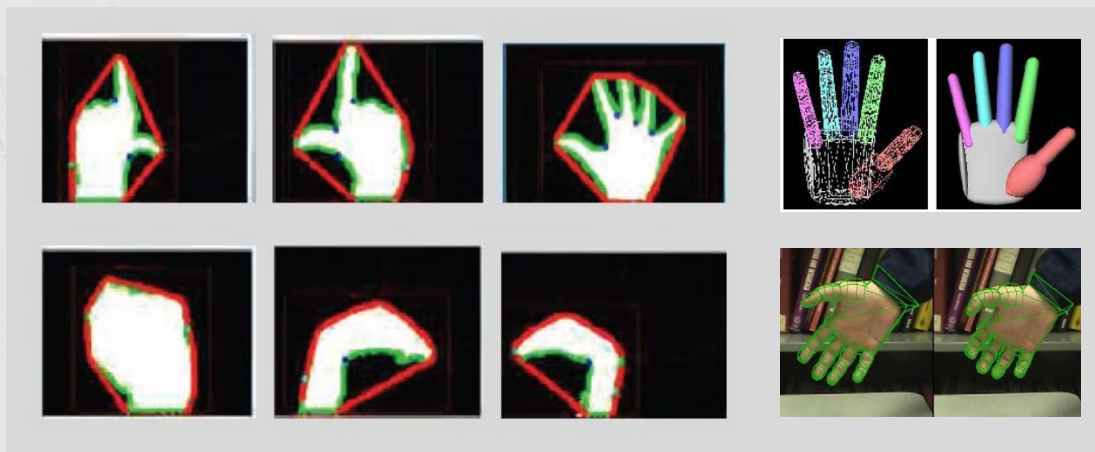


소형 가전제품의 파지 자세 측정을 위한 손 추적 기술 문헌 조사



최영근, 권도훈, 김민재, 홍영기, 김진원, 김현중, 유희천

포항공과대학교 산업경영공학과 인간공학설계기술 연구실

본 연구는 산업통상자원부의 "미래첨단 사용자편의서비스 기반조성사업"의 지원을 받아 수행된 연구결과임 (R0004840, 2018)

2019 대한인간공학회 춘계학술대회

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 - ✓ 개발 목적
 - ✓ 사용하는 device
 - ✓ Algorithm
- 토의

제품 파지 자세 이해의 중요성

- 소형 가전제품들은 **한 손으로 파지와 조작이 모두 이루어져** 사용성이 높은 인터페이스를 설계 하기 위해서는 **사용자들의 선호 파지 자세에 대한 이해가 필요함**
 - 조작하는 대상의 위치에 따라 파지 자세가 달라짐 (Wobbrock et al., 2008)
 - 파지 자세에 따라 interaction 방법이 달라져 사용성에 영향을 미침(Yang., 2012)
 - 부적절한 파지 자세를 취할 경우 slip으로 인한 기기 손상 발생 가능



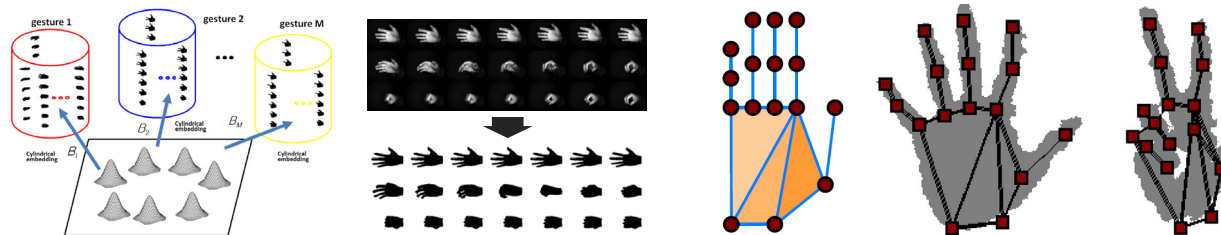
연구 목적

제품 파지 자세 분석에 활용 가능한 Hand Tracking 기술 문헌 조사

➤ 측정 장비 조사



➤ Hand tracking algorithm 유형



➤ 활용 가능성 검토

문헌 검색 방법

- 문헌 조사 site: www.sciencedirect.com
- 검색 조건: title, abstract, keyword
- 검색 keyword: (hand) and (tracking)
 - 1차 검색 결과: 2,435건
 - Title screening: 68건
 - Abstract screening: 45건

