and showing good sales in the market

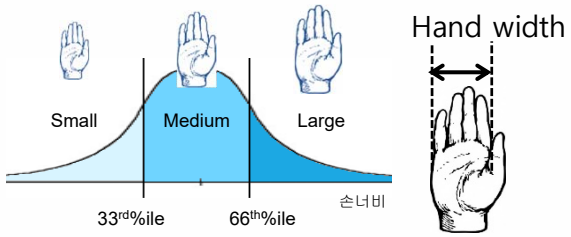
						
VC ID	B	D	E	L	M	T
Side view						
Plan view						

S2. Analysis of Handle Design Features: Illustrated (2/2)

Design factors		M	T	B	L	E	D
							
Cylindrical 	Rectangular 						
Middle transverse curvature of upper part (mm)		19.9	11.2	17.8	13.3	7.6	4.9
Cylindrical 	Rectangular 						
Middle transverse curvature of lower part (mm)		20.0	12.3	12.6	10.1	13.2	13.6
Tapered 	Uniform/inversely tapered 						
Front/middle lateral curvature of upper part (mm)		35.1/35.0	25.4/26.2	36.0/30.9	32.8/27.9	32.2/32.2	27.5/27.8
Open 	Closed 						
-							
Flared guard 	Flat guard 						
-							
Long grip	*Short grip*						
Length of upper part (mm)		154.8	118.4	150.3	98.2	170.5	68.7

S3. Establishment of Evaluation Protocol: Participants

- Recruitment of participants: 36 participants in total
  - ✓ Gender: 18 females, 18 males
  - ✓ Age: 20s ~ 50s
  - ✓ Hand size groups: small (≤ 33rd %ile), medium (33rd ~ 67th %ile), and large (≥ 67th %ile) groups of hand width by referring to Size Korea anthropometric data



Gender	Male						Female						Total
Age group	20s ~ 30s			40s ~ 50s			20s ~ 30s			40s ~ 50s			
Hand width group (mm)	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large	
	≤ 83.8	83.8 ~ 87.5	≥ 87.5	≤ 83.8	83.8 ~ 87.5	≥ 87.5	≤ 76.0	76.0 ~ 79.2	≥ 79.2	≤ 76.0	76.0 ~ 79.2	≥ 79.2	
Number of participants	3	3	3	3	3	3	3	3	3	3	3	3	36

S3. Establishment of Evaluation Protocol: Apparatus

1. Motion Analysis

Hawk system
(Motion Analysis, USA)

Sampling rate = 50 Hz

2. EMG Analysis

Telemyo DTS Telemetry
(Noraxon, USA)

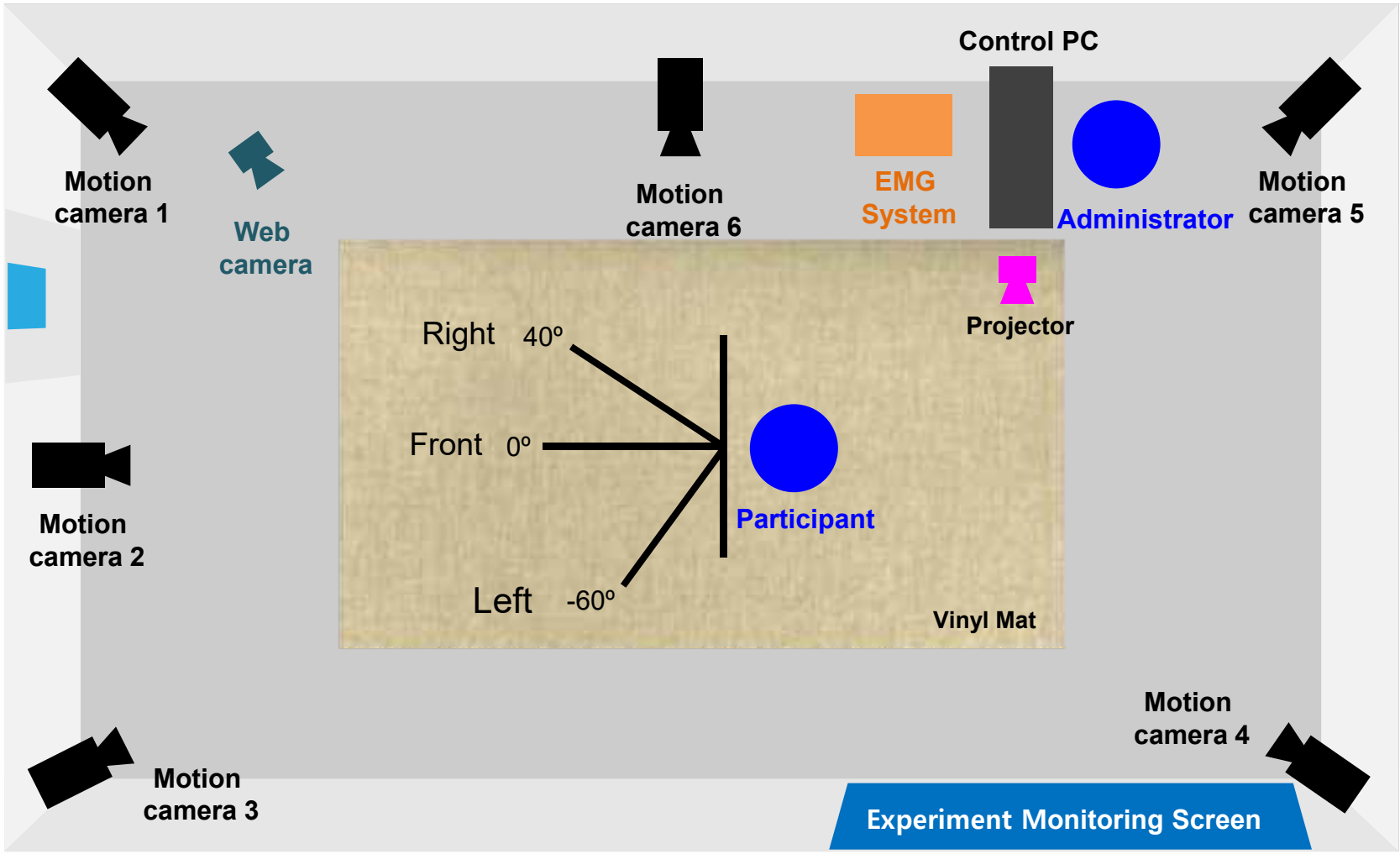
Sampling rate = 1,000 Hz

3. Force Analysis

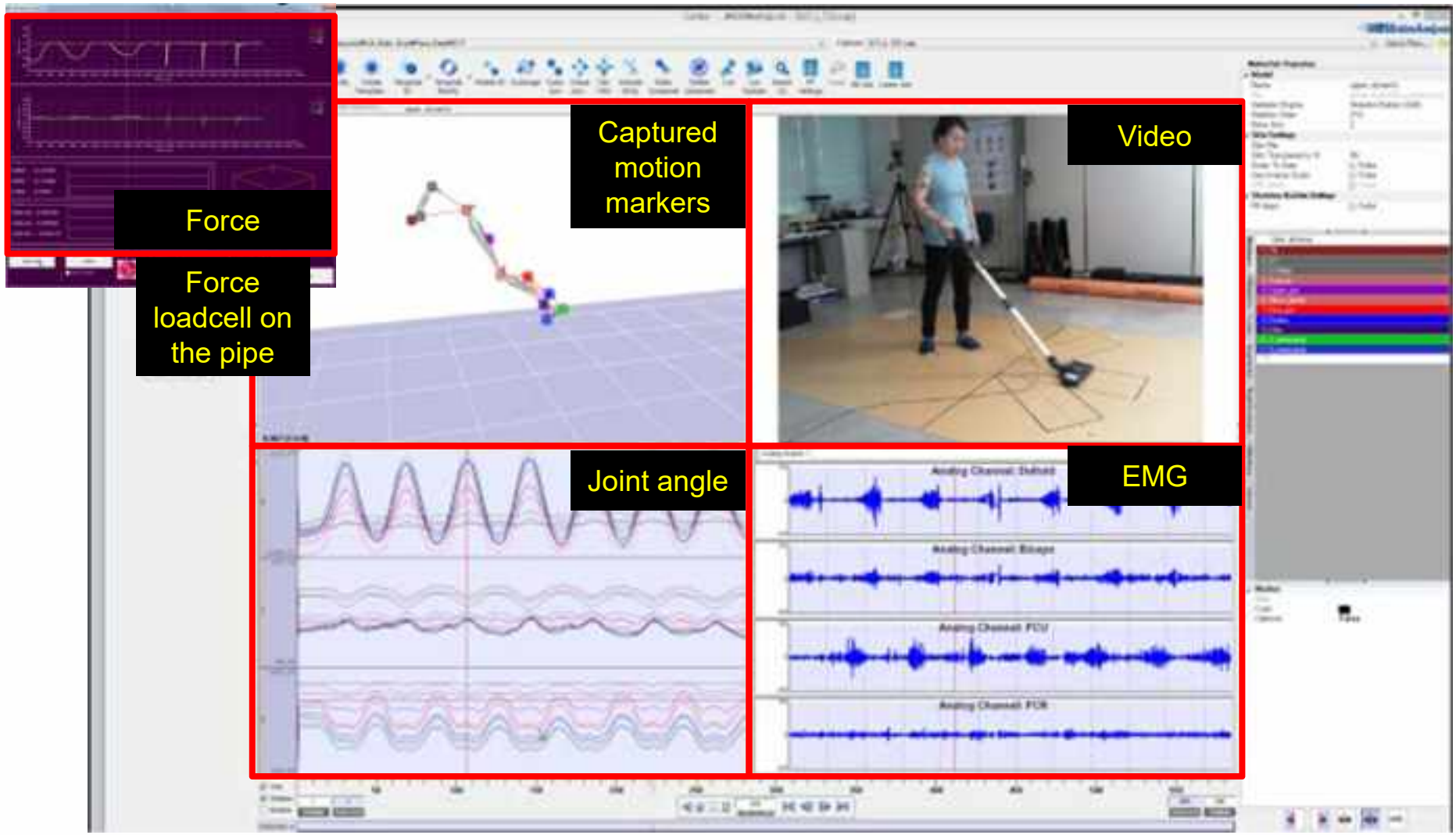
Nano 25
(ATI, USA)

