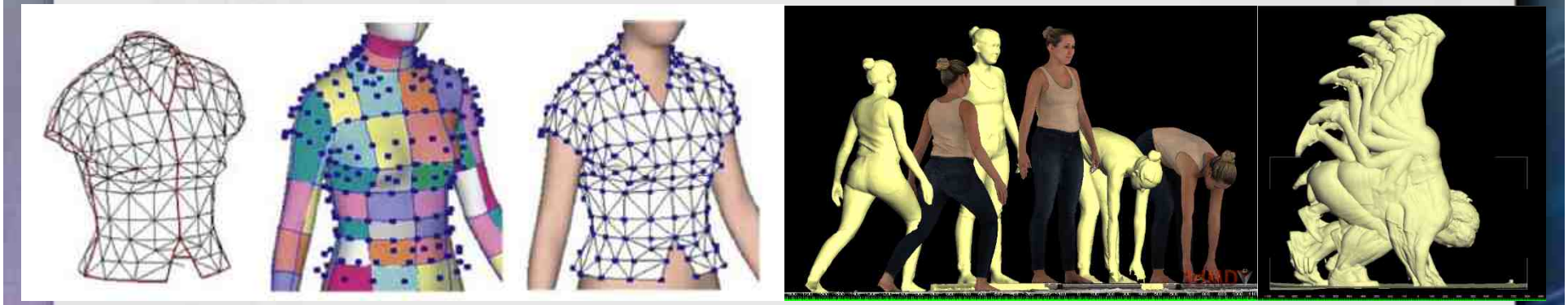
INDUSTRIAL AND MANAGEMENT ENGINEERING, POSTECH

Ergonomic Design Technology Lab

Human Body Scanning Techniques for Clothing Design



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2017 한국의류산업학회 춘계학술대회

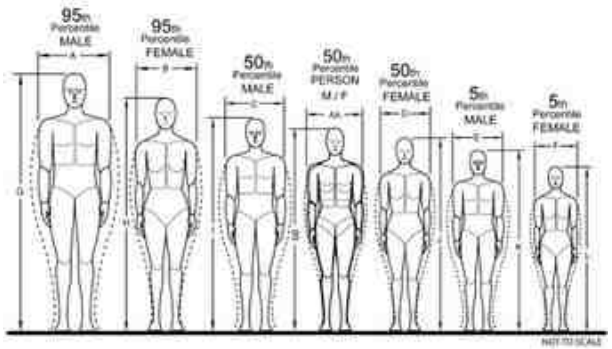
Global Contributor to Eco-Techno-Humanopia

Agenda

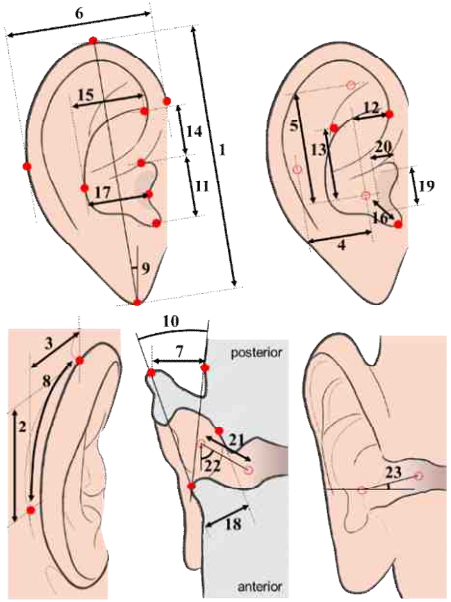
- Introduction
  - Background
  - Objectives of the Study
- 3D Scanning Techniques: Static & Temporal
- Applications
- Discussion

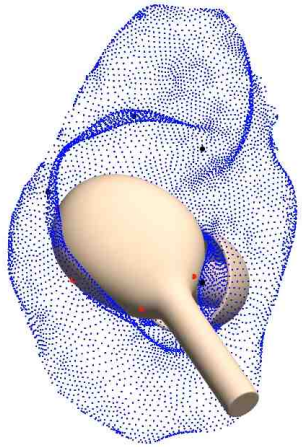
Background: Anthropometry

- Ergonomic design of wearable products highly depends on anthropometric measurements in 1D, 2D, and 3D.



	Female					Male				
	Dreyfuss		Woodson			Dreyfuss		Woodson		
	1%	99%	5%	50%	95%	1%	99%	5%	50%	95%
Height	58.1"	69.6"	59.0"	62.9"	67.1"	62.6"	75.6"	63.6"	68.3"	72.8"
Weight	92.0	217.6	104.0	139.0	208.0	100.3	244.0	124.0	168.0	224.0
Standing Eye Height	54.0"	65.1"	57.3"	60.3"	65.3"	58.5"	70.9"	60.8"	64.7"	68.6"
Standing Overhead Reach	64.5"	NA	73.0"	79.0"	86.0"	NA	85.7"	92.0"	88.0"	94.0"
Standing Forward Reach	23.5"	NA	29.7"	31.8"	34.1"	NA	32.5"	31.9"	34.6"	37.3"
Sitting Height	30.8"	37.1"	30.9"	33.4"	35.7"	32.7"	39.3"	33.2"	35.7"	38.0"
Sitting Eye Height	26.8"	32.2"	27.4"	29.3"	31.0"	28.7"	34.5"	28.7"	31.3"	33.5"
Buttock-to-Popliteal	16.5"	21.1"	17.0"	18.9"	21.0"	17.8"	21.6"	17.3"	19.5"	21.6"
Buttock-to-Knee	19.8"	25.5"	20.4"	22.4"	24.6"	20.8"	26.5"	21.3"	23.3"	25.2"
Sitting Popliteal Height	15.0"	18.0"	14.0"	15.7"	17.5"	15.5"	19.5"	15.5"	17.3"	19.3"
Sitting Knee Height	17.3"	22.4"	17.9"	19.6"	21.5"	18.8"	24.5"	19.3"	21.4"	23.4"
Thigh Clearance	NA	NA	4.1"	5.4"	6.9"	NA	NA	4.3"	5.7"	6.9"
Waist Depth	7.5"	13.0"	5.8"	6.6"	7.9"	7.9"	13.7"	7.1"	9.7"	12.3"
Elbow Rest Height	NA	NA	7.1"	9.2"	11.0"	NA	NA	7.4"	9.5"	11.6"
Sitting Hip Breadth	11.2"	18.3"	12.3"	14.3"	17.1"	11.4"	16.9"	12.2"	14.0"	15.9"
Forearm-to-Forearm Breadth	NA	NA	12.3"	15.1"	19.3"	NA	NA	13.7"	16.5"	19.9"
Hand Thickness at Metacarpal	NA	NA	0.8"	1.0"	1.1"	NA	NA	1.1"	1.2"	1.3"