문헌 검색 결과: Summary

□ 선별된 45건 문헌들의 **기술 개발 목적, 사용하는 device, algorithm**을 review함

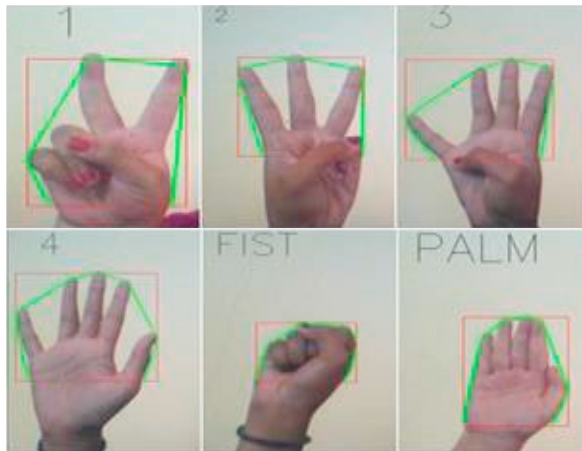
No.	Year	Title	Authors	Affiliation	Journal	Objective	Device	Model/image base	Algorithm
1	2011	Feature extraction from hand image based on new detection operator	Zhiqian Feng, Bo Yang, Yuehui Chen, Yanwei Zheng, Tao Xu, Yi Li, Ting Xu, Deling Zhu	Ji Wei Road 106, Jinan, Shandong, China School of Information Science and Engineering, University of Jinan, Jinan 250022, PR China Provincial Key Laboratory for Network Based Intelligent Computing, University of Jinan, Jinan 250022, PR China	Pattern Recognition	Gesture recognition	2D camera	Image base	Coarse location for feature - polygon boundaries 이용하여 배경에서 손 검출 후 link model 생성
2	2007	A real-time hand tracker using variable-length Markov models of behaviour	Nikolay Stefanov, Aphrodite Galata, Roger Hubbard	Advanced Interfaces Group, School of Computer Science, University of Manchester, Manchester M13 9PL, UK	Computer Vision and Image Understanding	Gesture recognition	2D camera	Image base	Gaussian mixtures algorithm (Stauffer and Grimson)을 이용하여 손의 hue value를 기준으로 배경과 손(low hue)을 분리 후 손을 polygon으로 단순화 시켜 관절 각도 검출
3	2000	Gesture recognition using the multi-PDM method and hidden Markov model	Chung-Lin Huang, Ming-Shan Wu, Sheng-Hung Jeng	Institute of Electrical Engineering, National Tsing-Hua University, Hsin-Chu, Taiwan, ROC	Image and Vision Computing	Gesture recognition	2D camera	Image base	PDM과 Hidden Markov Model(HMM)을 결합한 검출 알고리즘: 추가 조사 필요
4	2010	A variational approach to monocular hand-pose estimation	Martin de La Gorce, Nikos Paragios	MAS Laboratory, Ecole Centrale de Paris, Grande Voie des Vignes, 92 295 Chatenay-Malabry, France	Computer Vision and Image Understanding	Gesture recognition	2D camera	Model base	Hand silhouette 검출 후 각 관절 모델 분석하여 자세 추정
5	2011	A multi-view vision-based hand motion capturing system	Meng-Fen Ho, Chuan-Yu Tseng, Cheng-Chang Lien, Chung-Lin Huang	Institute of Electrical Engineering, National Tsing Hua University, HsinChu, Taiwan, ROC Department of electronic Engineering, Hsiuping Institute of Technology, Taichung, Taiwan, ROC Department of Computer Science and Information Engineering, Chung-Hua University, HsinChu, Taiwan, ROC	Pattern Recognition	Gesture recognition	2D camera, depth camera	추가 조사 필요	배경 분리, 각 관절 각도 계산, multi-view data 활용, separable state based particle filtering (SSBPF) 추가 조사 필요