Sampling rate = 1,000 Hz

S3. Establishment of Evaluation Protocol: Experiment Setup

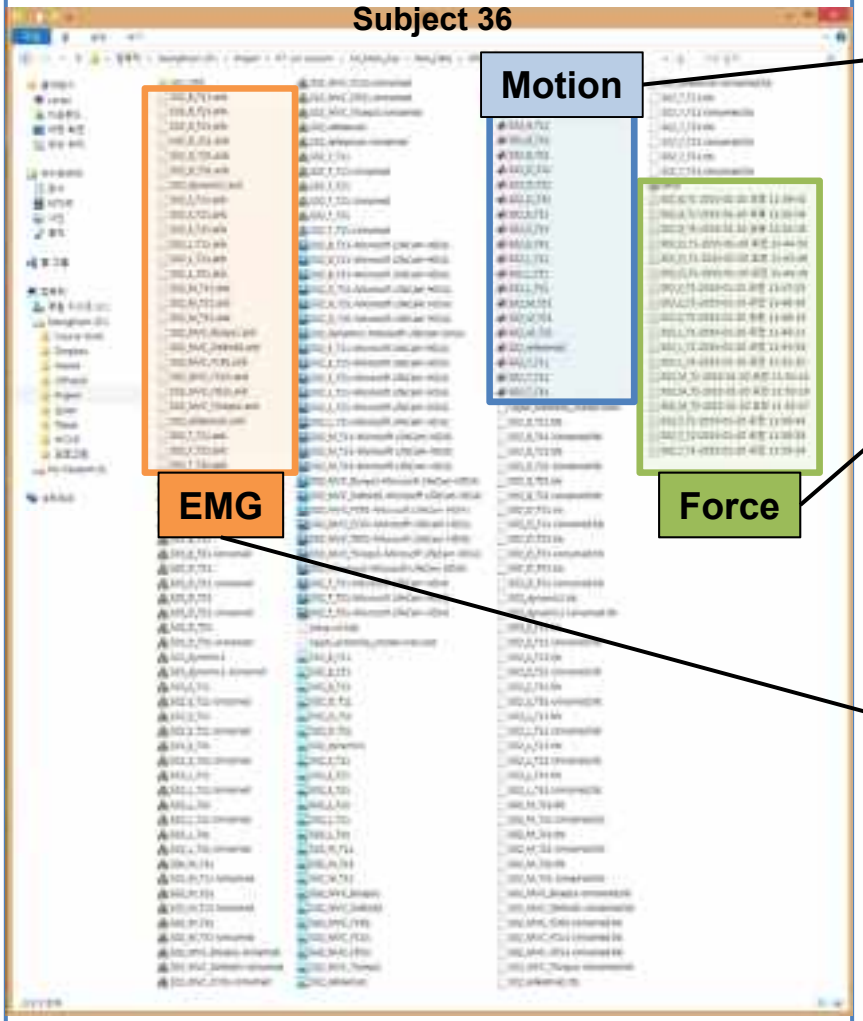


S4. Evaluation of Handle Designs



S5. Analysis of Evaluation Results

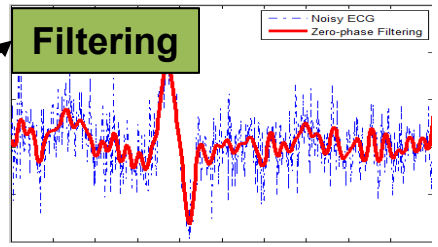
S1. Collection of measurements



S2. Pre-processing

Editing missing data

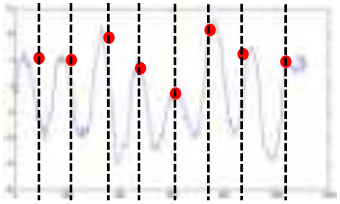
Filtering



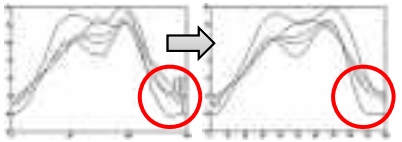
Rectification & filtering

S3. Synchronization

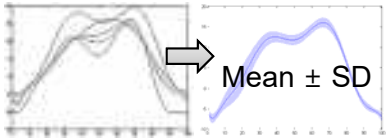
S1. Data trim



S2. Time synchronization



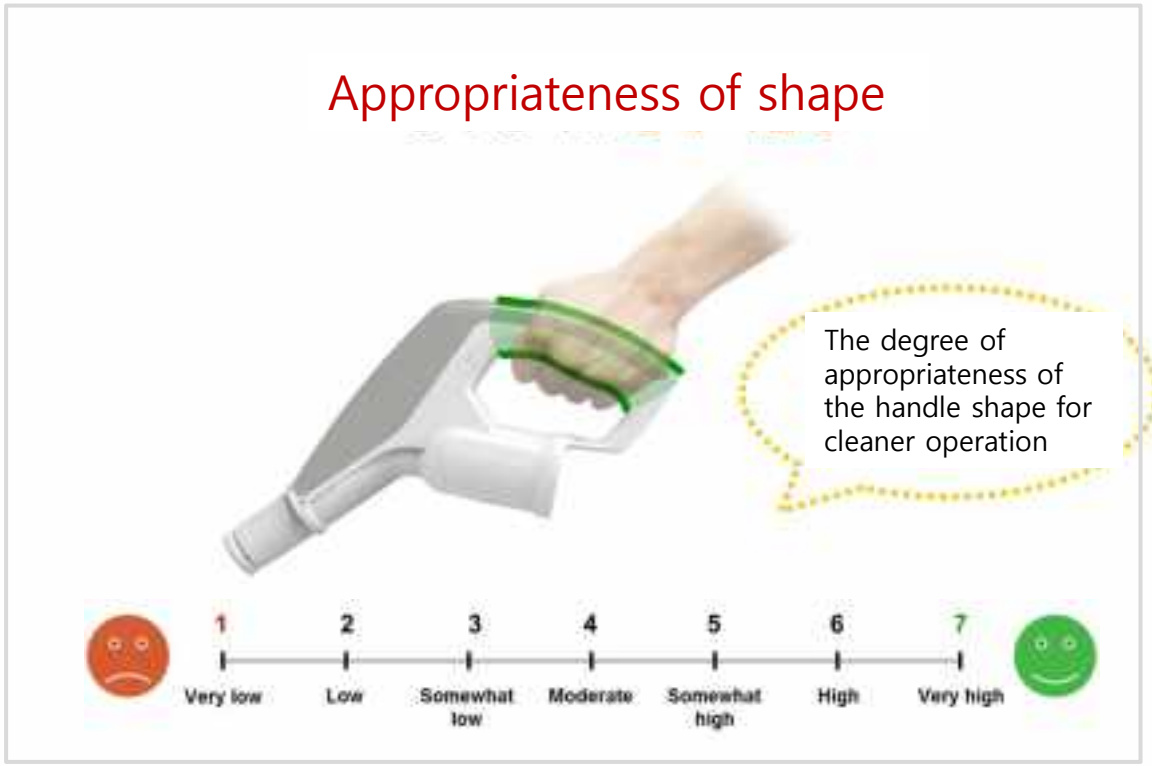
S3. Data summary



S5. Analysis Method: Subjective Satisfaction

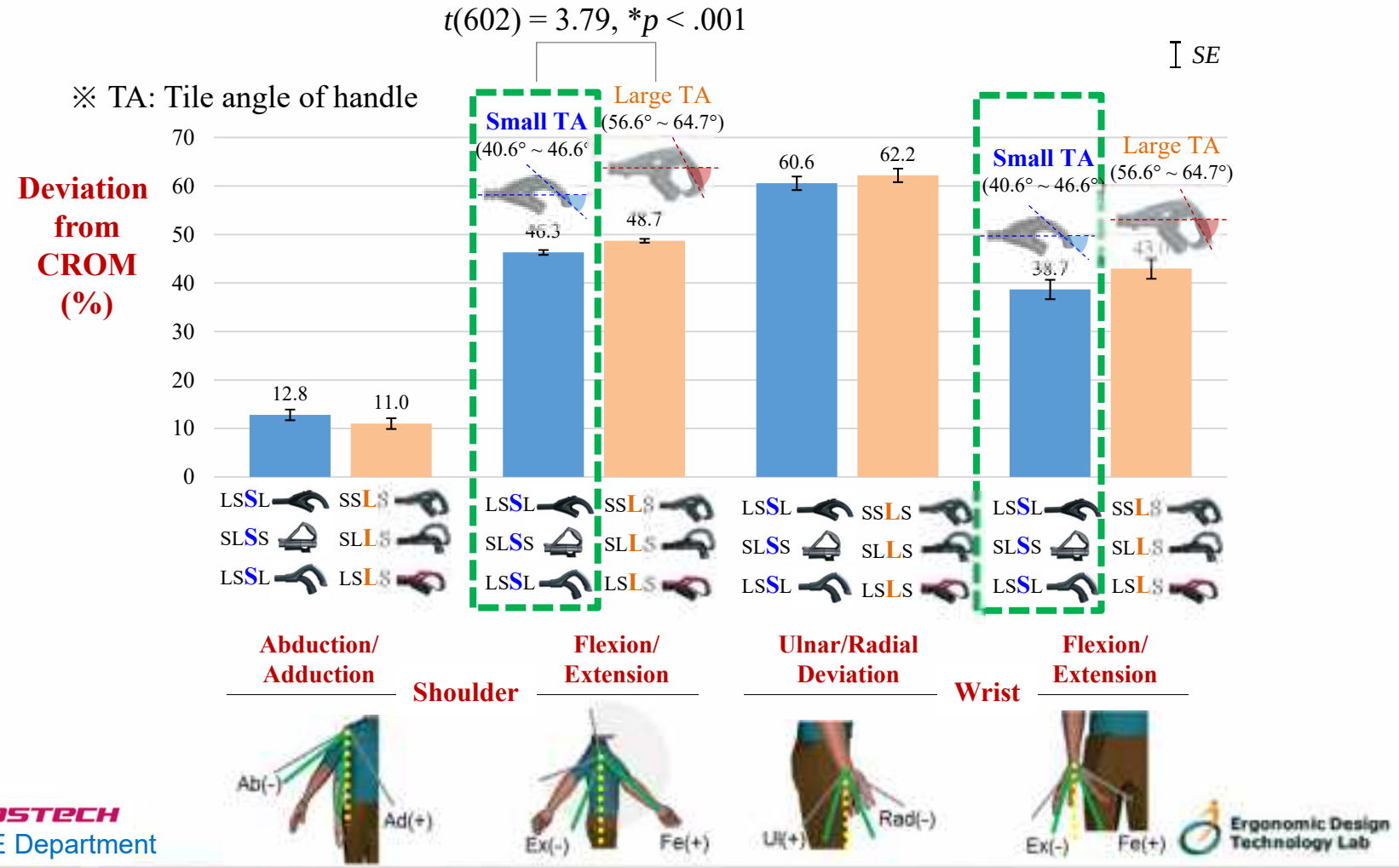
- Evaluated each handle design in terms of various subjective evaluation criteria using a 7-point Likert scale

Criteria
Ease of manipulation
Appropriateness of shape
Comfort of grip posture
Efficiency of force exertion
Efficiency of motion
Fit of grip
Overall satisfaction



Preferred Design Features: Motion

- Handles with a small tilt angle (40° ~ 47°) of handle were preferred to those with a large tilt angle (55° ~ 65°) for comfortable motion at the shoulder and wrist

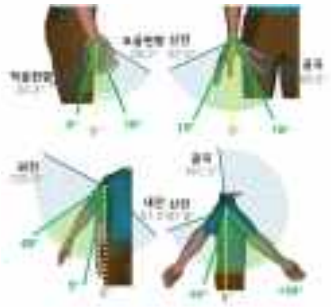


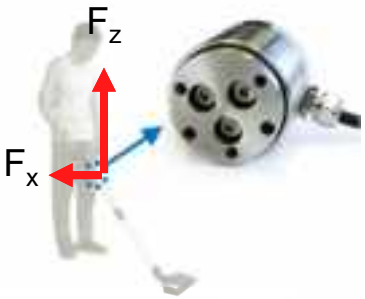
Discussion

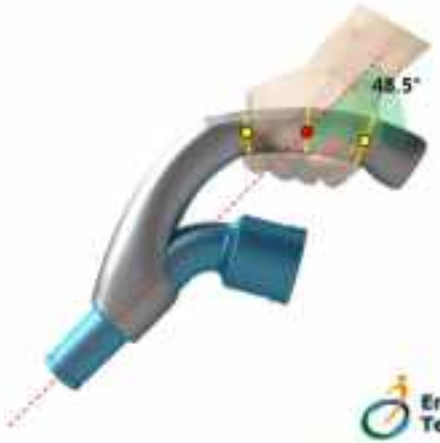
- Identified preferred design features of vacuum cleaner handle based on ergonomic evaluation in terms of motion, EMG, force, and satisfaction

  ⇒ Use of an ergonomic design guideline of vacuum cleaner handle

  ⇒ Development of an ergonomic design of vacuum cleaner handle







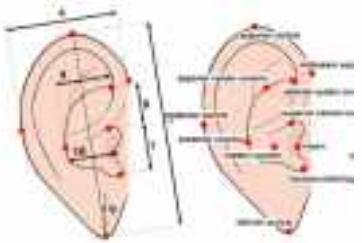
LG Cordless Vacuum Cleaner: Cord Zero CYKING

Commercialized in June 2016

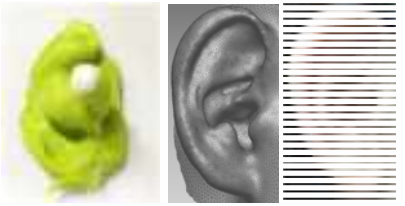
LG Cordless Vacuum Cleaner

Ergonomic Ear Set Design Using 3D Ear Scans

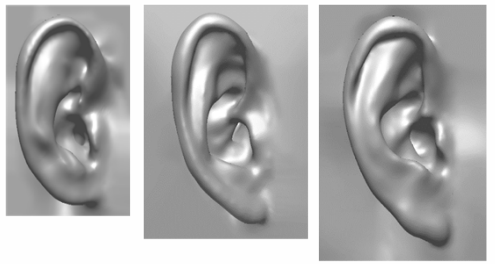
1. Identification of ear dimensions and landmarks related to earphone



2. Collection of 3D ear scans and measurements: scanning, editing, landmarking, and measurement



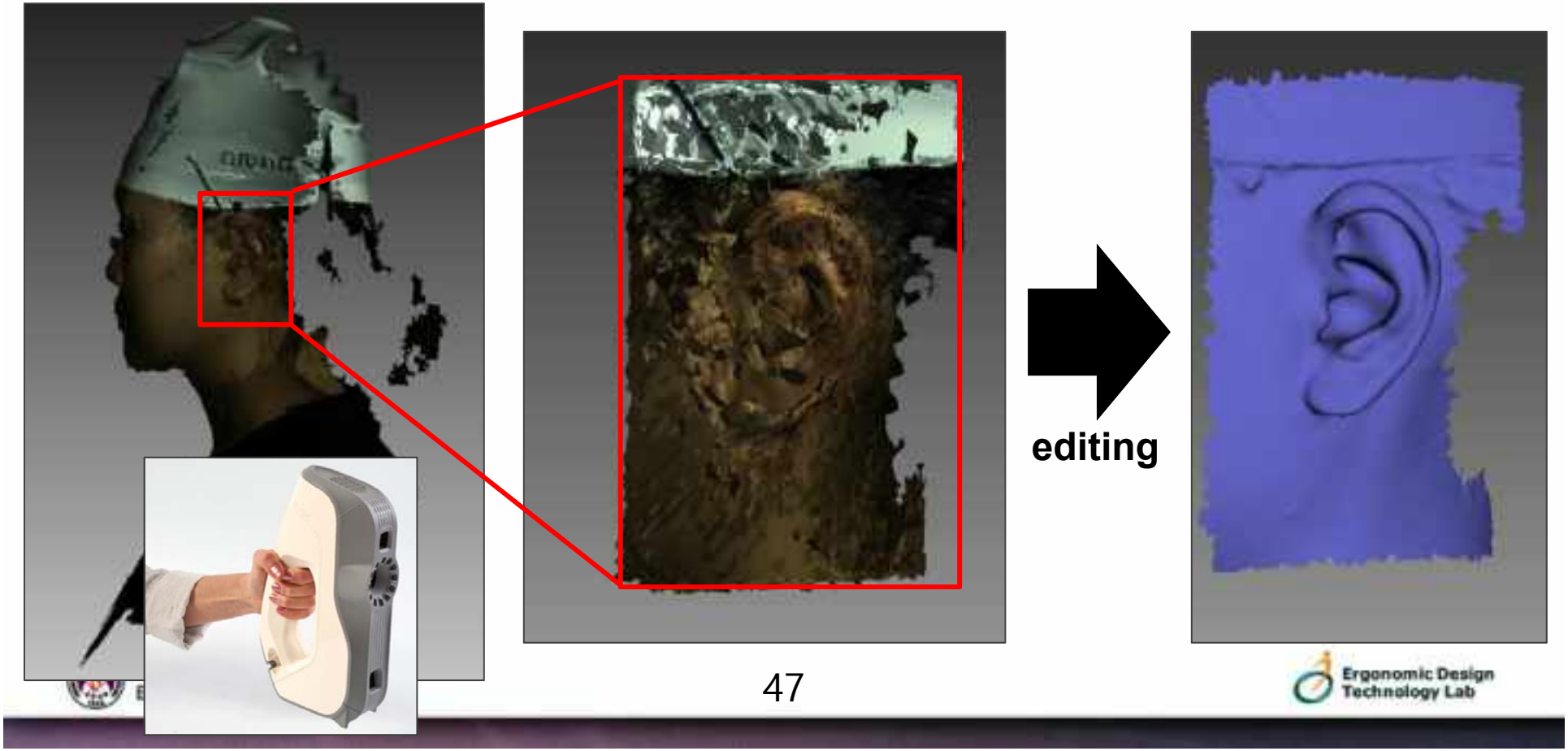
3. Analysis of the size, shape, volume of the ear



4. Application of 3D ear scans to design of earphone

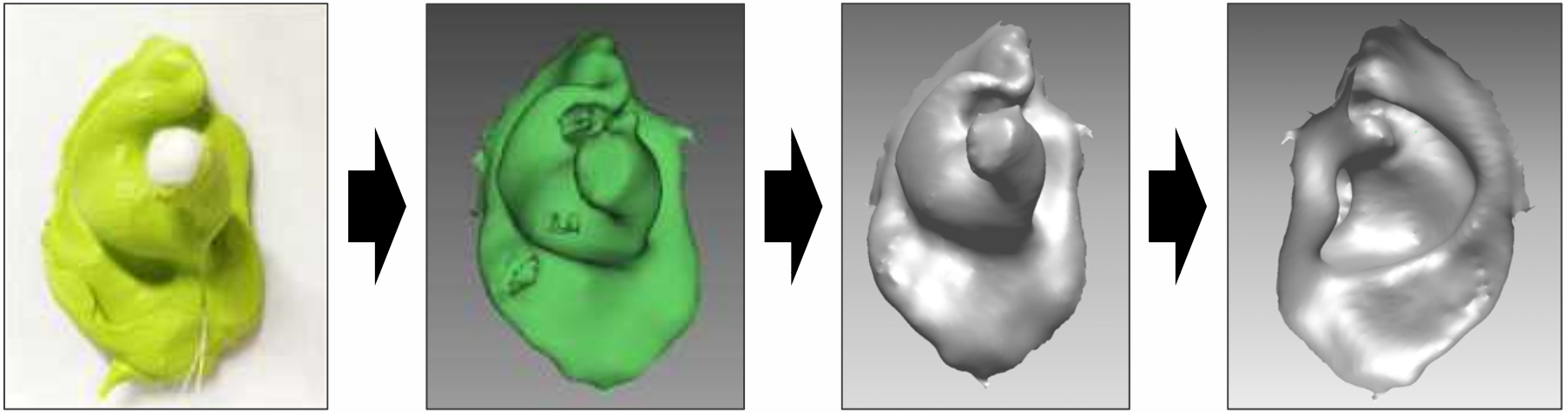
3D Scanning of the Outside Ear (Pinna)