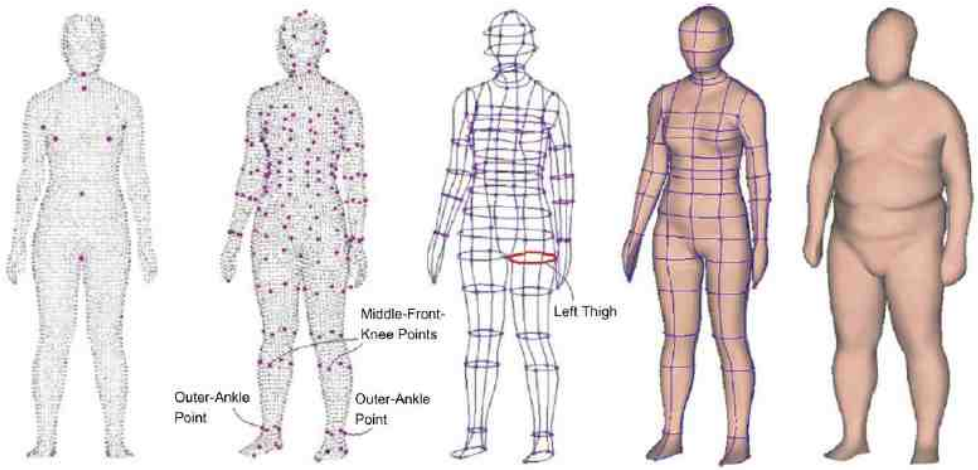
Smallest (2.5%ile)	Small (25%ile)	Medium (50%ile)	Large (75%ile)	Largest (97.5%ile)
				

http://dominicjonesarch.weebly.com/

CAD Methods in Garment Design

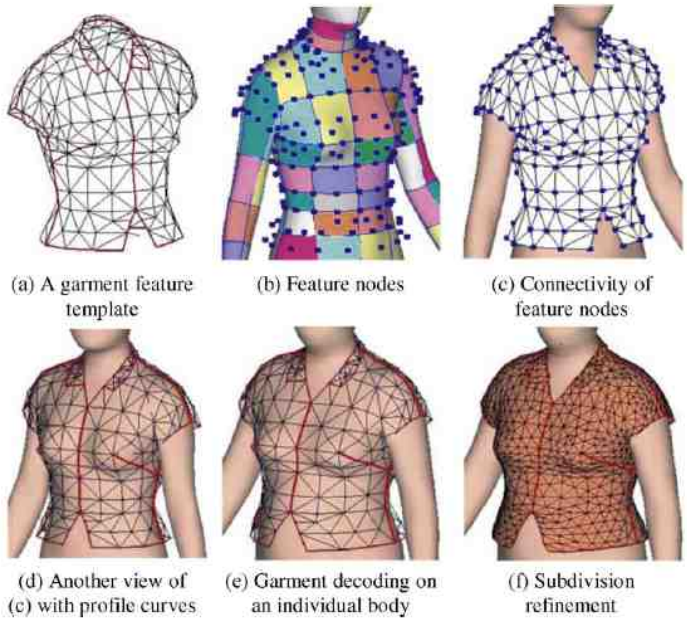
- CAD methods have been utilized in garment design.

Parametric human model



(a) Key feature points (b) The complete set of feature points (c) Feature graph (d) Feature patches on human body (e) Modification by sizing dimension

Encoding & decoding of garment feature template



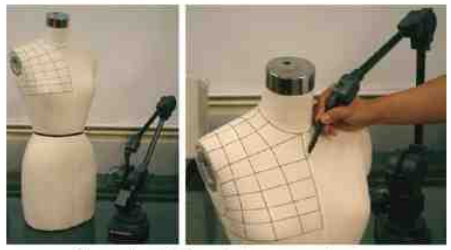
(a) A garment feature template (b) Feature nodes (c) Connectivity of feature nodes

(d) Another view of (c) with profile curves (e) Garment decoding on an individual body (f) Subdivision refinement

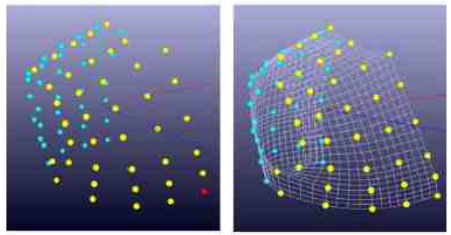
Liu et al. (2010) A survey on CAD methods in 3D garment design. *Computers in Industry, 61*, 576-593.

3D Human Body Surface Data

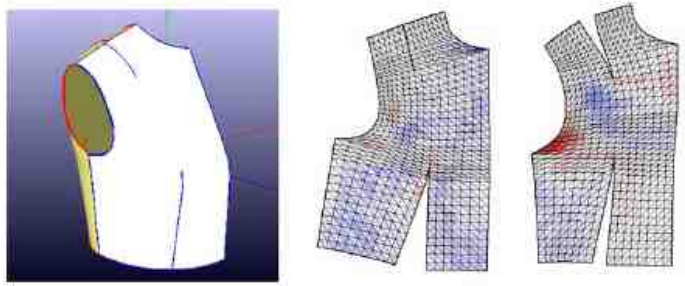
- The human body surface data obtained in 3D have been used for 3D garment design.