6	2012	3D hand tracking for human computer interaction	Victor Adrian Prisacariu, Ian Reid	Department of Engineering Science, University of Oxford, United Kingdom	Image and Vision Computing	Gesture recognition	2D camera, accelerometer	Image base	Hand 검출 후 가속도센서 값 활용하여 정확한 rotation 적용, Visual 3D tracker 정보 추가 조사 필요
7	2004	Model-based visual hand posture tracking for guiding a dexterous robotic hand	Jinshi Cui, Zengqi Sun	State Key Laboratory of Intelligent Technology and Systems, Department of Computer Science and Technology, Tsinghua University, Beijing 100084, China	Optics Communications	Gesture recognition	2D camera	Model base	Hand model 검출 시 PF (particle Filter) 와 GA (genetic algorithm) 을 융합하여 GA기반 particle filter를 개발
8	2012	Gravity optimised particle filter for hand tracking	Malik Morshidi, Tardi Tjahjadi	School of Engineering, University of Warwick, Gibbet Hill Road, Coventry CV4 7AL, United Kingdom	Pattern Recognition	Gesture recognition	2D camera	Model base	PF를 개선한 GOPF 방법으로 검출
9	2017	Non-parametric hand pose estimation with object context	Javier Romero, Hedvig Kjellström, Carl Henrik Ek, Danica Kracic	Perceiving Systems Department, Max Planck Institute for Intelligent Systems, 72076 Tübingen, Germany CVAP/CAS, KTH, SE-100 44 Stockholm, Sweden	Computer Vision and Image Understanding	Hand pose in product use	2D	Image base	물건을 쥐고 있는 hand tracking 기술과 기존 기술 비교
10	2017	Guided optimisation through classification and regression for hand pose estimation	Philip Krejov, Andrew Gilbert, Richard Bowden	Centre for Vision, Speech and Signal Processing, Faculty of Engineering and Physical Sciences, University of Surrey, United Kingdom	Computer Vision and Image Understanding	Gesture recognition	Depth camera	Image base	Voxel grid filter를 이용해 point cloud data에서 손 형상 분석
11	2008	Hand gesture recognition and tracking based on distributed locally linear	S.S. Ge, Y. Yang, T.H. Lee	Social Robotics Lab, Interactive Digital Media Institute & Department of Electrical and Computer Engineering, National University of Singapore, Singapore 117576	Image and Vision Computing	Gesture recognition	2D camera	Model base	Distributed locally linear embedding (DLLE), modified version of the locally linearly embedding (LLE), Probabilistic neural