- Scanned the outside of the ear (pinna) using an Artec Eva 3D scanner for 296 participants in 20s to 50s
  - ✓ 200 Koreans: 100 males and 100 females
  - ✓ 96 Caucasians: 50 males and 46 females



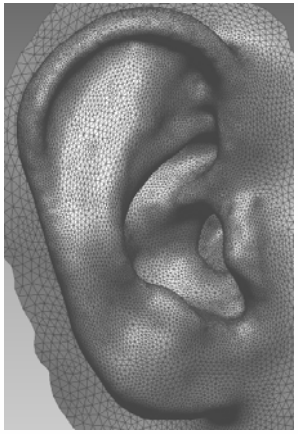
Scanning of the Concha & Earhole

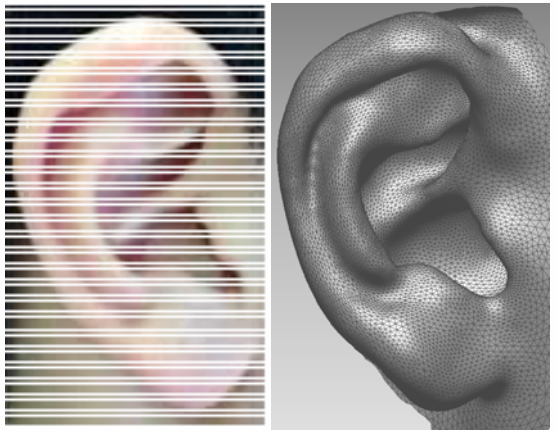
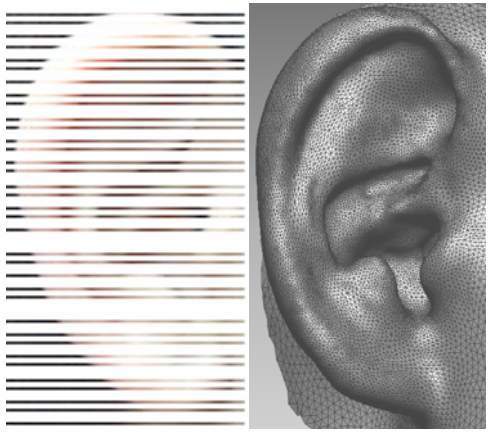
- Applied casting materials to obtain the shape of the concha and ear hole
- Scanned the cast using the Artec Eva 3D scanner



3D Ear Scans

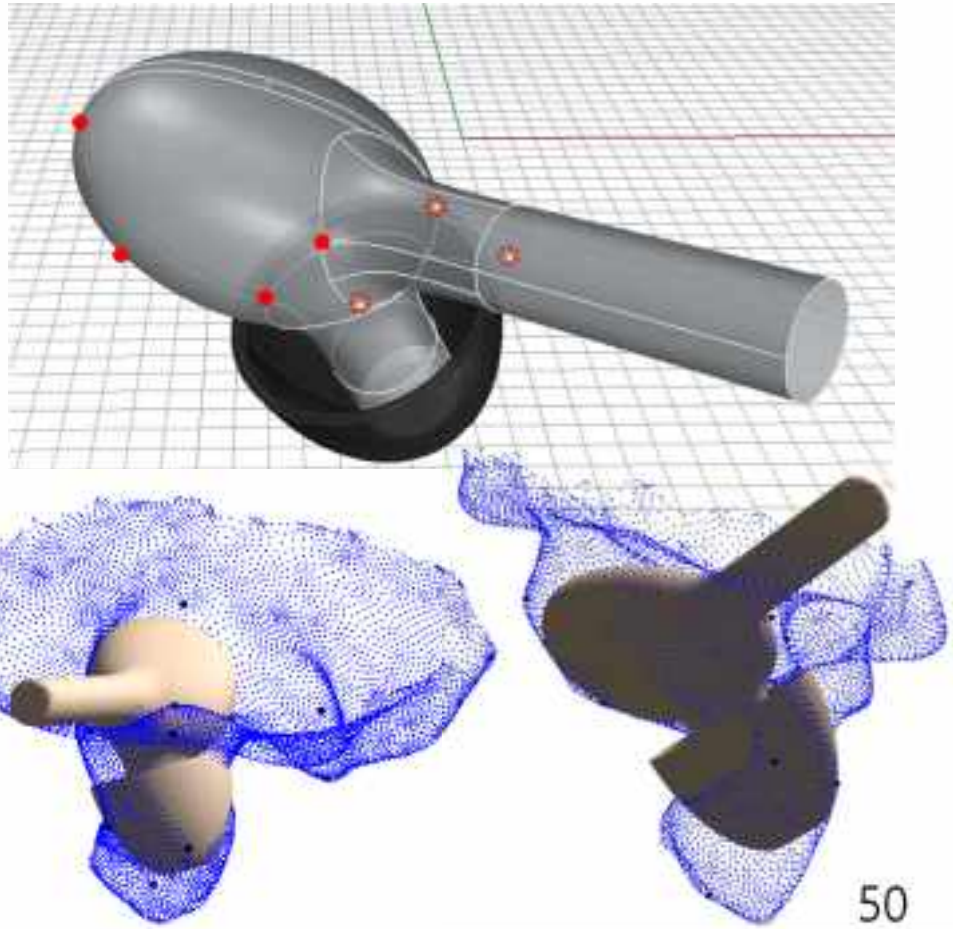
(*n* = 296)

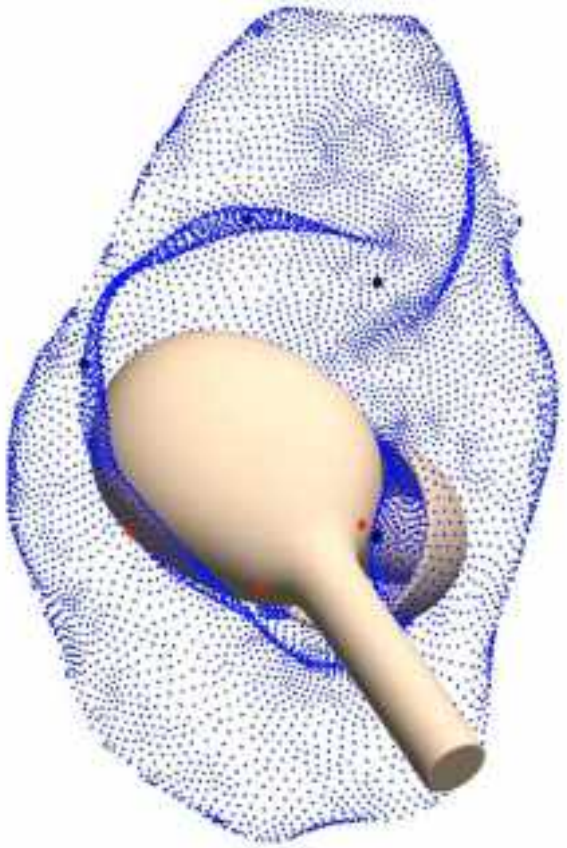


Virtual Fit Analysis

- Virtual fit simulation to find an optimal shape and size of earphone
- Placed an earphone based on the relationship between ear landmarks and earphone landmarks identified from the use characteristics analysis of earphone





Ergonomic Ear Set Design

Commercialized in Sept. 2016

LG V20 bundle earphone

Ergonomic Ear Set Design

Commercialized in July 2017

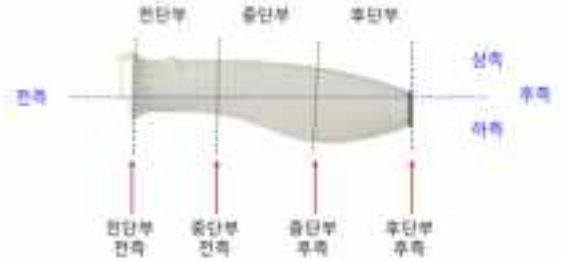
LG Quadbeat 4

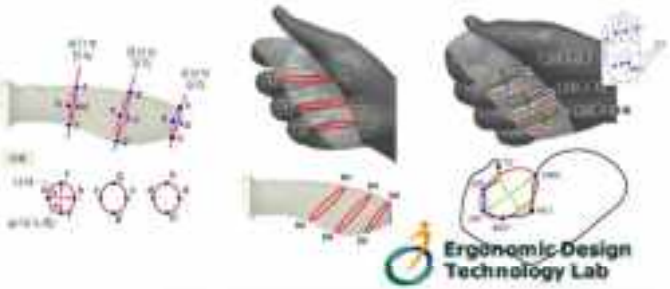
PD Techniques with Temporal Body Scan Data





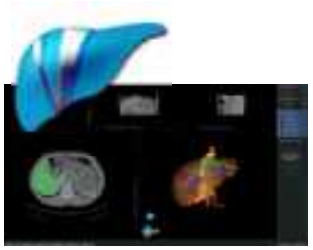


Ergonomics & Product Development

Dr. Liver
for Preoperative Liver Surgery Planning



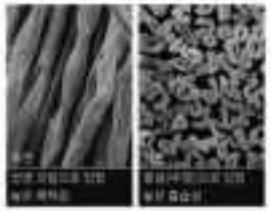
Smart Harmony
for Brain Fitness

Finger Touch
for Motor Intentional Disorders

Swallow Monitoring & Assessment System
for Dysphasia

Aria Fresca: Natural Dyeing Health Mask

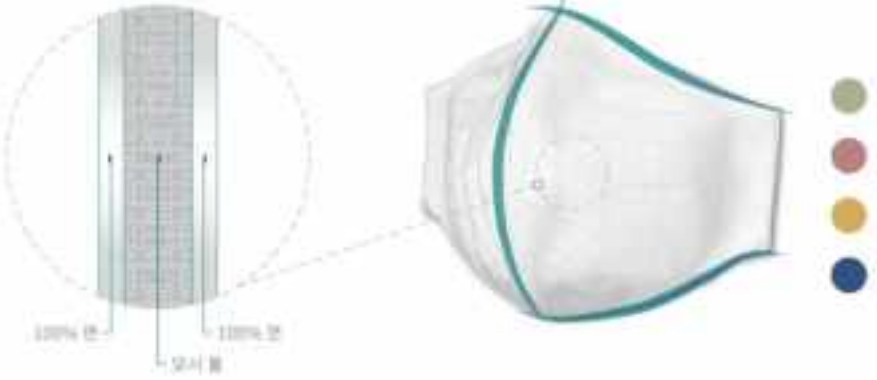
Natural, Healthy, Aesthetic



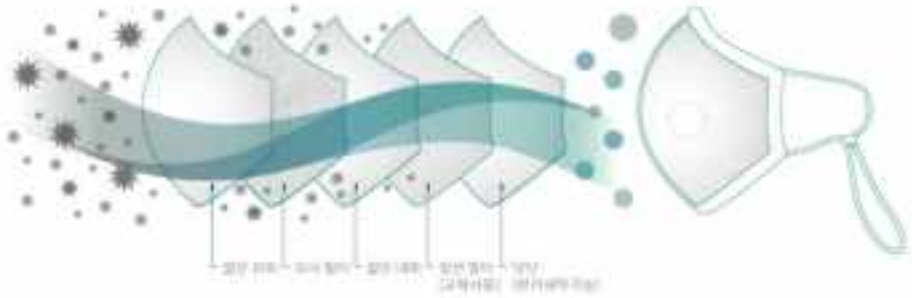
| 유려(流麗)한 곡선이 적용된 마스크 패턴

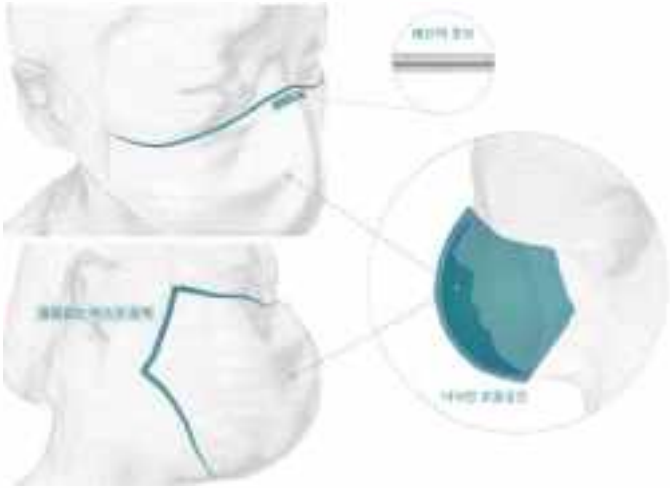
얼굴에 아름다움을 더 할 수 있도록 마스크 패턴에 [illegible]를 적용하였습니다.

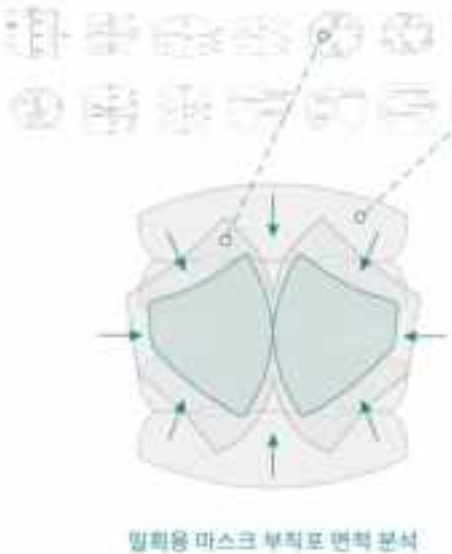
[illegible] 때도 곡선 패턴이 [illegible]되도록 마스크 안에 [illegible]을 사용하였습니다.