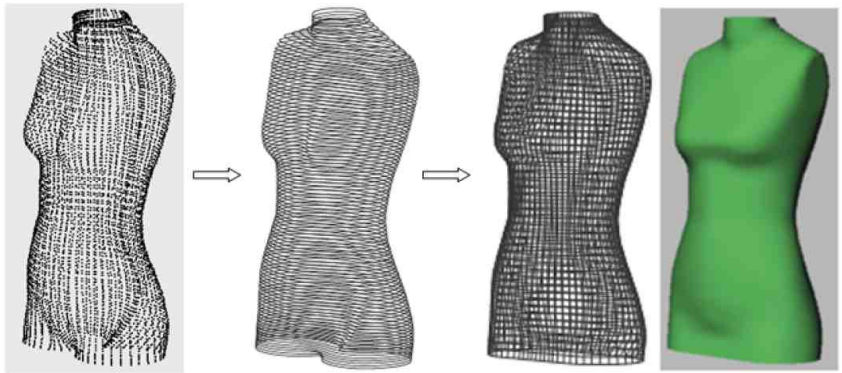
Mannequin and 3-D coordinate measurement system



Measured points and reconstructed B-Spline surface



Kim & Park (2007) Basic garment pattern generation using geometric modeling method. *International J. of Clothing Science and Technology, 19*(1), 7-17.

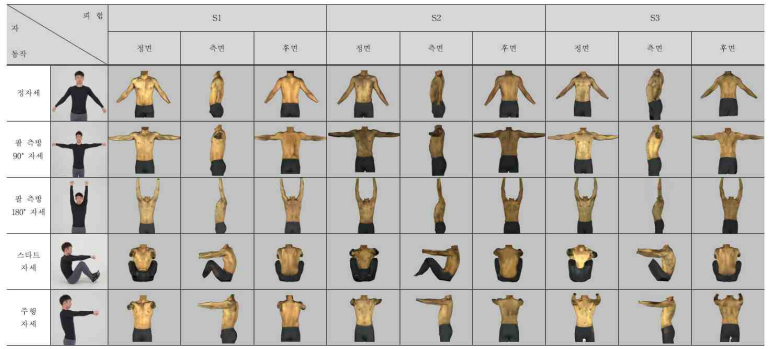


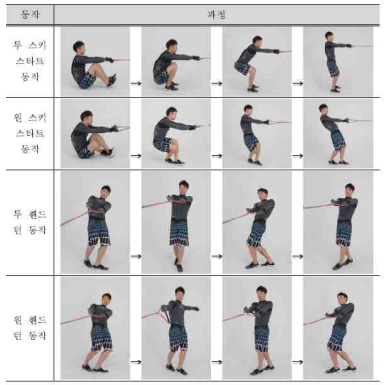
3D scaning data Cross-section preprocessing 3D curve network and surface model

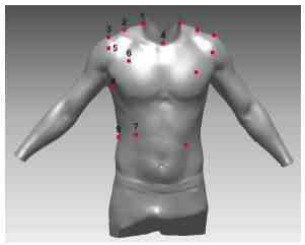
Yang et al. (2011) Development of a prototype pattern based on the 3D surface flattening method for MTM garment production. *Fibers & Textiles in Eastern Europe, 19*(5), 107-111.

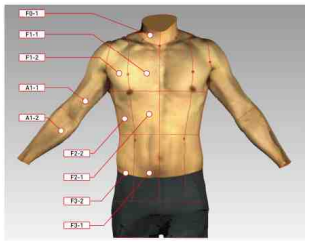
Needs for Dynamic Anthropometry

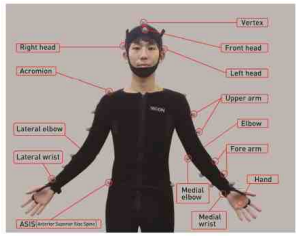
- The dynamics of the human body (deformation of human skin by motion) needs to be understood in depth for better design of functional wear with better fit, comfort, and performance.

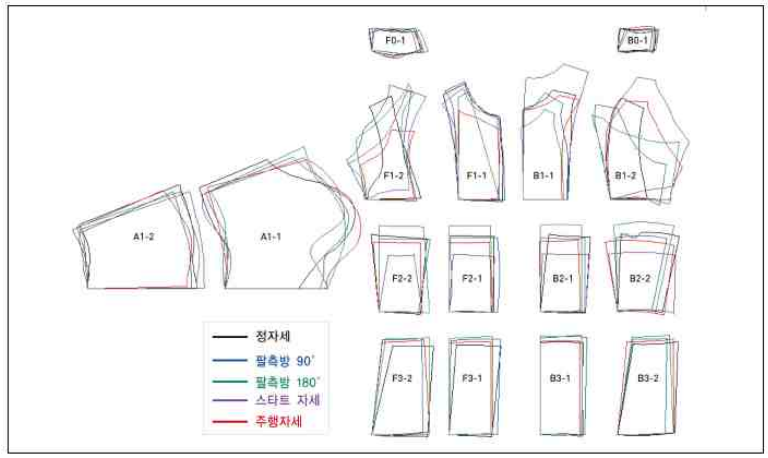


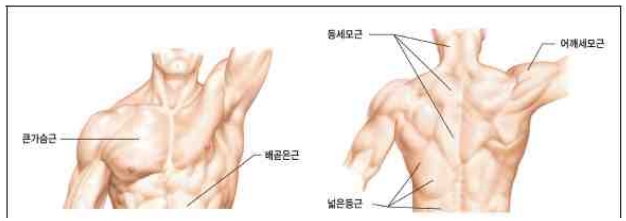


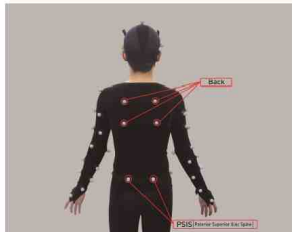












정윤경 (2016) 3D 인체데이터 및 수상 스키 동작적합성에 따른 래시가드 패턴 개발 연구. 성신여자대학교 박사학위논문.

Objectives of the Presentation

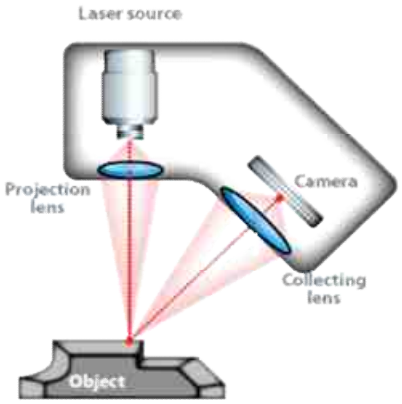
- Review static and temporal 3D (4D; dynamic) body scanning techniques.
- Reflect the potential application of temporal 3D body scanning techniques to ergonomic design of wearable products.