기술 개발 목적

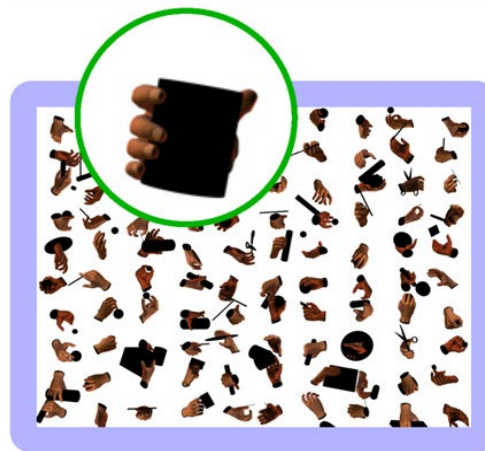
- **Gesture recognition:** hand gesture를 이용한 interaction 방법을 개발하기 위해 **손의 움직임 또는 세부적인 손의 모양**을 추적함
- **Hand pose in product use:** **제품을 사용할 때의 손 자세**를 다양한 각도에서 파악함
- **Behavioral research:** **특정 상황 또는 감정 상태에서 사람이 보이는 손 움직임**을 파악함

Gesture recognition



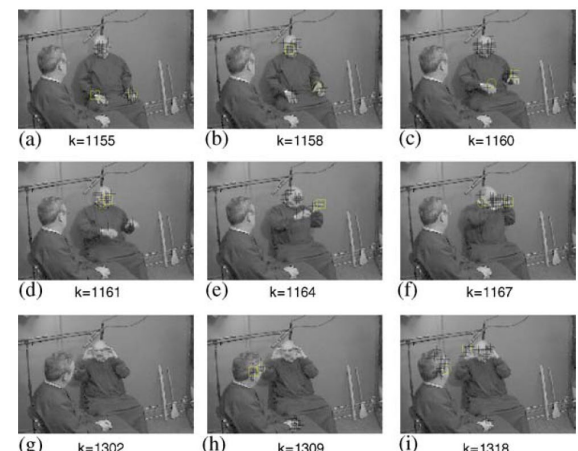
(Haria et al., 2017)

Hand pose in product use



(Romero et al., 2013)

Behavioral research



(Wu and Hong, 2005)

활용 Device (1/2)

□ 2D camera: 일반적인 video camera

□ Depth camera: 대상의 심도를 측정하여 3차원 형태를 파악할 수 있는 장비

2D camera



(Color industrial camera, Imaging Source Asia Co., Ltd., Taiwan)



(C270, Logitech Inc., Switzerland)

Depth camera



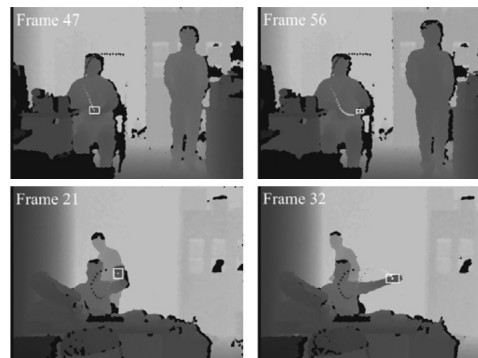
(CamBoard, PMD Technologies, Germany)



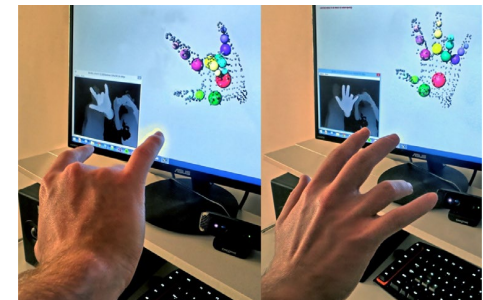
(Kinect, Microsoft, Inc., USA)



(Leap motion controller, Leap Motion, Inc., USA)



(Wu et al., 2015)

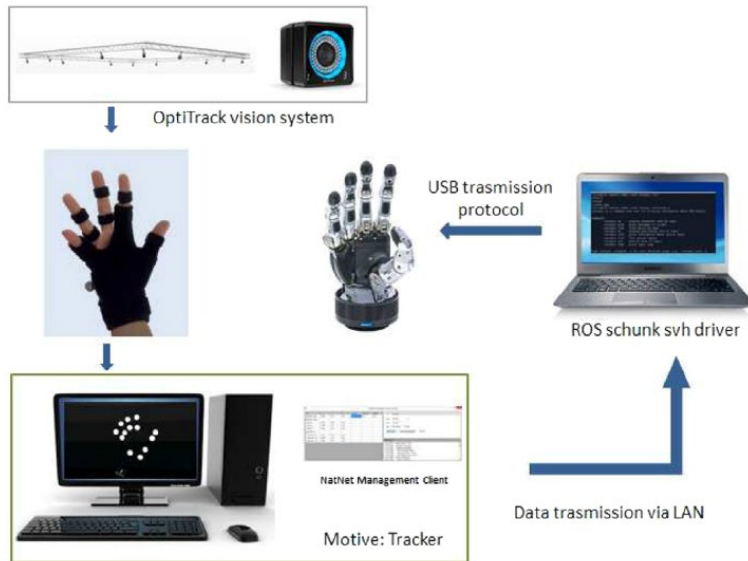


(Krejov et al., 2017)

활용 Device (2/2)