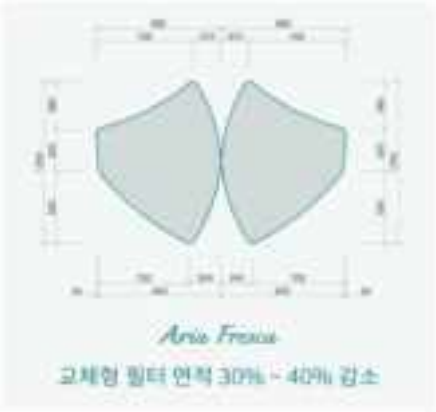
Dust-Proof, Fit, Eco-Friendly







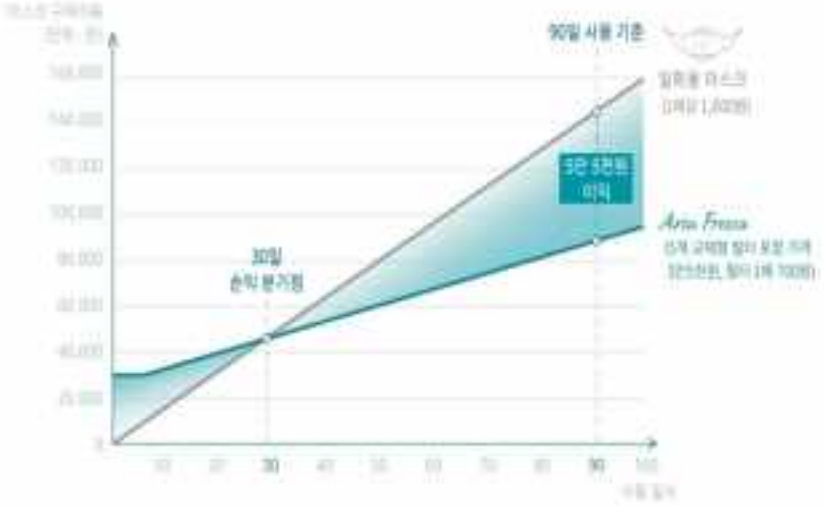
남희용 마스크 부직포 면적 분석



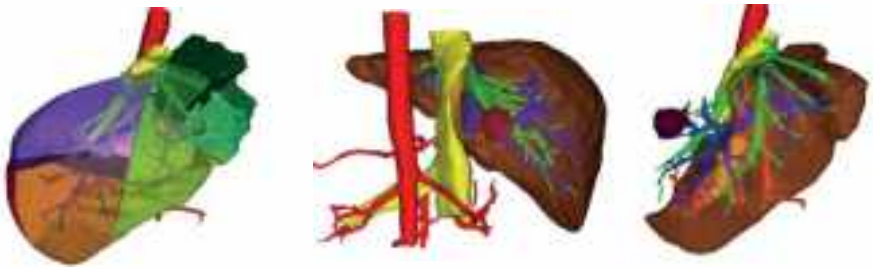
Arvio Finance

고체형 필터 면적 30% ~ 40% 감소

Sustainable, Professional, Economical, Sharing



Dr. Liver for Preoperative Liver Surgery Planning



포항공과대학교 산업경영공학과

전북대학교병원 CHONBUK NATIONAL UNIVERSITY HOSPITAL


Heecheon You


Baik Hwan Cho


Hee Chul Yu


Xiaopeng Yang


Younggeun Choi

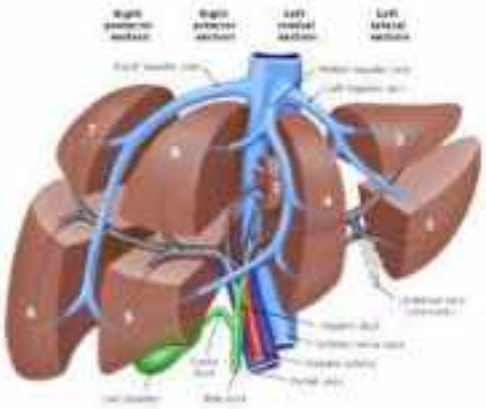

Wonsup Lee


Jihyun Kim


Jaedo Yang

Values of 3D Liver Surgery Planning System

- Location & size of tumor
- Vascular structures
- Segmentation of the liver

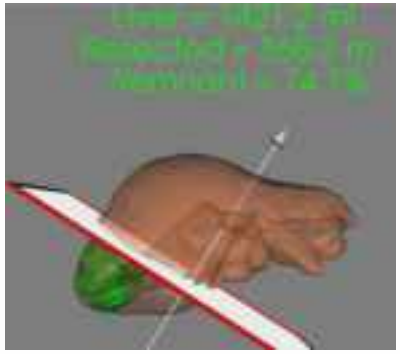


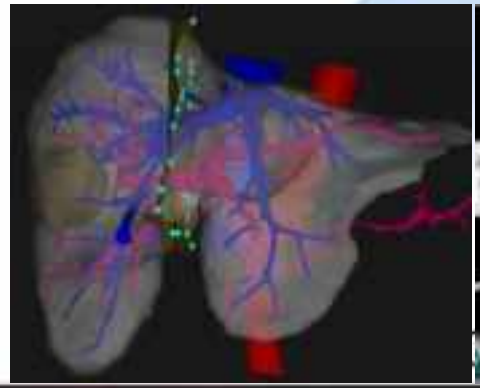
Analytical Visualization

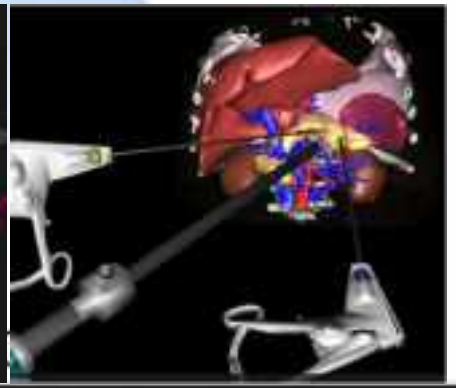
Quantitative Assessment

Safe & Rational Surgery

- Volumetry of the liver
- Volumetry of the remnant and/or graft







The User-Friendly Virtual Liver Surgery Planning System

1 SLV Estimation

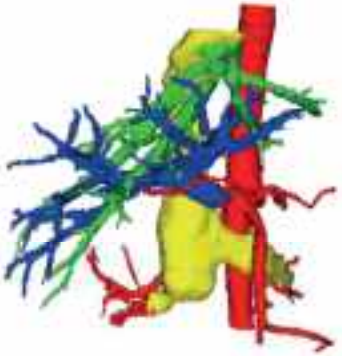
The standard liver volume of a patient can be estimated based on the height and weight of the patient using three formulas (Yu et al., 2004; Urata et al., 1995; and Heinemann et al., 1999)

2 Liver Extraction

The liver can be automatically extracted in 2 – 4 min using a sophisticated algorithm (termed as hybrid liver extraction method) once multiple seed points are selected on 5 – 6 slices by the user.

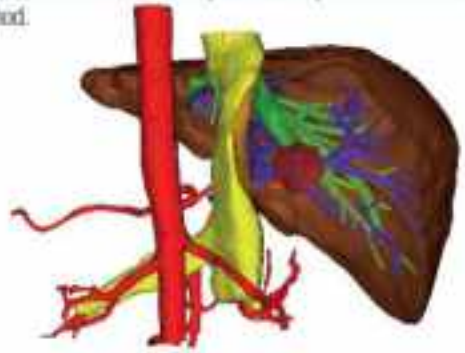
3 Vessel Extraction

The PV, HA, HV, and MC can be extracted in 2 min each using modified region growing methods, which use multiple seed points, masked CT images, and an optimal threshold interval identified by the K-means clustering method.



4 Tumor Extraction

The tumor(s) can be extracted in 2 min by a threshold-based level-set method, which uses multiple seed points and an optimal initial threshold interval automatically identified by the K-Means clustering method.

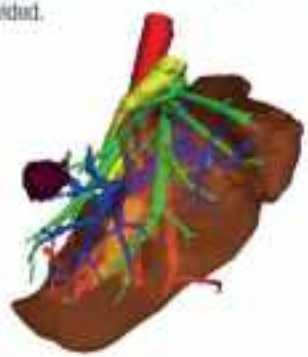


5 Liver Segmentation

The liver can be divided into segments in 1 – 3 min per segmentation according to Couinaud's classification method based on the PV and HV structures. Two modes (plane and sphere) are available for segmentation.

6 Liver Surgery Planning

The resected area of the liver can be defined using one of three different modes (plane, segment, and sphere). The volumes of the liver and remnant/graft and the percentage of the remnant liver volume are provided.



FEATURES

1 Clinical Decision Support for Safe and Rational Surgery

- Semi-automated extraction of the liver, vessels (PV, HV, HA, and IVC), and lesions
- Real-time, interactive boundary editing
- Customized liver segmentation based on PV and HV structures
- Volumetry of the liver, vessels, lesions, and liver segments
- Optimal surgery planning support based on risk analysis and resection strategies

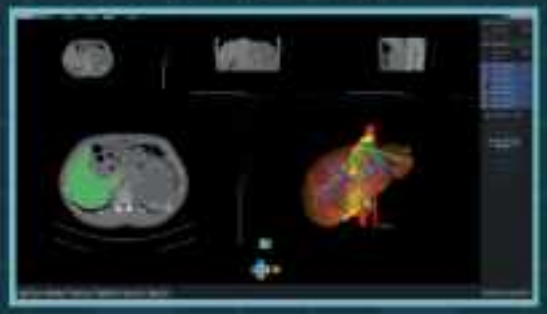
2 User-Friendly Interface

- Procedure-based and hierarchical workflow
- Easy to learn and use
- Multi-modal (text, graphic, and voice) guidance

3 Time Efficiency in Surgery Planning

- Efficient workflows (20 min from liver extraction to surgery planning)

System Overview



Dr. Liver
Virtual Liver Surgery Planning System

System Requirement

PC	OS	Windows 7 64 bit or higher
	HDD	2 GB or larger
	CPU	i5 3.1 GHz or higher
	RAM	8 GB or larger
	VGA	GeForce GT 630 or higher
Monitor	Resolution	1920 X 1080 or higher

Retailer Information

Distributor: Humanopia Co., Ltd.
Address: 323 Main Building, Pohang Techno Park
394 Jigok-ro, Nam-gu
Pohang, Gyungbuk, 790-834, South Korea
Tel: +82-54-223-2268~9
E-mail: eunnam@hotmail.com
Webpage: www.humanopia.co.kr

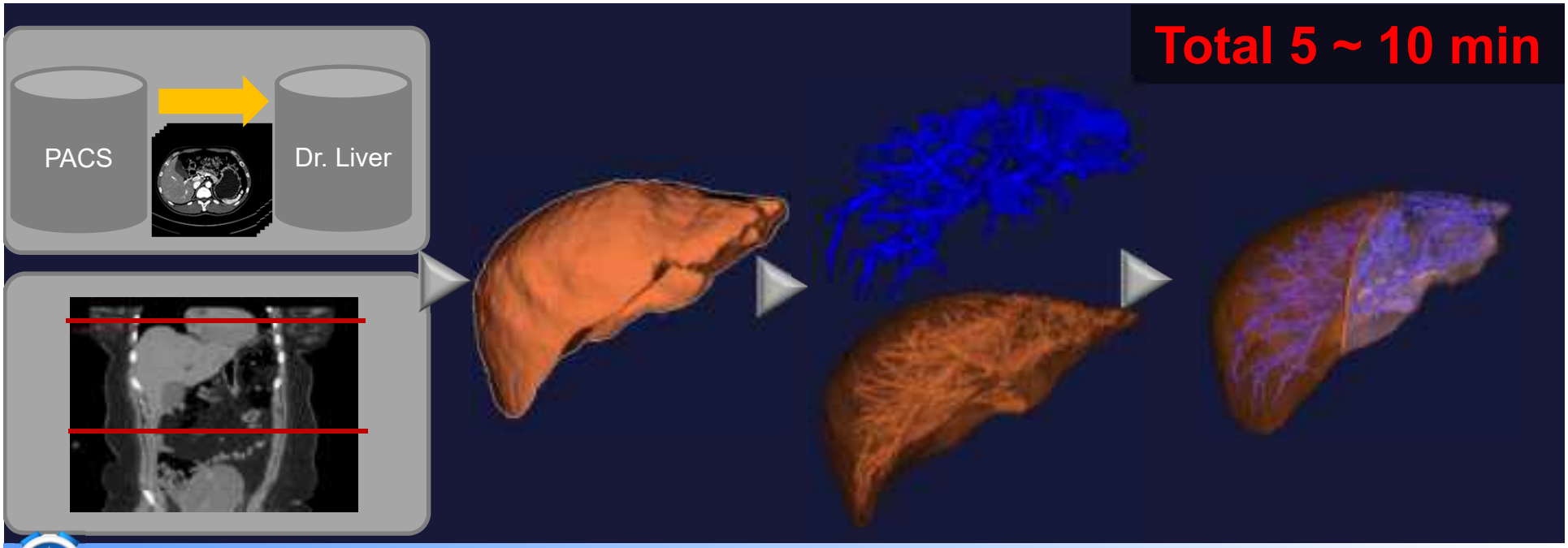
Dr. Liver
Virtual Liver Surgery Planning System

Dr. Liver is a virtual liver surgery planning system to help surgeons plan liver surgery with high accuracy and ease of use in a reasonable time.

Dr. Liver pursues excellence in functionality for clinical decision support for safe and rational surgery and user-friendly interface.

Surgery Planning for LDLT

S1(SA). Data preparation	S2(A). Liver extraction	S3(A). PV & HV extraction	S4(SA). Surgery planning



< 1 min	2 ~ 3 min	2 ~ 3min	1 ~ 2 min
• **Data transfer** from PACS • **Data cut**	• **Liver extraction** using our proposed hybrid method	• **Vessel extraction** using our proposed method • **Exclude vessels** from the liver	• **Resection simulation** • **Volumetric** measurement • **Print** the liver surgery planning results