3D Scanning Techniques

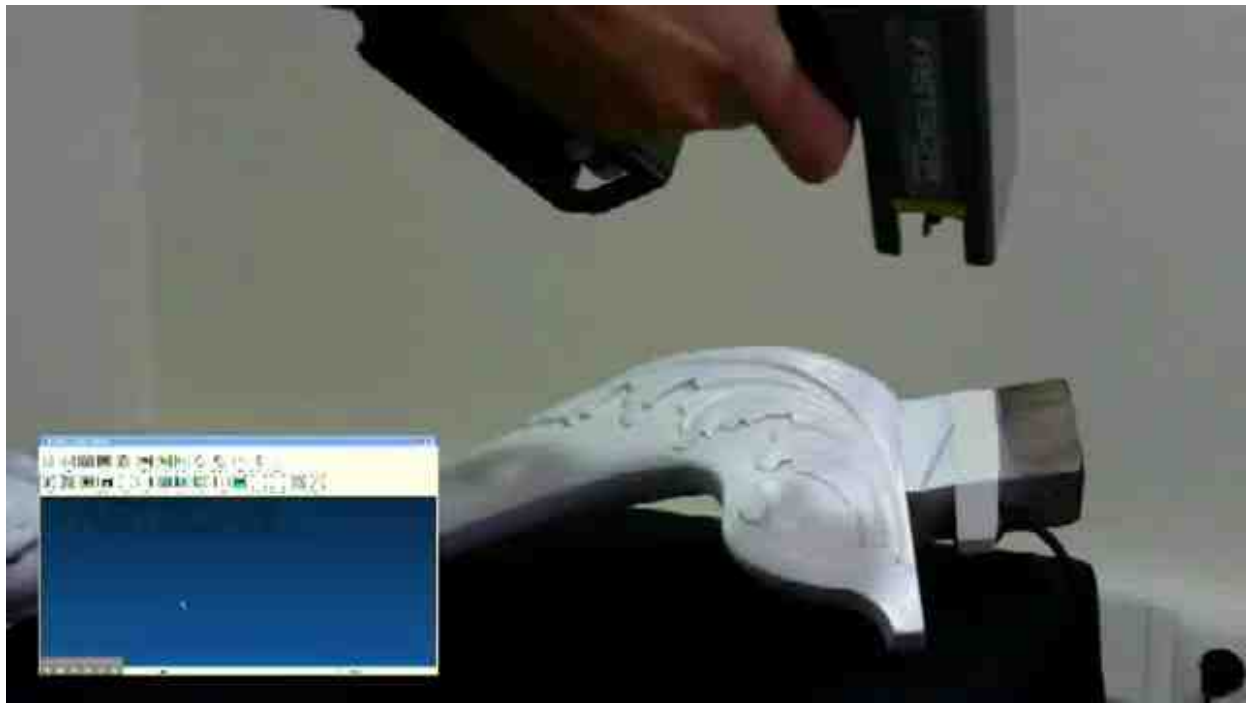
Classification	Laser scanning	Structured light scanning	Stereo photogrammetry scanning
Examples	  • Head & Face Color 3D Scanner (Cyberware Inc., USA) • FastSCAN (Polhemus, USA)	  • TC2-19R body scanner ([TC]^2, USA) • Artec Eva (Artec 3D, Luxembourg)	  • Active: 3dMD systems (3dMD, USA)
Techniques	Application of a laser beam (spot or stripe) across the target surface	Projection of organized patterns of white light, such as grids, dots, or stripes to the target surface	Software approach that creates a stereo pair from 2 pictures taken from the same object • Passive: using natural pattern or landmarks • Active: using natural pattern or landmarks with a projected unstructured light pattern
Strengths/ Limitations	• Accurate • Time demanding, difficult to use on living, breathing people, especially children	• Color texture well recorded • Hard to scan symmetric body surfaces at the same time due to light pattern interference	• Passive: requiring high resolution single-lens reflex cameras to capture enough surface detail, and careful control of lighting conditions • Active: flexible to lighting conditions; able to easily capture darker skins, fast, high data quality

Laser 3D Scanning

- Project a laser beam spot or stripe across the target surface and detect the surface location by trigonometry
- Limitation: Ineffective for scanning an object in motion

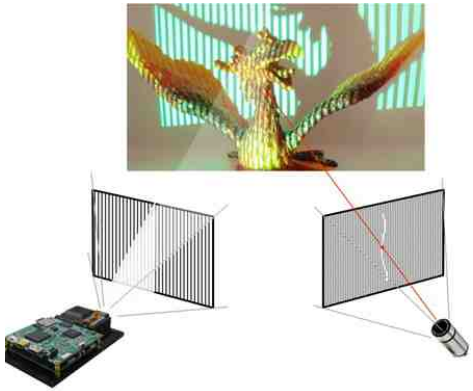


FastSCAN (Polhemus, USA)



Structured Light-Based 3D Scanning

- Project structured patterns of grids, dots, or stripes to the target surface and capture the distorted light over the object by 1 camera for surface generation
- Limitation: Inefficient to scan symmetric body surfaces due to light pattern interference



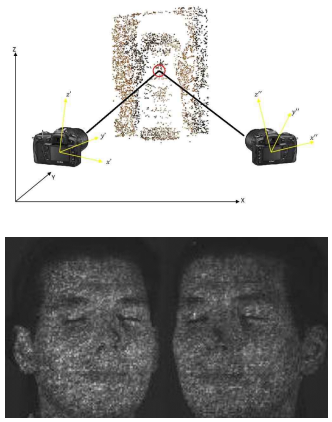
Light projector Camera

Cartesia body scanner (Spacevision, Japan)