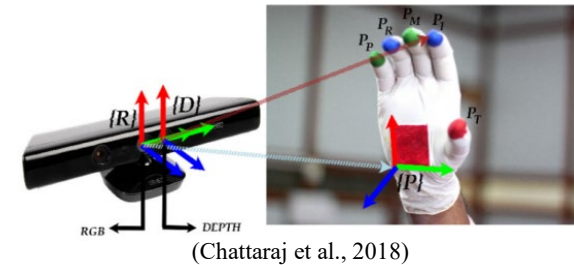
- Motion capture camera, glove: **marker가 부착된 glove를 착용**하고 적외선 **motion capture camera를 활용**하여 손의 각 link 위치를 측정
- Accelerometer: **손의 각도를 함께 측정**하여 camera에 촬영된 손의 configuration을 분석할 때 활용

Motion capture camera, glove

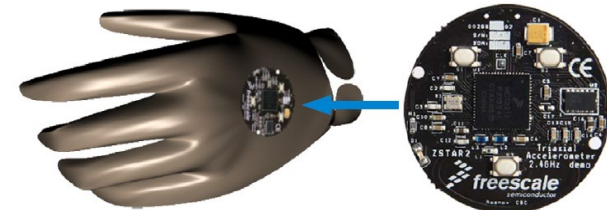


(Cerulo et al., 2017)

Kinect, glove



Accelerometer

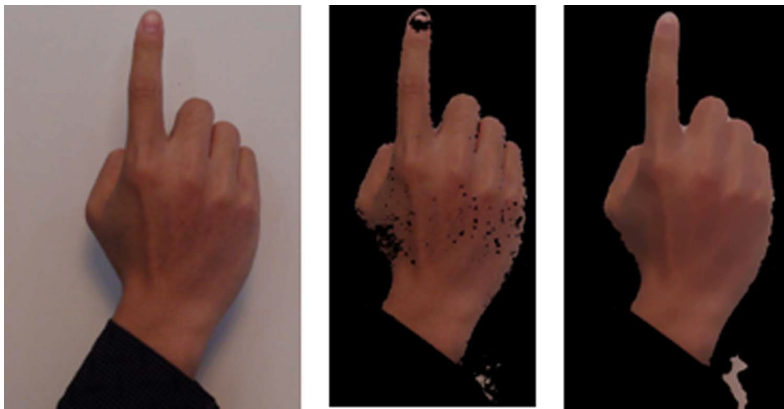


(Prisacariu and Reid, 2012)

손 추적 Algorithm

- Hand tracking은 공통적으로 (1) capturing, (2) finding, (3) analyzing의 3단계를 거치며, **hand shape을 분석하는 image 기반**과 **3D configuration을 분석하는 model 기반**으로 구분됨

Capturing and finding



(Premaratne et al., 2017)



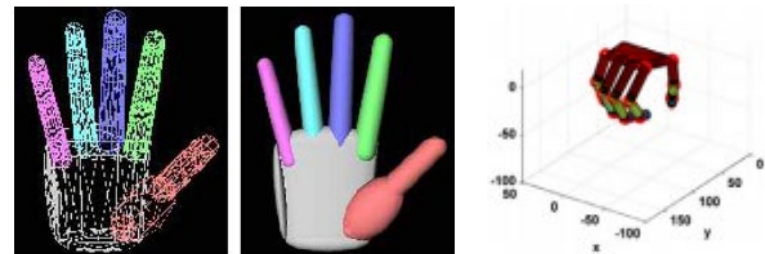
(Stefanov et al., 2007)

Image based analyzing



(Lee et al., 2013)

Model based analyzing



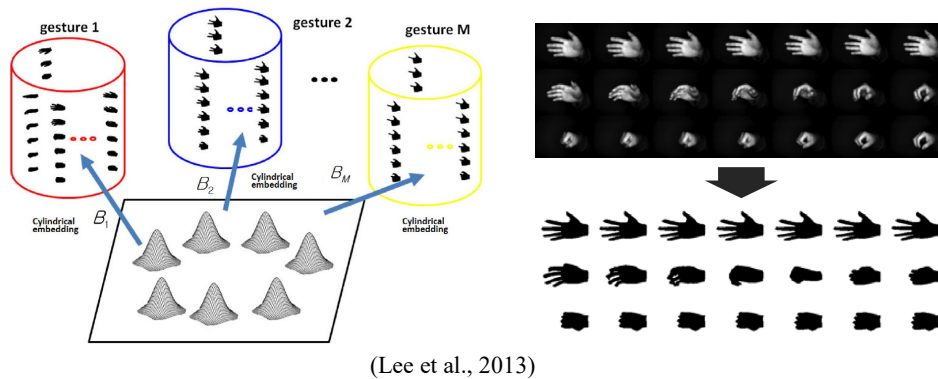
(Cui and Sun, 2004)