Demo: Surgery Planning Report

Liver Surgery Planning Report

Virtual Liver Surgery Planning System

Date: 2014. 02. 11

Patient

Name	ANONYMIZED
Age	34
Gender	M

Analyst

Name	YU*HUI CHEOL
Date	2014. 02. 11

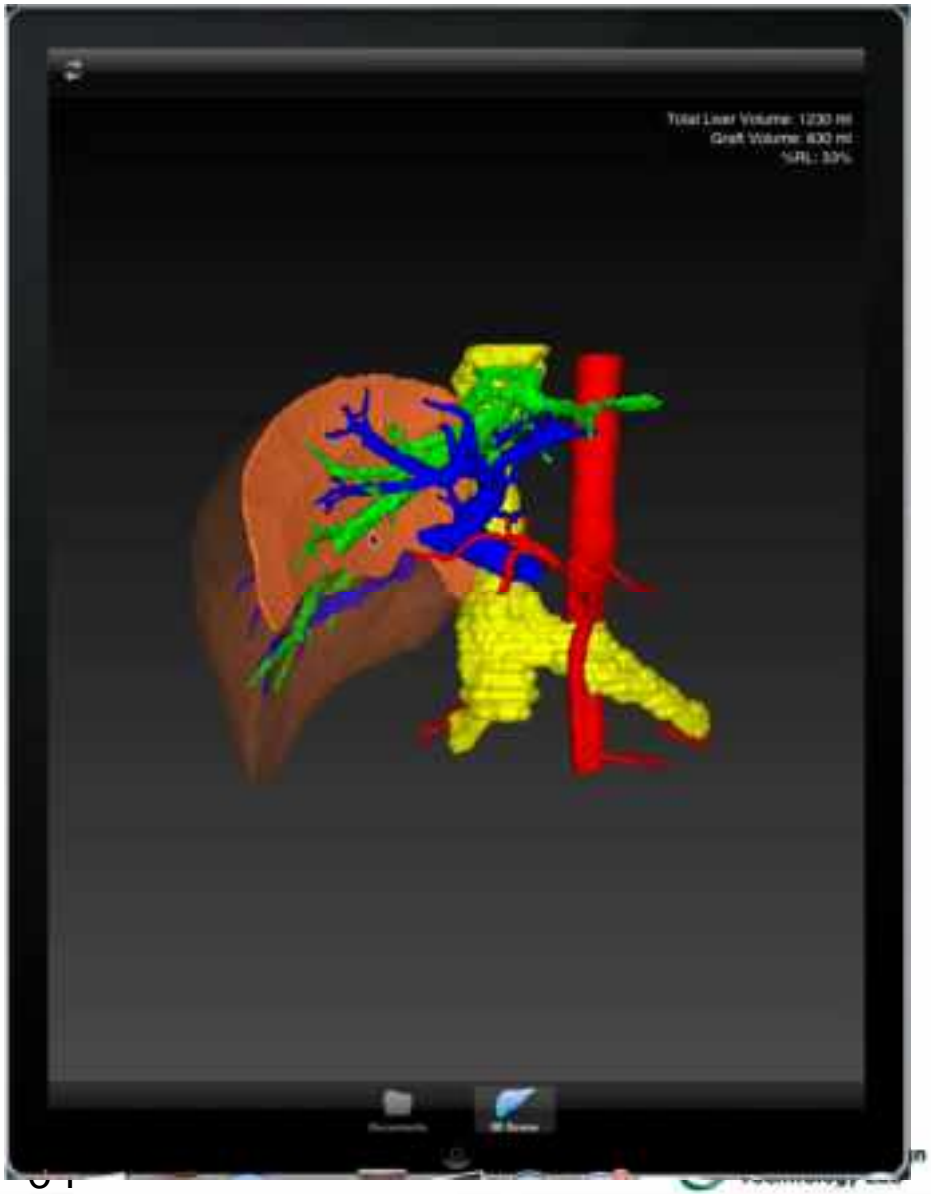
Planning Results

Liver Volume	**1114 ml**	**PV & HV**	**60 ml**
TFLV	**1054 ml**		
Right LV	**695 ml**	**Left LV**	**359 ml**
%RLV	**66 %**	**%LLV**	**34 %**

Right lobe
Left lobe
PV & HV

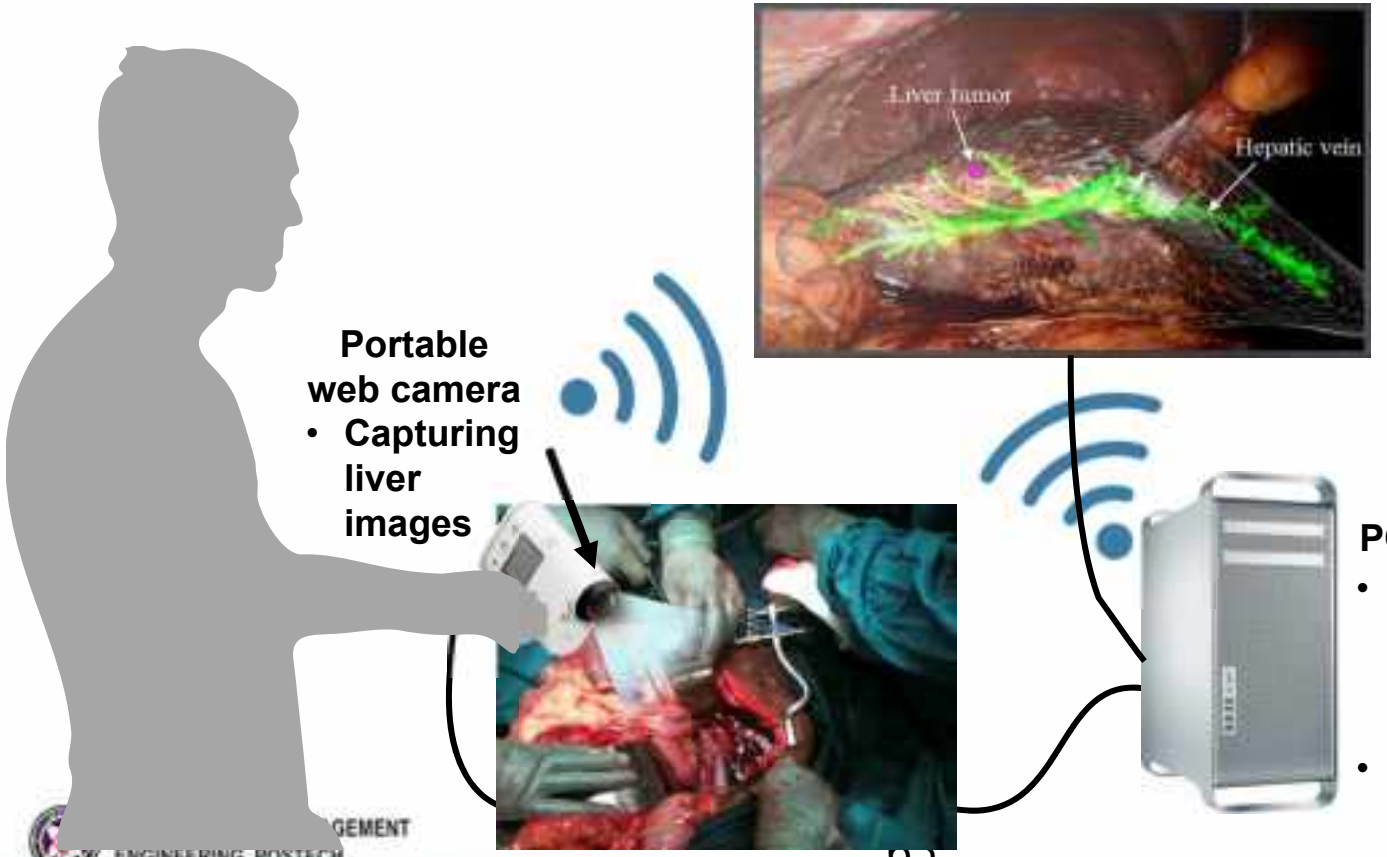
Memo

Dr. Liver



Intraoperative Navigation

- Develop **higher accuracy registration algorithms** to synchronize **preoperative surgery planning results using Dr. Liver** with **real liver images captured** during surgery
  - **Visualize vital structures** such as vessels and tumors invisible during surgery
  - Support more **safe and accurate** liver surgery



Evaluation of the Hybrid Liver Extraction Method

- Patient dataset
  - **15 CT datasets** of different age, gender, and liver volume provided by Chonbuk National University Medical School
  - Resolution: 512 × 512
  - **Thickness: 1 mm**

- Evaluation methods
  - **Golden standard: Manually traced liver regions** for each patient by a radiologist
  - No editing of the extracted liver region was conducted in evaluation,
  - Comparison

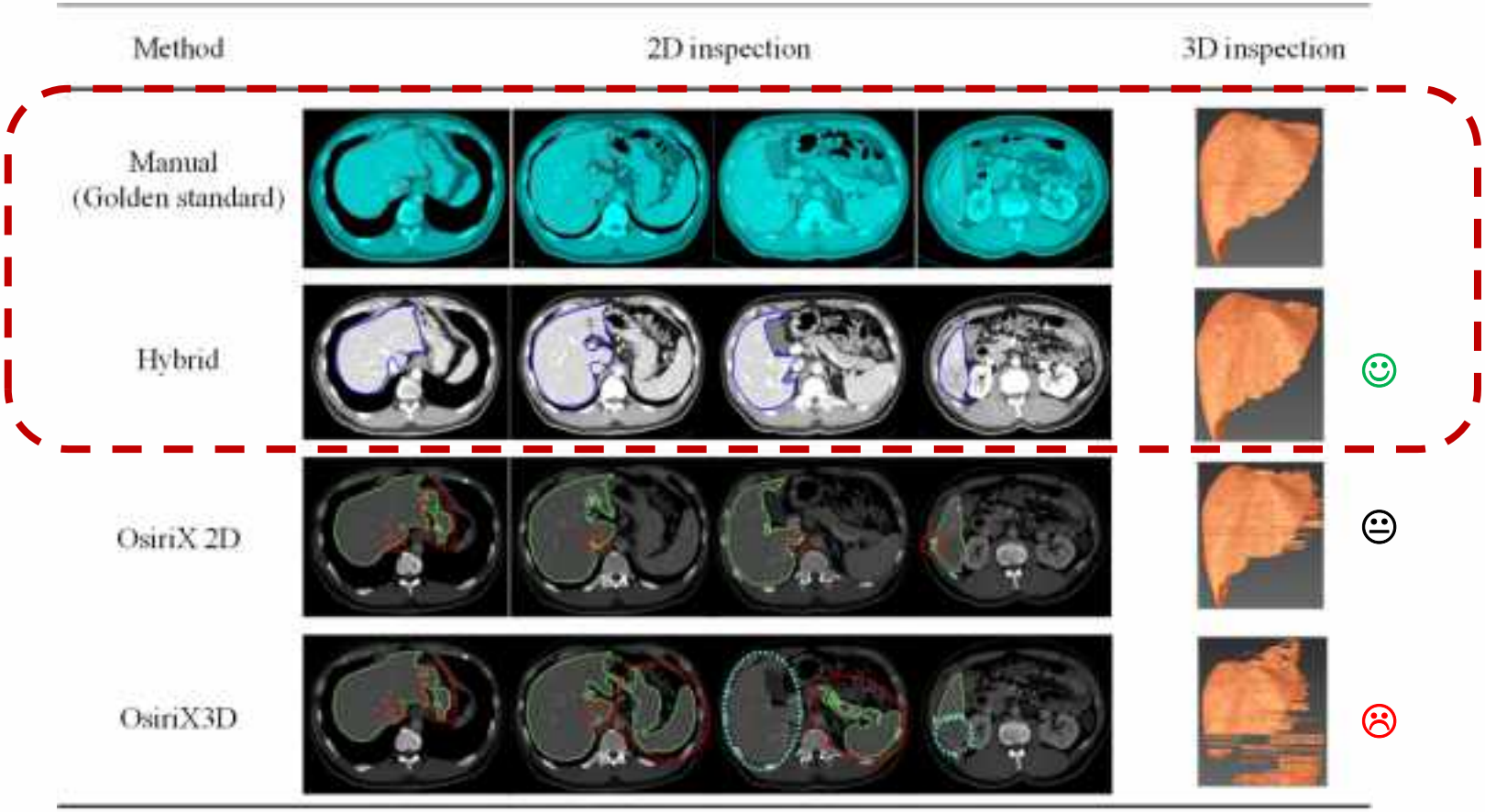
Dr. Liver	OsiriX	
Hybrid Method	Region Growing Method	
	2D Semi-Auto	3D Semi-Auto
• Initial liver contour detection • Contour refinement • 30 seed points on 4 ~ 5 slices	• Liver extraction slice by slice • One seed point for each slice	• Liver extraction based on entire volume data • One single seed point

Evaluation Measures

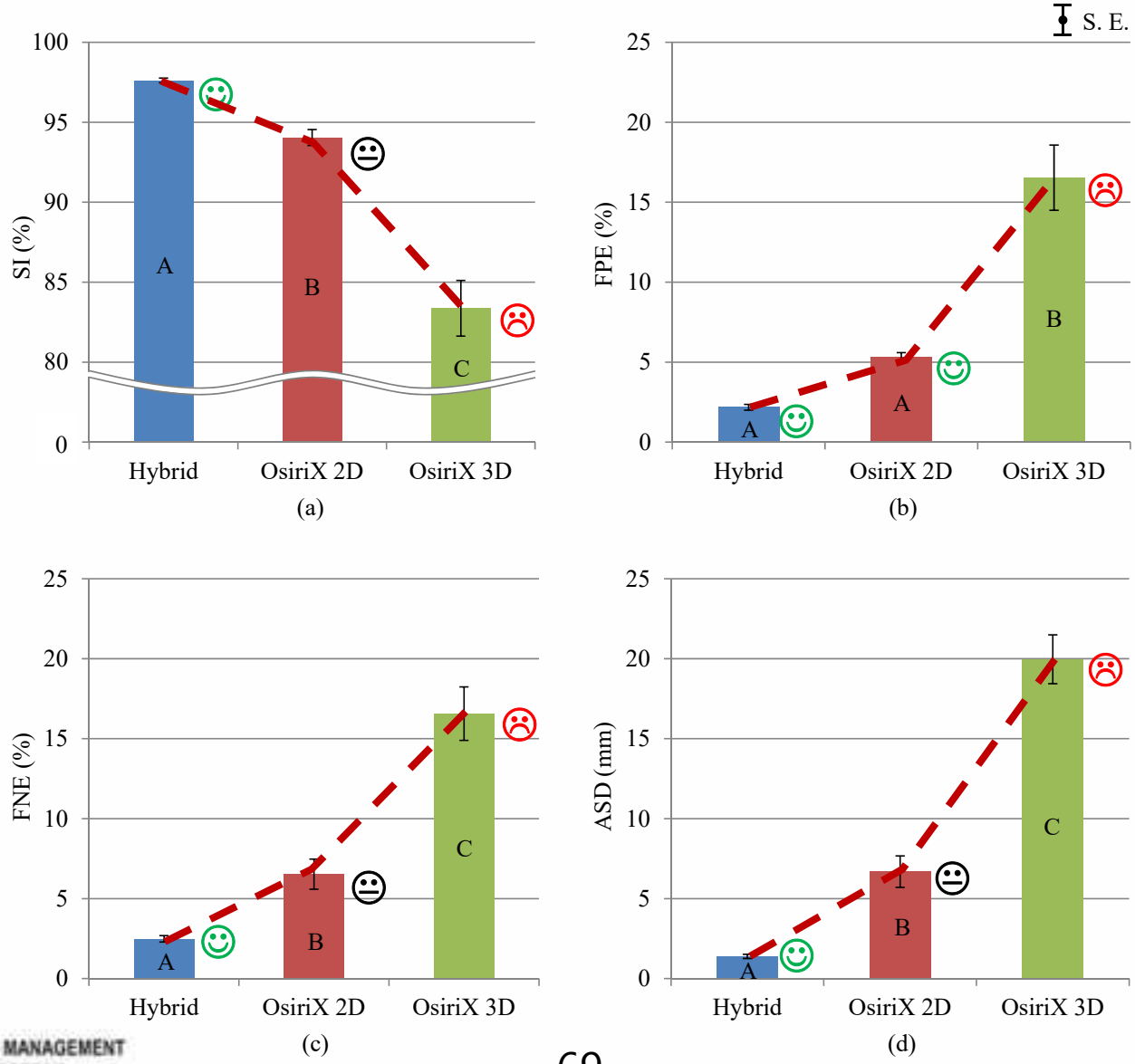
- **Accuracy**
  - **Similarity index** (SI: %)
    - ✓ defined as the overlapping ratio between the extracted liver region and the golden standard
  - **False positive error** (FPE: %)
    - ✓ defined as the ratio of falsely extracted parts to the golden standard
  - **False negative error** (FNE: %)
    - ✓ defined as the ratio of missing parts to the golden standard
  - **Average symmetric surface distance** (ASD: mm)
    - ✓ defined as the minimal distance between the extracted liver border to the golden standard liver border