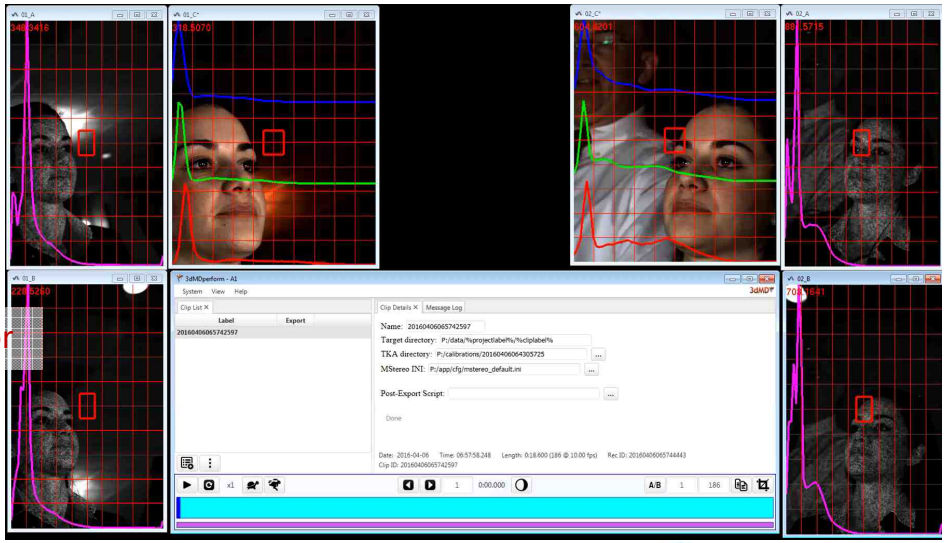
Stereo Photogrammetry-Based 3D Scanning

- Project unstructured patterns of dots or speckles on an object and capture the images of the object by 2 cameras for generation of surface reconstruction.
  - ✓ High data quality (< 0.2 mm RMS error)
  - ✓ Fast (up to 60 fps)
  - ✓ Easily capturing darker skins
  - ✓ Flexible to lighting conditions

Unstructured light pattern



3dMD face scanner (3dMD, USA)



Temporal Scanning: Structured Light-Based

Artec 3D body scanner
(Artec Group, Luxembourg)