(Chattaraj et al., 2018)

손 추적 Algorithm: Image 기반(1/2)

- 각 hand pose에 대한 다수의 Image를 촬영 혹은 생성하여 학습시킨 후 분석 대상의 **hand pose**를 분석
- 손의 세부적인 자세보다는 **손의 움직임을 추적하여 gesture**를 인식하는 연구들이 많음

Hand pose analysis



Hand movement tracking

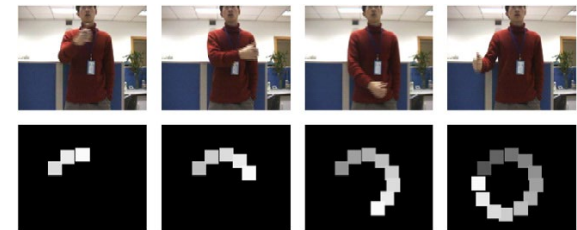
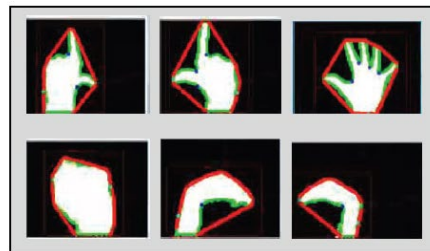
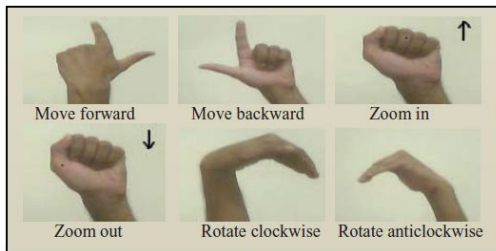
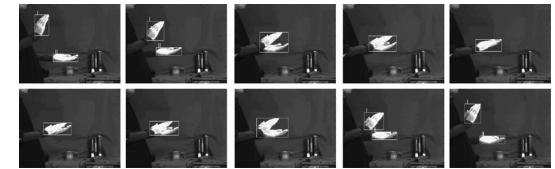
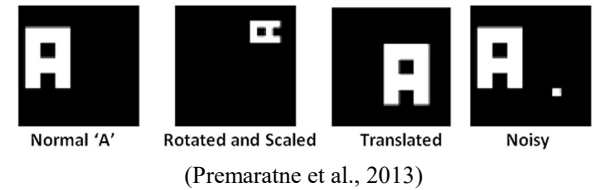


Image based Hand Tracking



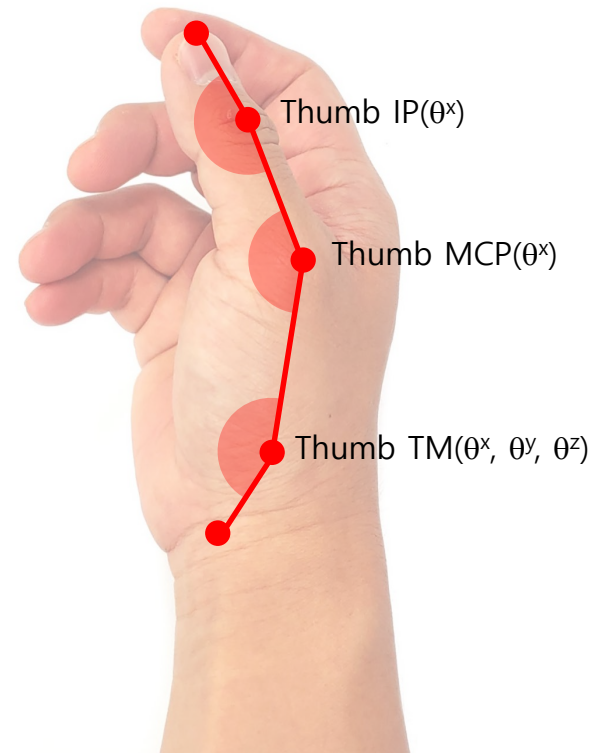
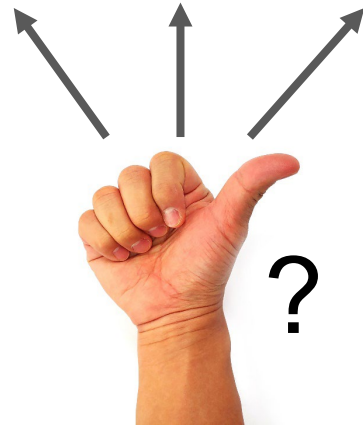
손 추적 Algorithm: Image 기반(2/2)