- **Time efficiency**
  - Liver extraction time per CT slice

Performance Comparison: Visual Inspection



Performance Comparison: Accuracy



Performance Comparison: Summary

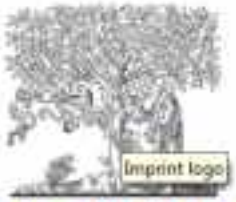
- The proposed hybrid method is superior to the existing methods in accuracy and time efficiency

Performance		Hybrid method	OsiriX 2D region growing method	OsiriX 3D region growing method
Accuracy	SI (%)	97.6 ☺	94.0 😐	83.4 ☹
	FPE (%)	2.2 ☺	5.3 😐	16.5 ☹
	FNE (%)	2.5 ☺	6.5 😐	16.6 ☹
	ASD (mm)	1.4 ☺	6.7 😐	20.0 ☹
Time Efficiency (sec/CT slice)		0.4 ☺	2.8 😐	0.5 ☺

Note: SI: similarity index, FPE: false positive error, FNE: false negative error,
ASD: average symmetric surface distance

Computation Algorithm of Dr. Liver

COMPUTER METHODS AND PROGRAMS IN BIOMEDICINE 113 (2014) 69–79



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journal homepage: www.intl.elsevierhealth.com/journals/cmpb

A hybrid semi-automatic method for liver segmentation based on level-set methods using multiple seed points

Xiaopeng Yang[a], *Hee Chul Yu*[b], *Younggeun Choi*[a], *Wonsu*
Baojian Wang[b], *Jaedo Yang*[b], *Hongpil Hwang*[b], *Ji Hyun Ki*
Baik Hwan Cho[b], *Heecheon You*[a,*]

[a] *Pohang University of Science and Technology, Pohang 790-784, South Korea*
[b] *Chonbuk National University Medical School, Jeonju 561-712, South Korea*

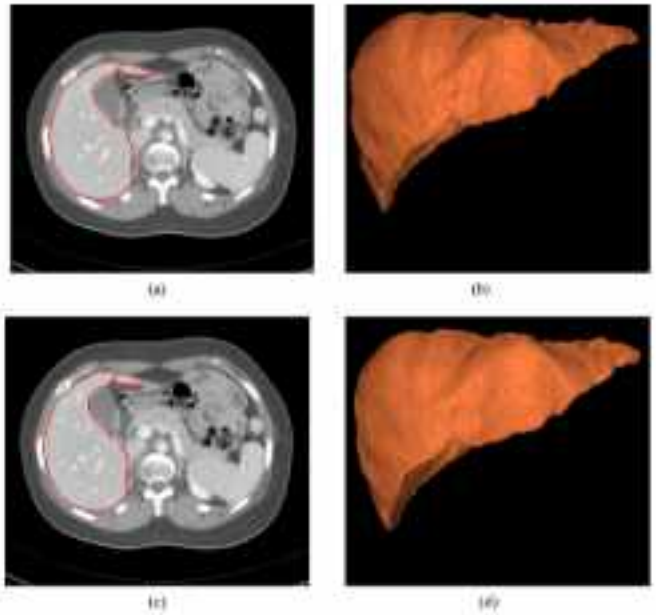
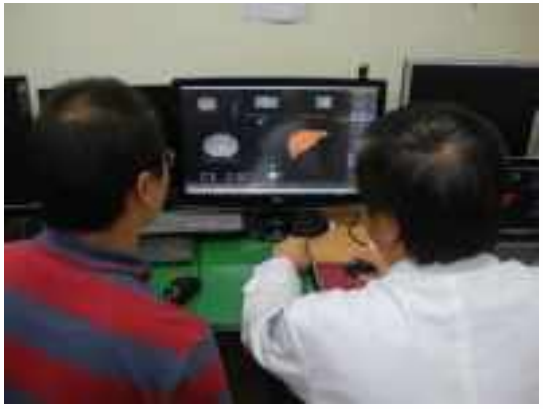


Fig. 6 – Result of postprocessing: (a) refined liver region before postprocessing, (b) 3D view of refined liver regions before postprocessing, (c) surface-smoothed liver region after postprocessing, and (d) 3D view of postprocessed liver regions.

Usability Testing

- Participants
  - 3 medical doctors at Chonbuk National University Medical School
  - Age: 30 ~ 50 years

- Patient dataset
  - One dataset of abdominal CT images provided by Chonbuk National University Medical School, South Korea
  - Resolution: 512 × 512
  - Thickness: 1 mm



Test Design

1. Pre-Test Session (1 h)
   1. Informed consent
   2. Introduction of usability testing
   3. Training of Dr. Liver
2. Test Session (1.5 h)
   - Liver extraction
   - Vessel extraction
     - Portal vein
     - Hepatic artery
     - Hepatic vein
     - IVC
   - Tumor extraction
   - Liver segmentation
     - Plane
     - Sphere
   - Liver surgery planning
     - Plane
     - Segment
     - Sphere
3. Post-Test Session (10 min)
   - Debriefing

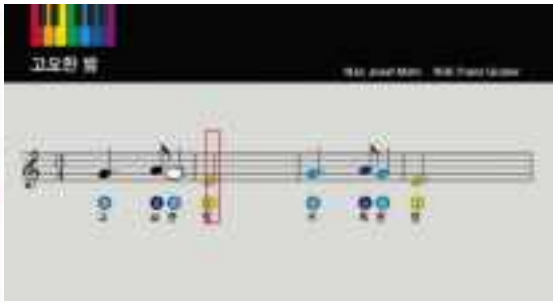
Measure/Instrument Matrix (selected)

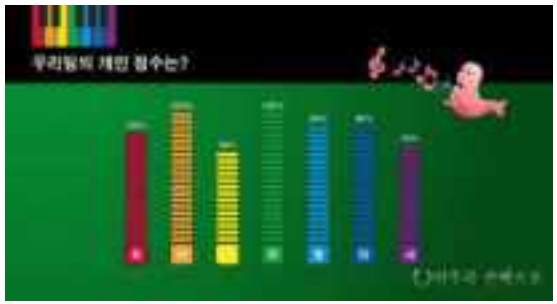
Measures		Liver Extraction	Vessel Extraction	Surgery Planning	Instrument/ Scale
Performance	Accuracy (Similarity index; false positive error; false negative error)	❍			Comparison to golden standard
	Completion Time	❍	❍	❍	Programming
	Number of mouse clicks	❍	❍	❍	Programming
	Number of keystrokes	❍	❍	❍	Programming
Subjective Satisfaction	Usefulness	❍	❍	❍	Questionnaire with 7-point Likert scales
	Ease of Use	❍	❍	❍	
	Learnability	❍	❍	❍	
	Informativeness	❍	❍	❍	
	Clarity	❍	❍	❍	
	Tolerance	❍	❍	❍	
	Satisfaction	❍	❍	❍	

Quantitative Assessment Results (selected)

Measures		Liver Extraction	Vessel Extraction	Surgery Planning
Accuracy	SI (%)	97.0 (0.3) ☺	–	–
	FPE (%)	2.0 (0.2) ☺	–	–
	FNE (%)	2.3 (0.4) ☺	–	–
Time (min)	Interaction	1.8 (0.5) ☺	0.6 (0.1) ☺	1.0 (0.2) ☺
	Auto processing	1.3 (0.2) ☺	1.6 (0.3) ☺	1.2 (0.4) ☺
Number of mouse clicks	Before editing	30 (8) ☺	20 (5) ☺	10 (7) ☺
	Editing	56 (10) 😐	0 (0) ☺	4 (2) ☺
Number of keystrokes	Before editing	0 (0) ☺	6 (4) ☺	9 (3) ☺
	Editing	17 (10) 😐	0 (0) ☺	3 (2) ☺

Smart Harmony for Brain Fitness





POSTECH

SAMSUNG Samsung Medical Center

SEED Technology

휴머노피아 Humanopia

Your Brain Power?

red blue orange purple

orange blue green red

blue purple green red

orange blue red green

purple orange red blue

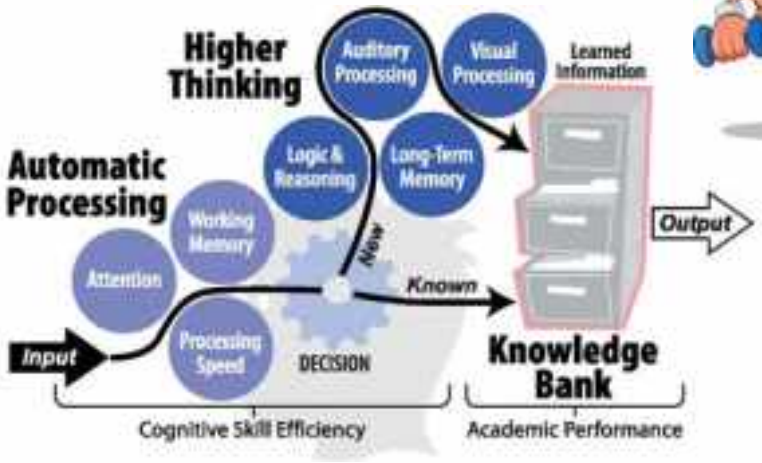
green red blue purple

orange blue red green

green purple orange red

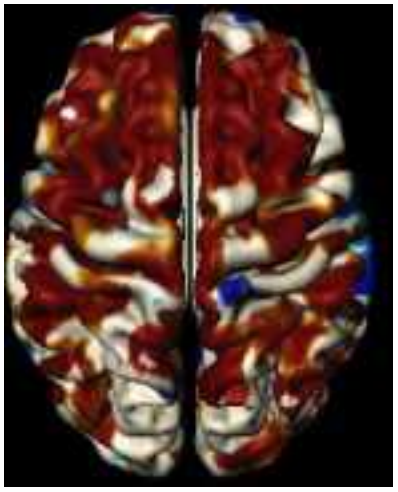
Brain Power (Fitness)

- The capacity of a person to meet various cognitive demands of life
  - Attention
  - Memory (working memory, long-term memory)
  - Information processing (visual & auditory processing)
  - Decision making (logic & reasoning, judgment, intelligence)