Chest Deformation by Breathing

Normal Breathing

Heavy Breathing

Breathing After Exercise

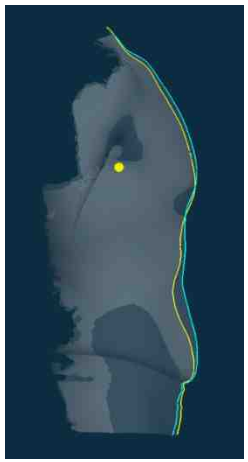
Chest Deformation: Contour Profile

Normal Breathing | Heavy Breathing | Breathing After Exercise

Normal Breathing
Frames 58 & 70

Heavy Breathing
Frames 26 & 37

Breathing Post Exercise
Frames 15 & 20



Chest Deformation: Cross-Sectional Profile

Normal Breathing

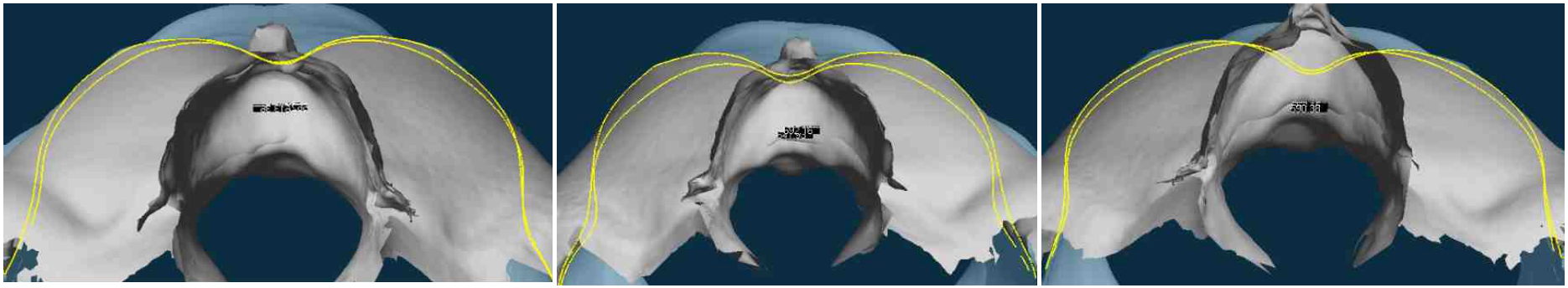
Heavy Breathing

Breathing After Exercise

Normal Breathing
Frames 58 & 70

Heavy Breathing
Frames 26 & 37

Breathing Post Exercise
Frames 15 & 20



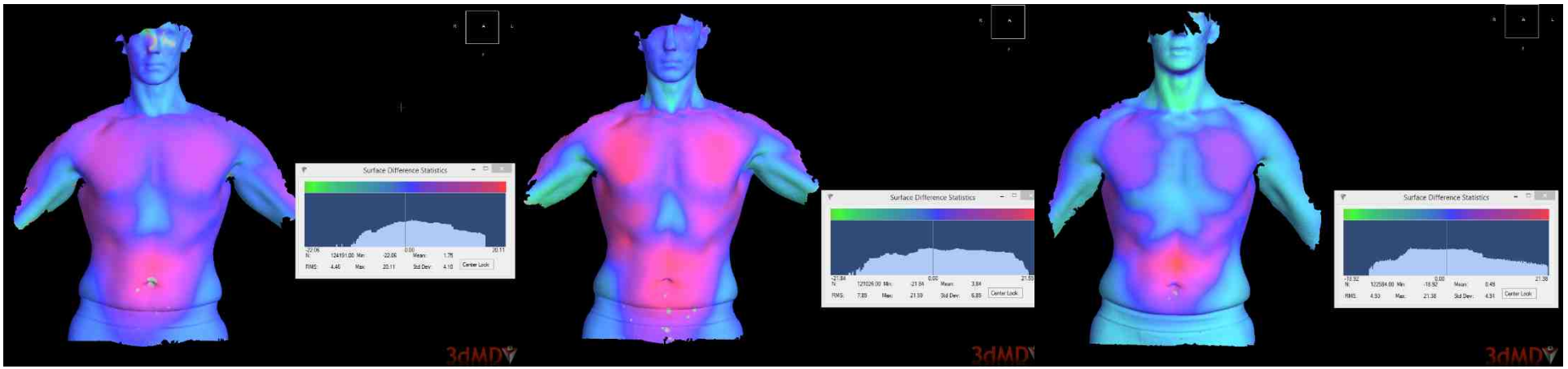
Chest Deformation: Histogram

Normal Breathing | Heavy Breathing | Breathing After Exercise

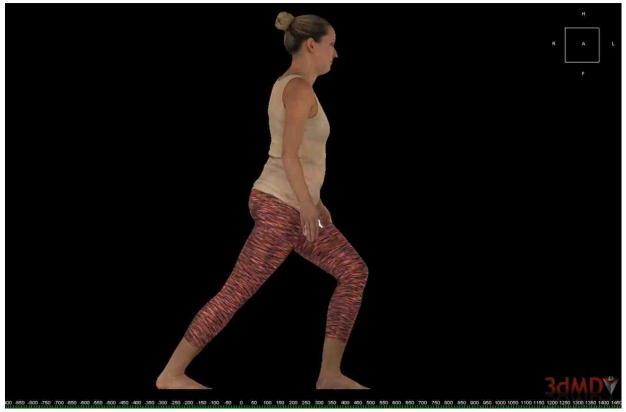
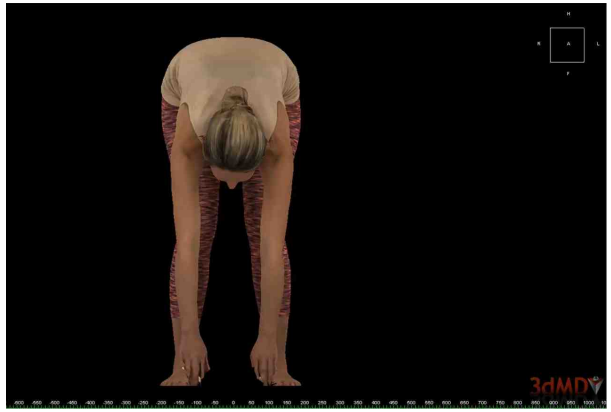
Normal Breathing
Frames 58 & 70

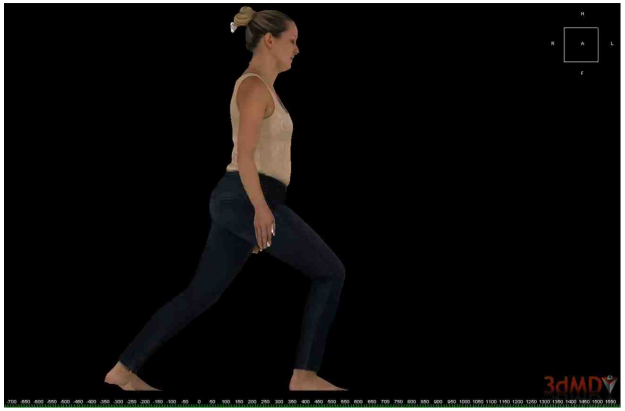
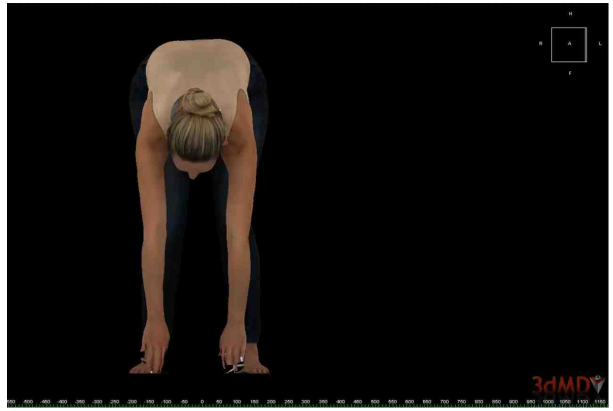
Heavy Breathing
Frames 26 & 37