- 학습된 pose 외의 새로운 hand pose에 대한 분석이 불가능함
- 각 손가락의 세부적인 위치 및 각도 분석이 제한됨

학습용 hand pose



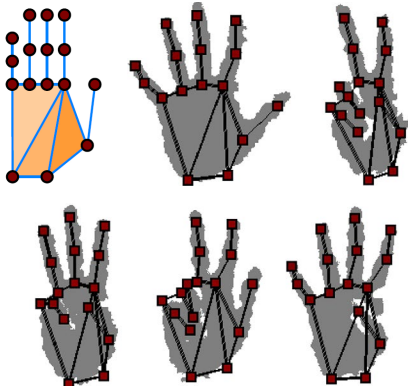
분석 대상 hand pose



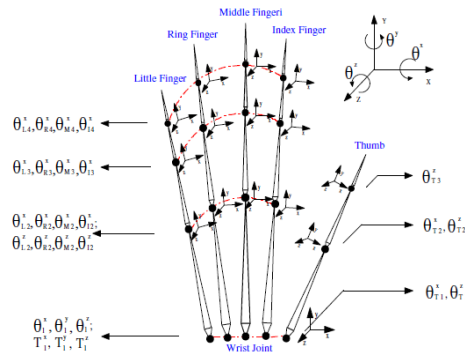
손 추적 Algorithm: Model 기반(1/2)

- Hand kinematic model을 **link의 수와 joint의 자유도를 연구 목적에 적절한 수준으로 생성**하여 측정 대상 hand data를 fitting

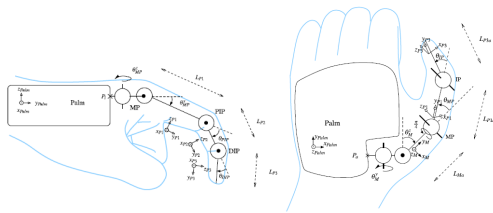
Hand kinematic models



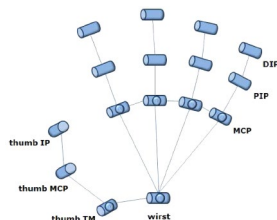
Coleca et al. (2015)



Ge and Lee (2008)

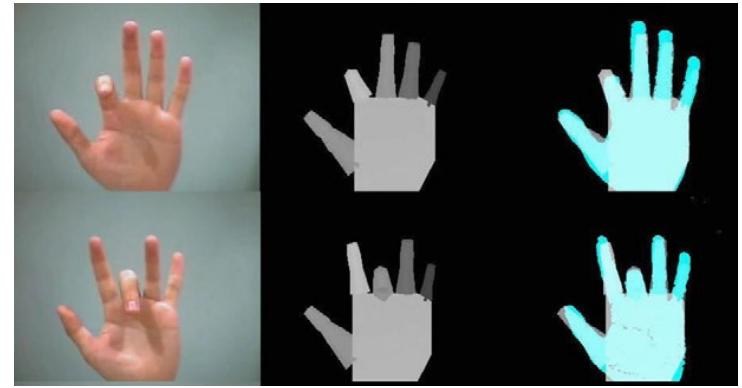


Gorce and Paragios (2010)

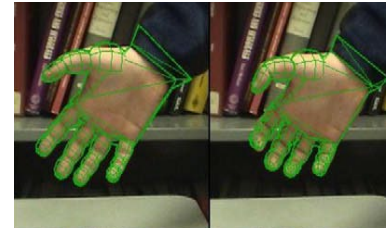


Cerulo et al. (2017)