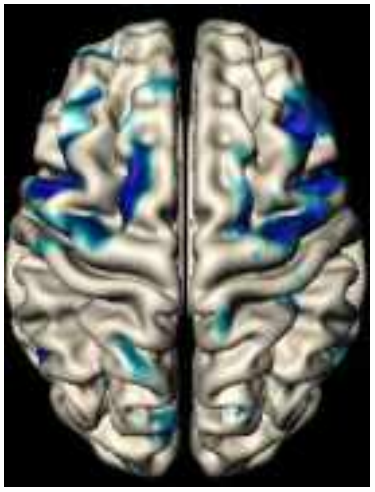


Red: Thick area
Blue: Thin area

CEO

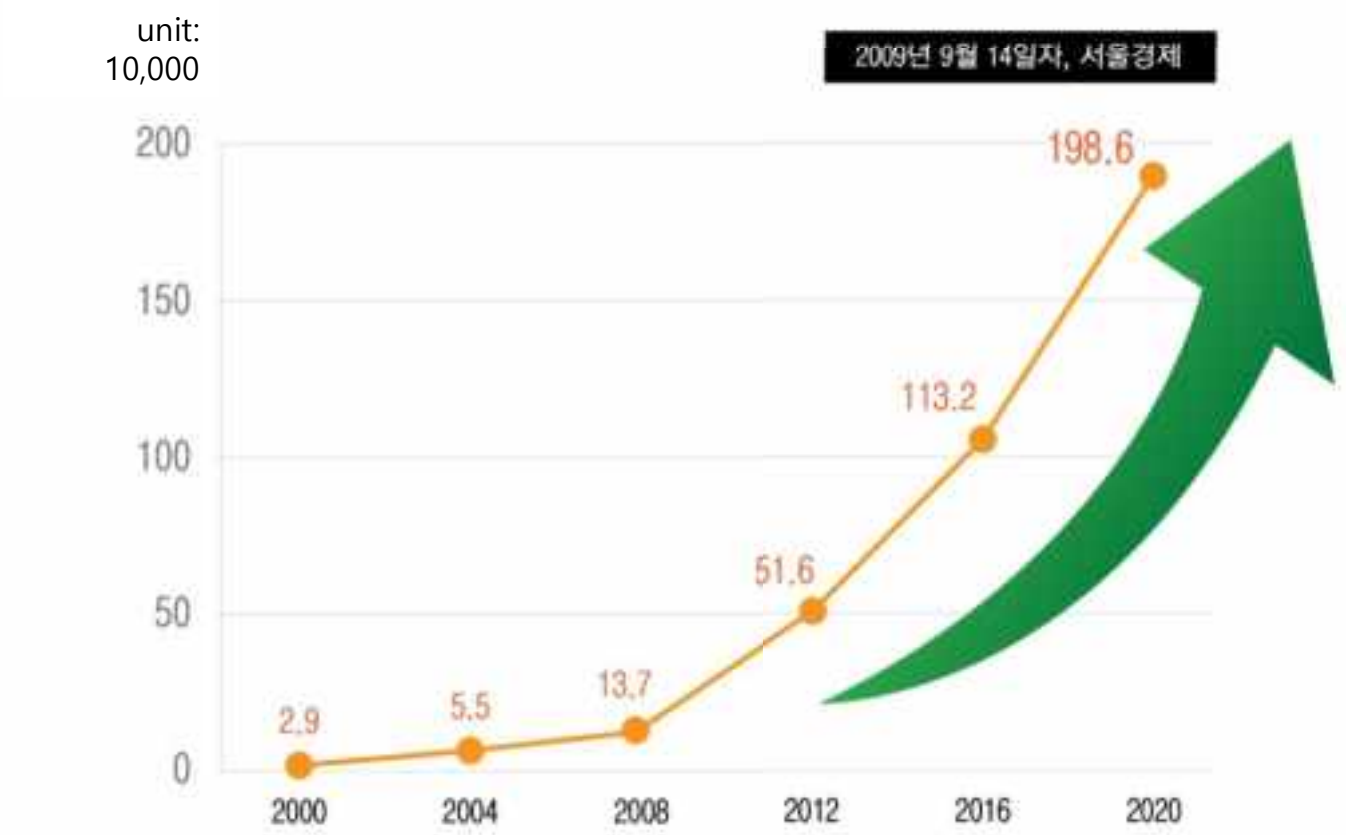


Binge Drinking



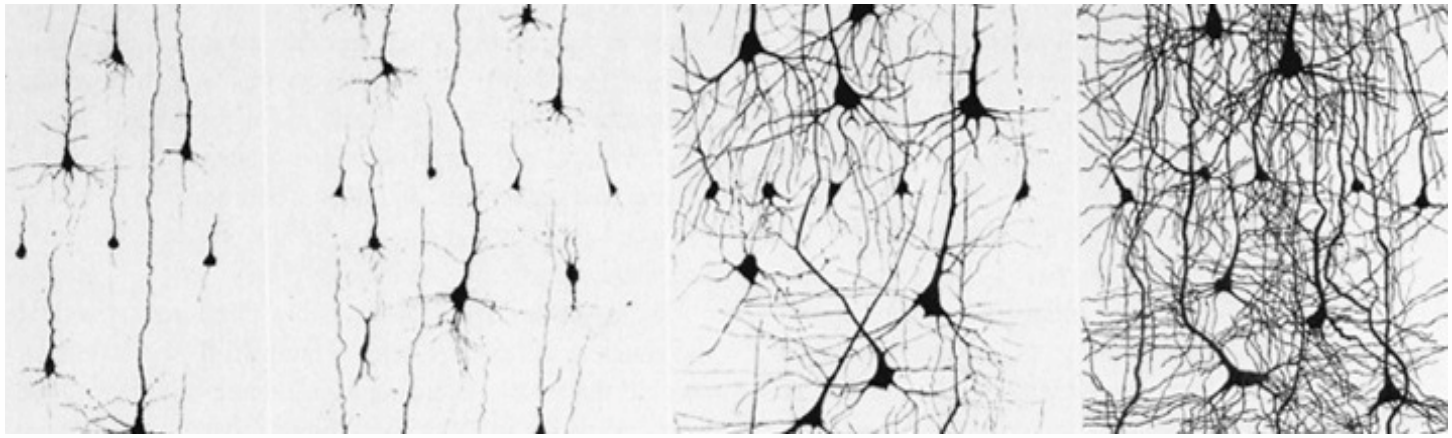
Population of Older (55+) Koreans

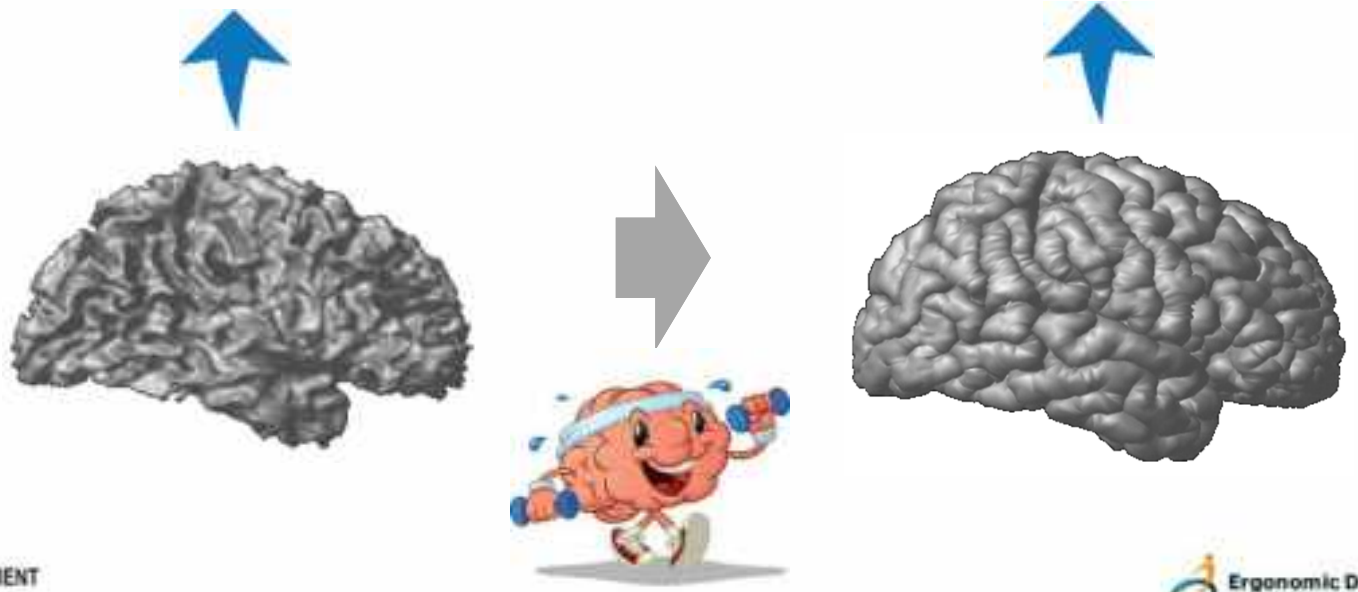
Dementia Patients in Korea



Dementia & Quality of Life

Brain Plasticity





Dementia Prevention Measures: SPEC + N

Social **P**hysical **E**motional **C**ognitive




+

Nutritional

brainHQ: Attention Exercise

Benchmarking of Brain Fitness Products

Social	Physical	Emotional	Cognitive
Brain Fitness Gym CoTras-G	Brain Fitness Gym E-CoRe	Brain Fitness Gym Dakim	brainHQ Lumosity Dakim RehaCom EPOC/EEG CoCoMo CoCoTa E-CoRe Co-Kiost CoSAS CoTras-M CoTras-G CoTras-C CoTras

Brain Fitness Product: Smart Harmony

음악으로 뇌가 운동한다!! Smart Mu..

악기를 다루는 것은 사람의 뇌를 자극하여 인지기능, 신체기능, 감성적 기능을 향상시킨다. 아울러 사람들과 어울려 함께 하는 합주는 사회적 기능도 향상시킨다. 통계조사에 따르면 노인들도 젊은 사람들처럼 음악을 연주하고 싶어한다. 그러나 악기를 배우는 것은 만만치 않은 것이 현실.. 그렇다면 노인이 쉽게 다룰 수 있는 악기를 개발하면 어떨까..?
이 질문에 대한 답으로 쉽고 재미있는 연주 프로그램 Smart Mu를 소개한다.

Smart Harmony Demo

Clinical Testing of Smart Harmony

MDCTC
Medical Device Clinical Trial Center
전북대학교병원 의료기기임상시험센터

Clinical Test Results of Smart Harmony

Journal of the American Geriatrics Society

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Edited By: Thomas T. Yoshikawa

Impact Factor: 4.216

ISI Journal Citation Reports © Ranking: 2013: 2/31 (G
(Geriatrics & Gerontology)

Online ISSN: 1532-5415

Effects of a Serious Game Training on Cognitive Functions in Older Adults

Younggeun Choi, MS[1], Duk L. Na, M.D., Ph.D.[2], Myeung-Sook Yoh, Ph.D.[3], Heecheon You, Ph.D.[1]

[1] Department of Industrial and Management Engineering, Pohang University of Science and Technology, Pohang, Republic of Korea

[4] Department of Neurology, Sungkyunkwan University School of Medicine, Samsung Medical Center, Seoul, Republic of Korea.

[6] Department of Creative IT Engineering, Pohang University of Science and Technology, Pohang, Republic of Korea

Objectives: To examine the potential benefits of a music game training program on cognitive functions in healthy older adults using Smart Harmony™, which requires motor responses to visual and auditory stimulations.

Design: A randomized controlled trial with pre- and post-training tests in a training group and a control group without training.

Setting: A community senior center in Jeon-Ju, South Korea.

Participants: Community-dwelling healthy adults (n = 28) 65 years of age or older were randomly assigned to a training group (n = 14) or a control group (n = 14)

Interventions: The training group received the music game training program and the control group was involved in typical community senior center-based activities. Participants in the training group played Smart Harmony for approximately 40 minutes a day, 3 days a week, for 8 weeks.

Measurements: Neuropsychological assessments and questionnaires of health-related quality of life were conducted before and after training in both the training and control groups. Seven categories of cognitive functions (attention, memory, visuomotor ability, visuospatial cooperation, flexibility of cognition, executive function, and verbal cognition) were evaluated and two neuropsychological questionnaires (geriatric depression scale (GDS) and 8-item short form survey (SF-8) were administered.

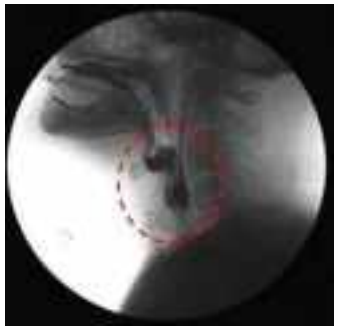
Results: After participating in the music game training program using Smart Harmony, scores in trail making test A, trail making test B, Reyfigure test, and SF-8 questionnaires showed significantly improved ($p < 0.01$). In addition, Stroop test and verbal fluency test scores improved after Smart Harmony training ($p < 0.05$).

Conclusion: The newly developed serious game intervention could enhance high cognitive functions such as working memory, visuomotor ability, visuospatial cooperation, executive function, and verbal cognition.

INDUSTRIAL AND MANAGEMENT ENGINEERING, POSTECH

Smart Harmony for Kids

Swallow Monitoring & Assessment System (SMAS) for Dysphagia



Digital ECHO

Sensor Developer

- Ultrasonic sensor development (strip-type & patch-type sensors)

POSTECH

Creative System Integrator

- Ergonomic design & usability testing
- Signal processing model development (severity assessment model, personal therapy protocol)

SEED Technology

Device Developer

- Signal processing
- SAD and FES interoperation

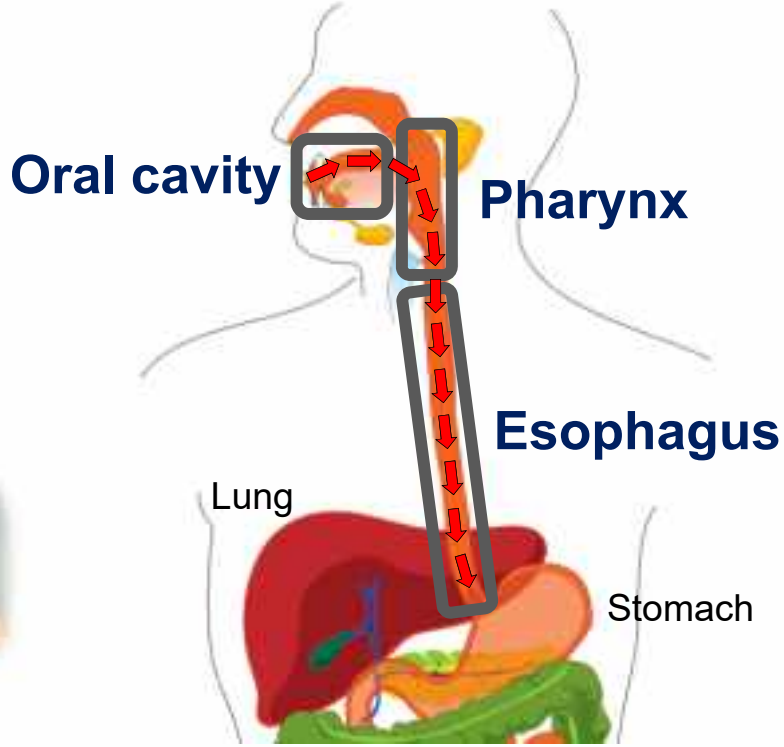
SAMSUNG 삼성서울병원

Dysphagia Expert

- IRB protocol preparation
- Clinical experiments
- Diagnosis and interpretation

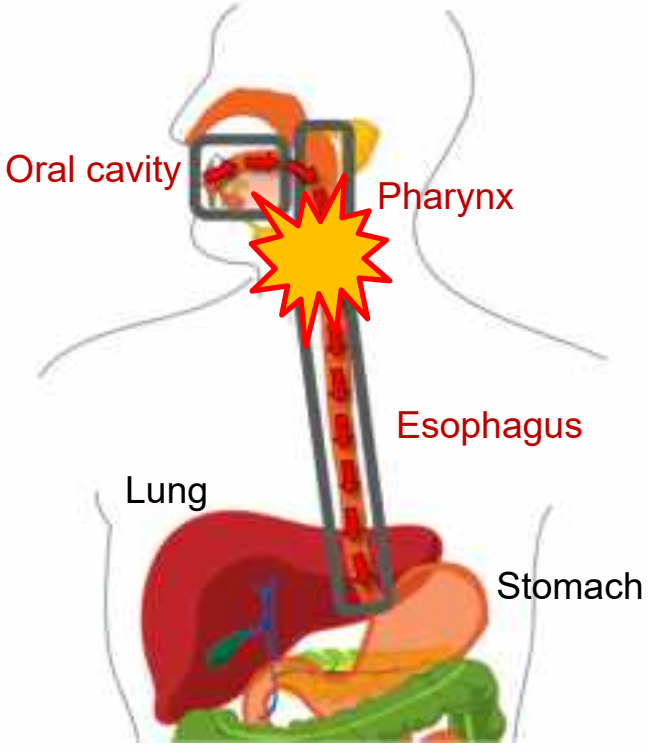
Swallowing

- Transporting food from the oral cavity, to pharynx, and into esophagus (Ekberg et al., 2002; Garliner, 1974; Logemann 1983, 1998)
  - ✓ One of the most frequent activities of human body: 580 ~ 2,000 times/day
  - ✓ Vital primary function contributing to quality of life



Dysphagia?

- Disturbance of the intake or transport of food from the oral cavity to stomach



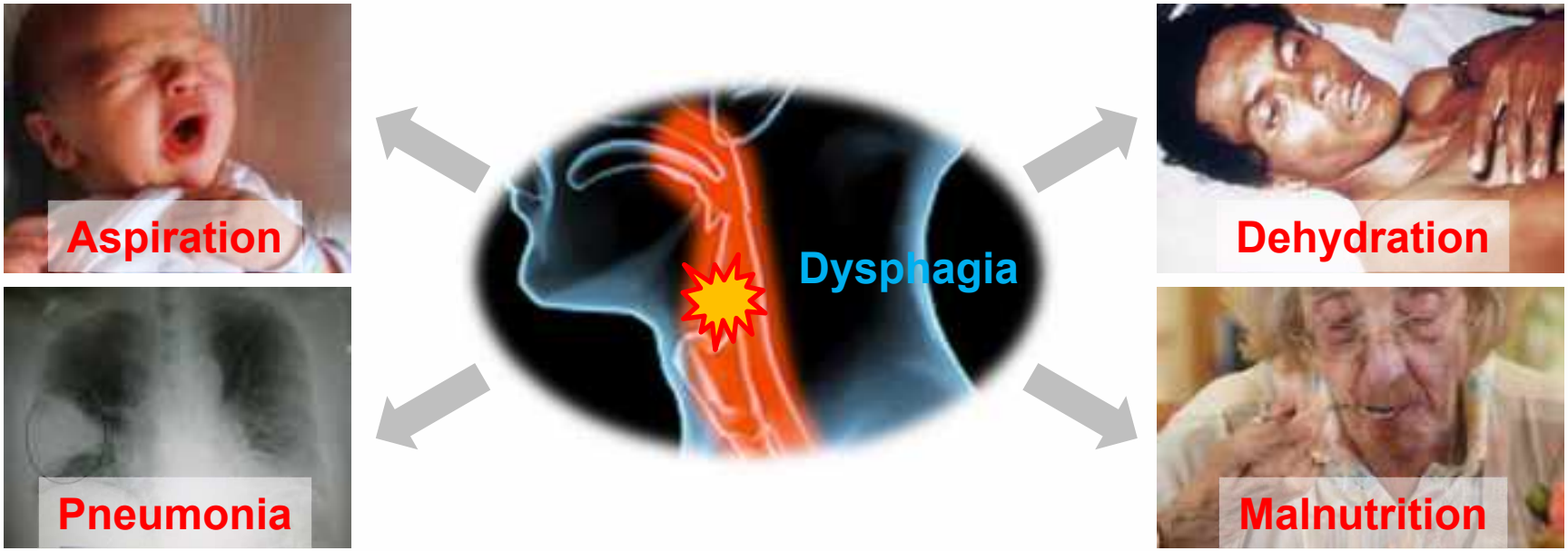
Normal

Abnormal

Adverse Outcomes of Dysphagia

- Aspiration, pneumonia, dehydration, malnutrition, or even death

⇒ **Early identification and appropriate treatment of dysphasia** are important.