Breathing Post Exercise
Frames 15 & 20



Mobility Changes by Cloth Material

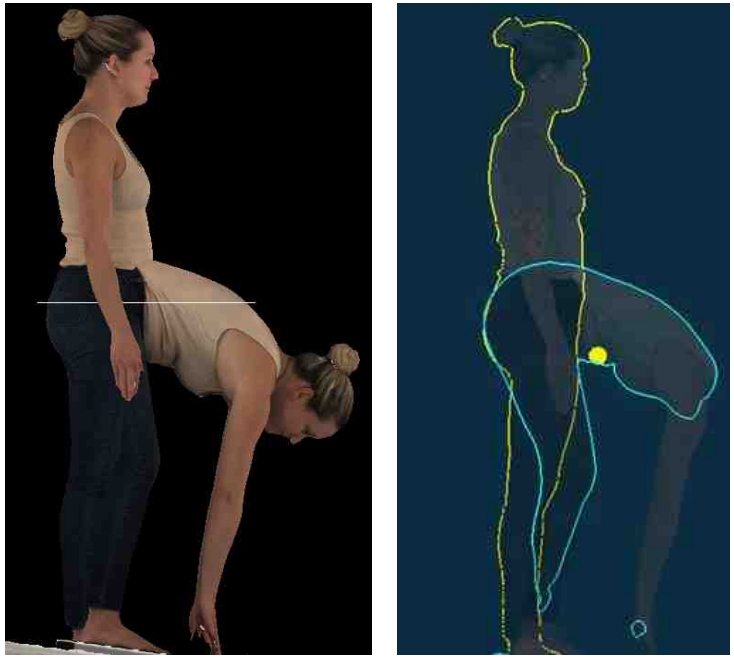




lunging in yoga pants & jeans

bending over in yoga pants & jeans

squatting in yoga pants & jeans

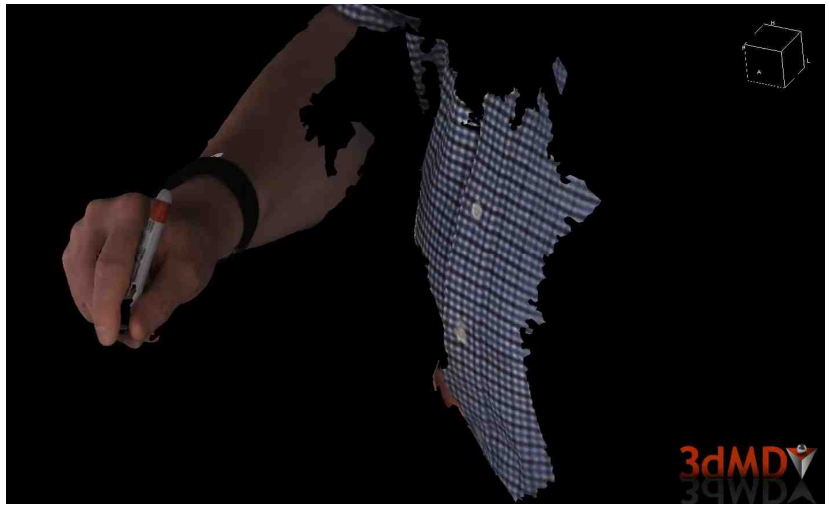
Mobility Changes: Contour Profile

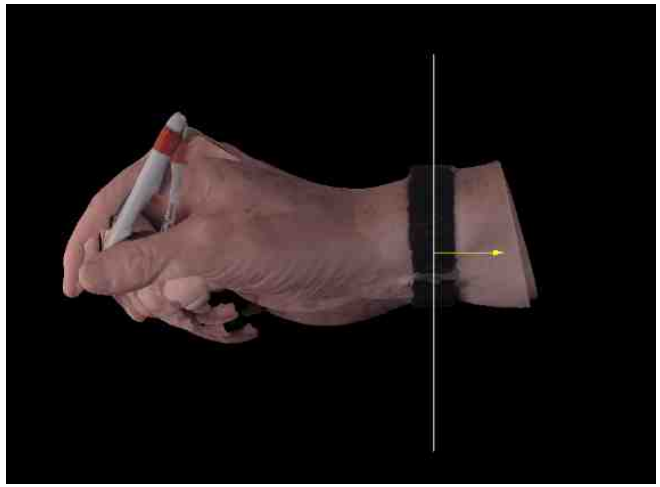


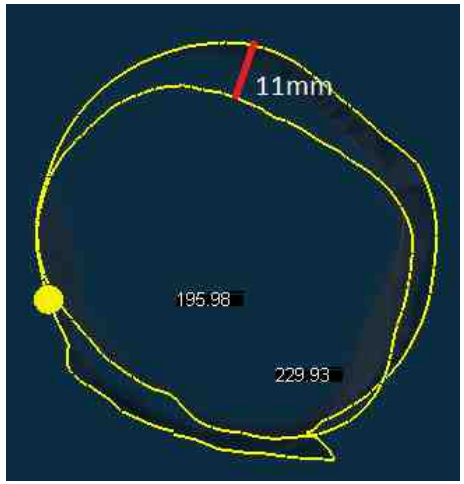
Superimposition of subject bending over with standard A-pose

Shape change with different body poses.