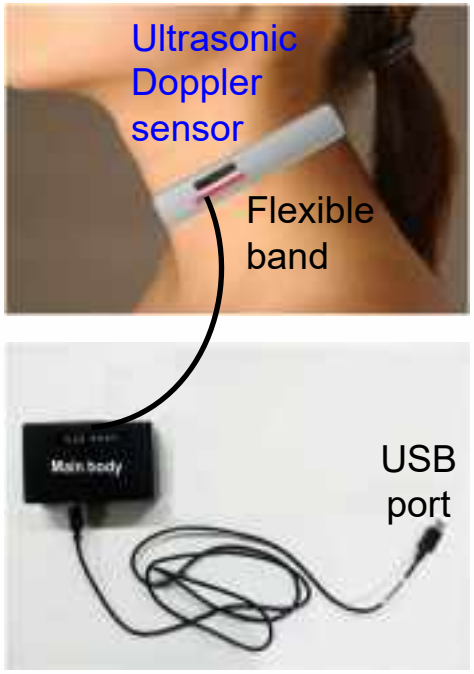


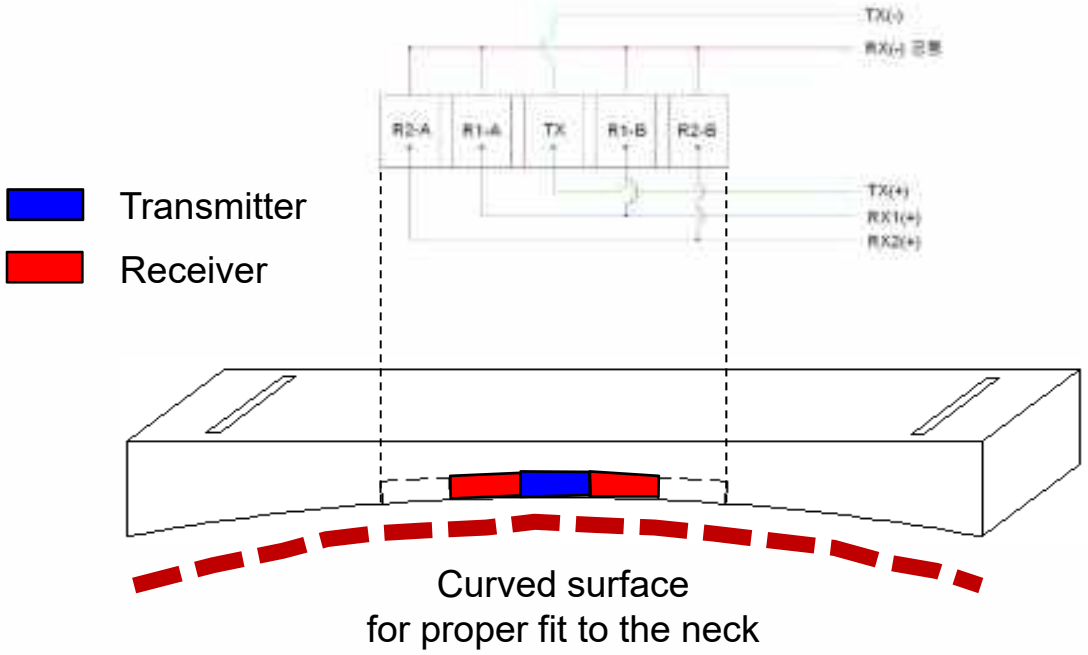
Diagnosis Methods of Dysphagia

	VideoFluorocopic Swallowing Study (VFSS)	Fiberoptic Endoscopic Evaluation of Swallowing (FEES)
Illustration		
Method	Record fluoroscopy images by X-ray and evaluate dysfunctions of swallowing	Insert a flexible endoscope through the nose
Limitations	▪ Radiation exposure	▪ Invasiveness
	▪ Qualitative assessment ▪ Expensive ▪ Not usable in daily activities	

SMAS using Ultrasonic Doppler Sensor

- Developed a **novel SMAS** (patent number: 10-1302193, granted in Aug. 2013) using a **custom-made ultrasonic Doppler sensor array**





Frequency	2 MHz
Element count	3
Element length	5 mm
Kurf	1 mm

Pitch	6 mm
Element width	6 mm
Wire	Micro coaxial cable (100pF)
Transducer surface radius	158R

Research Objectives

Comparison of Swallowing Characteristics

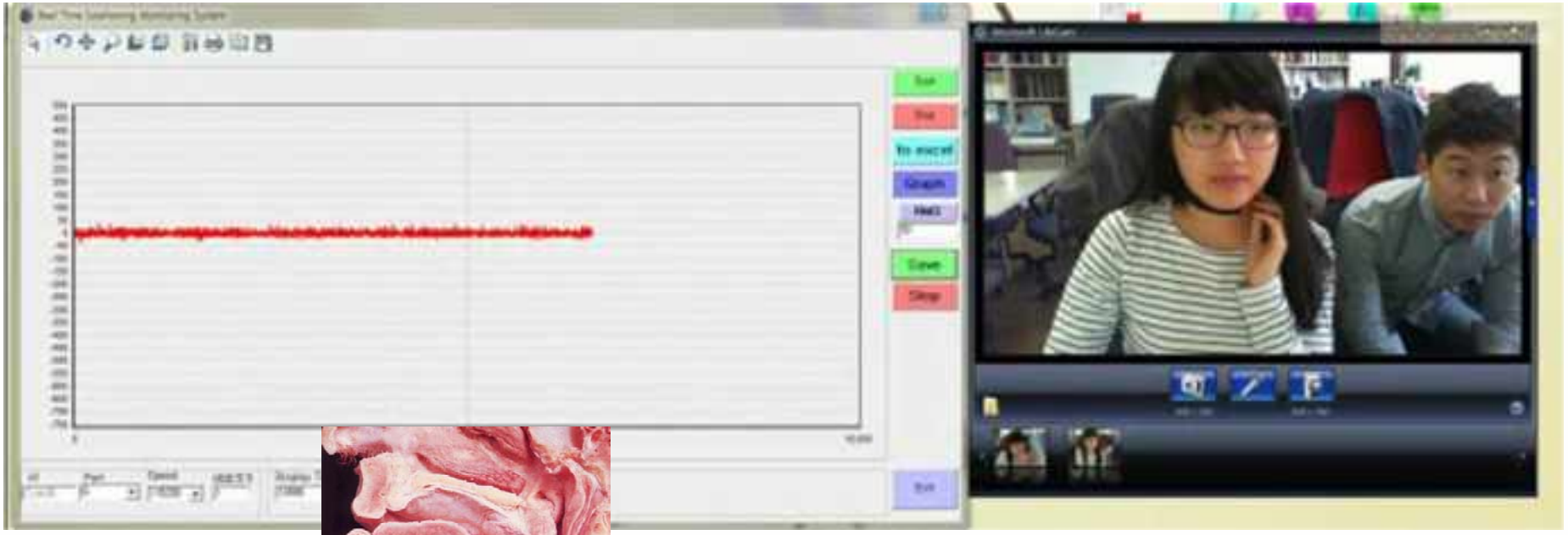
in Patients with Dysphagia and Normal Controls

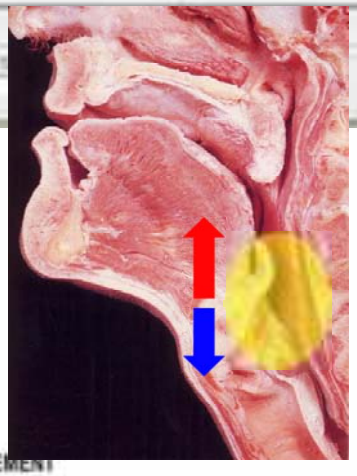
Using a Ultrasonic Doppler Sensor

1. **Development** of a swallowing measurement and analysis system
2. **Quantification** of the swallowing function in the pharyngeal phase
3. **Comparison** of dysphagic patients with normal controls
4. **Establishment** of a diagnostic model for dysphagia

SMAS: Major Functions (1/3)

- Converting laryngopharynx motions of swallowing into electric signals

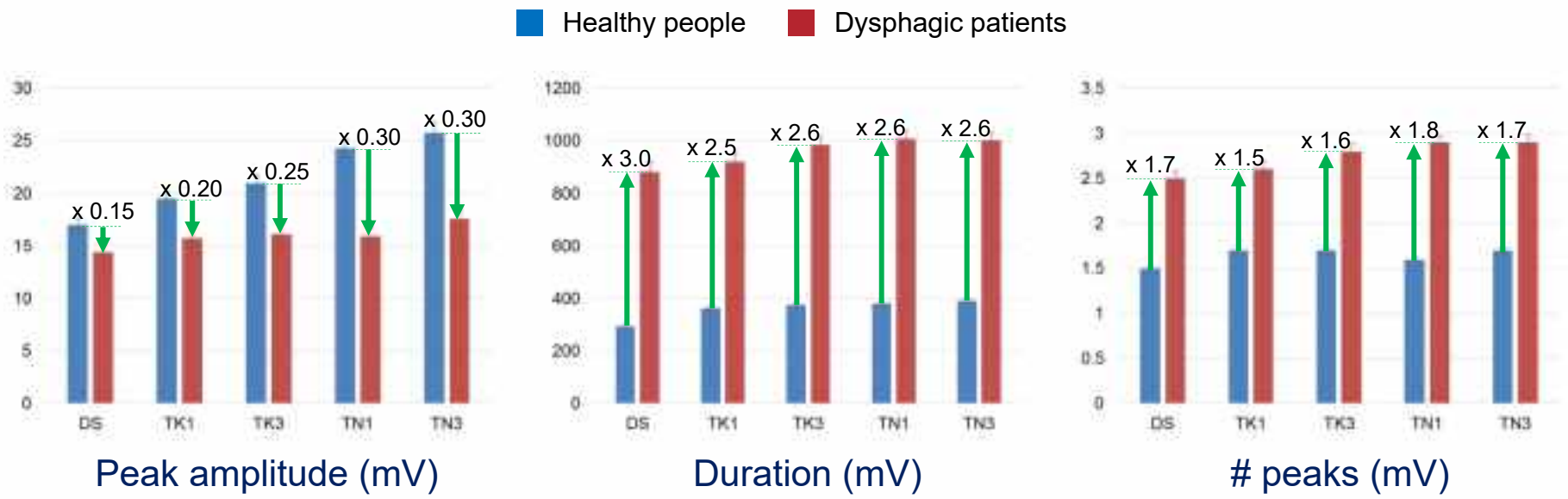




laryngopharynx movement

Discriminability of SMAS

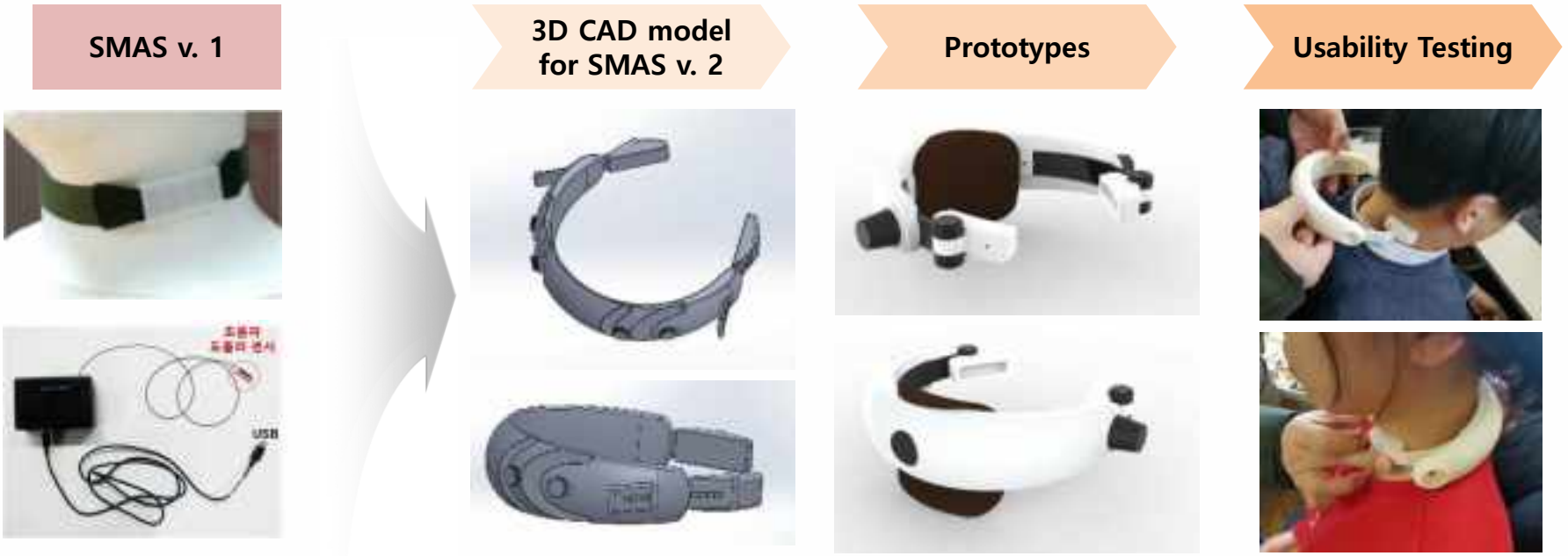
- **Clinical testing**: healthy people (HP; n = 120) vs. dysphagic patients (DP; n = 36)
- **Comparison**
  - (1) Peak amplitude of DP: 0.15 ~ 0.30 times lower ($t(982) = 13.13$, $p < 0.001$)
  - (2) Duration of DP: 2.5 ~ 3 times longer ($t(569) = -37.22$, $p < 0.001$)
  - (3) # peaks of DP: 1.5 ~ 1.8 times more ($t(617) = -26.70$, $p < 0.001$)



(note) DS: dry saliva; TK1 & TK3: 1 ml & 3 ml of thick liquid; TN1 & TN3: 1 ml & 3 ml of thin liquid

On-Going Upgrade of SMAS

- Upgrade of the current sensor array design for better signal detection and the current neck band for better wearability



On-Going Upgrade of SMAS

Q & A