Writing Comparison w/ and w/o Fitbit





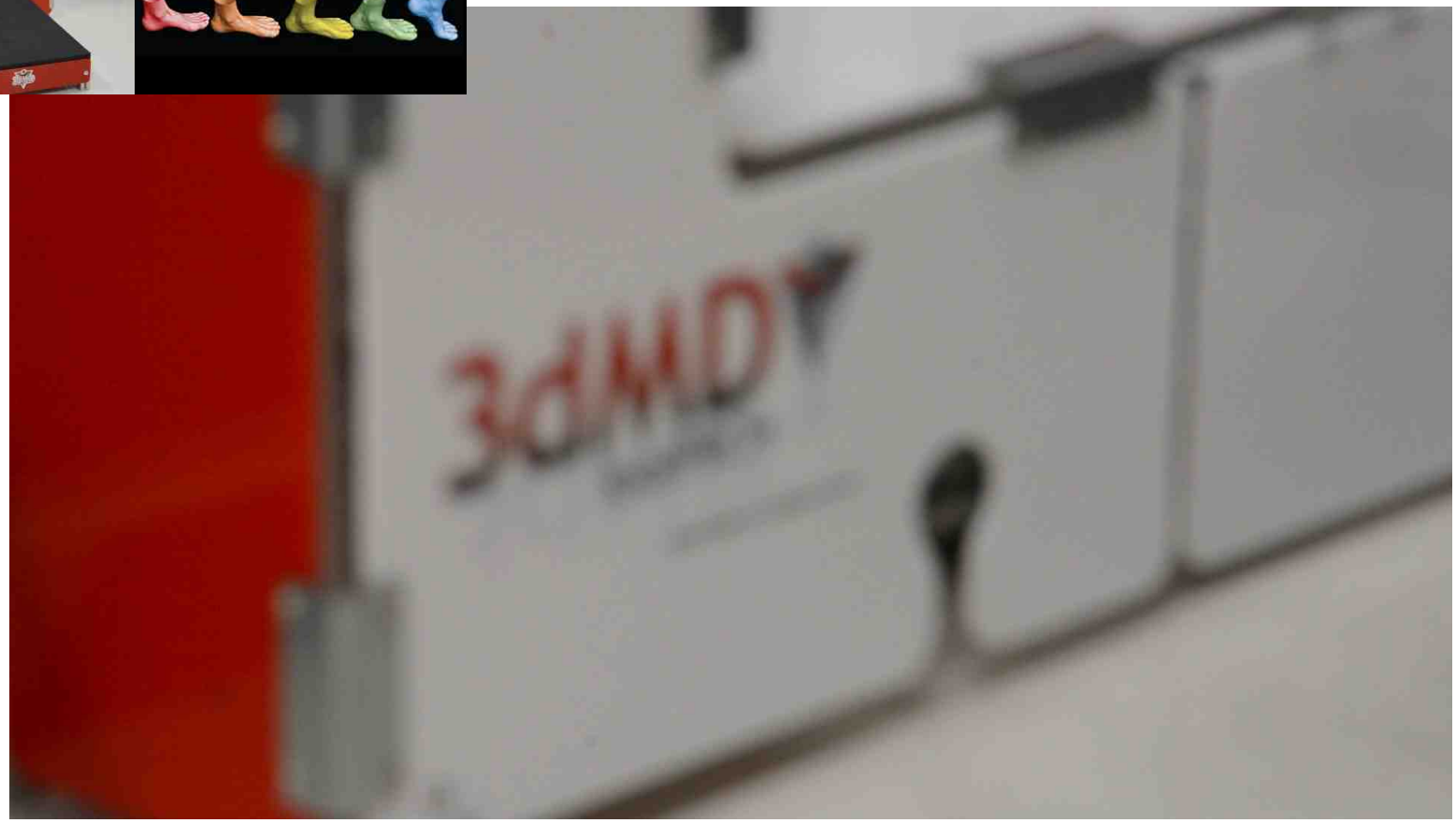


Micro Motion Analysis (60 fps)

- Ultra-dense analysis techniques of the subject's skin dynamics with posture, pose, and functional movement
- Provides the bridge between automated traditional point tracking and sparse meshing techniques to expressing movement in terms of dense surface deformation

Point-based Tracking & Analysis *Surface Deformation Tracking & Analysis* *Histogram Analysis*

Dynamic Anthropometry for Foot



Discussion

- The stereo photogrammetry-based scanning technique is superior to the laser-based and structured light-based techniques in terms of time and data quality to capture an object in motion.

Structured light-based
Artec 3D body scanner

Stereo photogrammetry-based
3dMD body scanner

Discussion

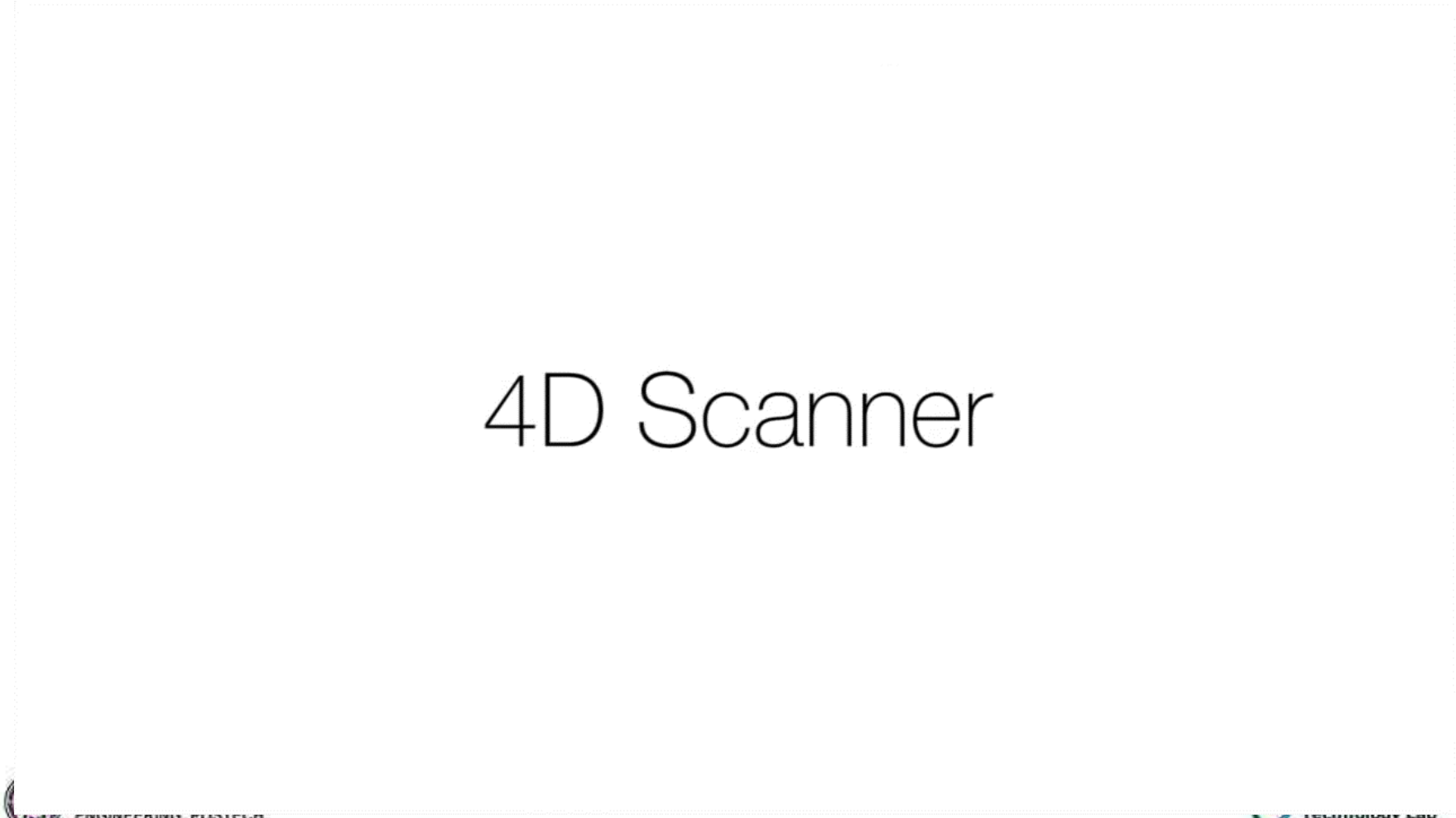
- The stereo photogrammetry-based scanning technique is superior to the laser-based and structured light-based techniques in terms of time and data quality to capture an object in motion.

- The temporal 3D canning technique enables to capture human body surfaces in motion with a certain frame rate (up to 60 fps), which is applicable to dynamic body dimensions for ergonomic design of wearable products such as sportswear and shoes to improve the comfort and performance of wearer.

- The temporal 3D scanning technique has high potential in R&D of dynamic anthropometry, human modeling, and product design.

Discussion

- The temporal 3D scanning technique has high potential in R&D of dynamic anthropometry, human modeling, and product design.



Q & A

Thank you for your attention!