Fitted hands



Ho et al. (2011)

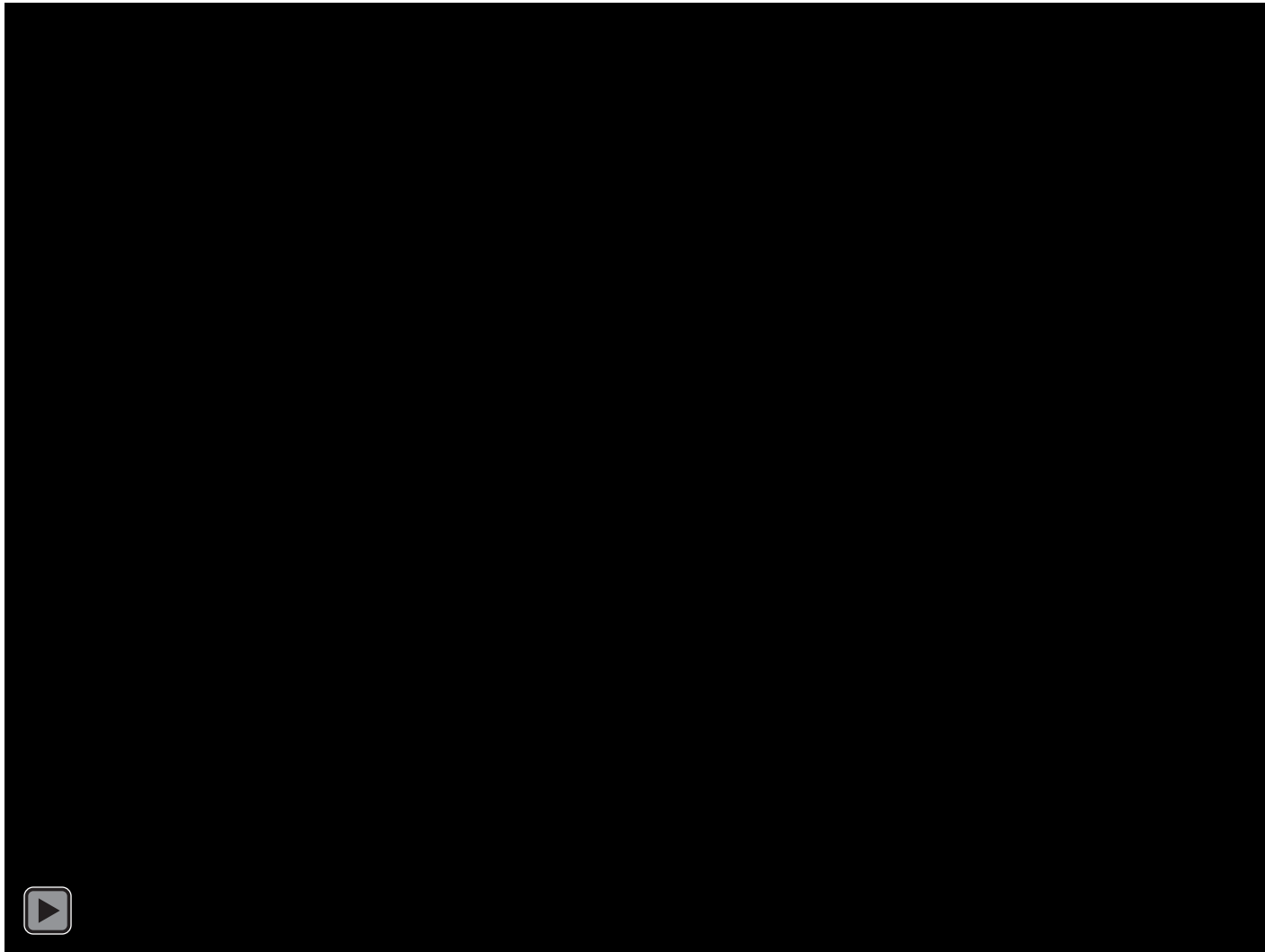


Gorce and Paragios (2010)

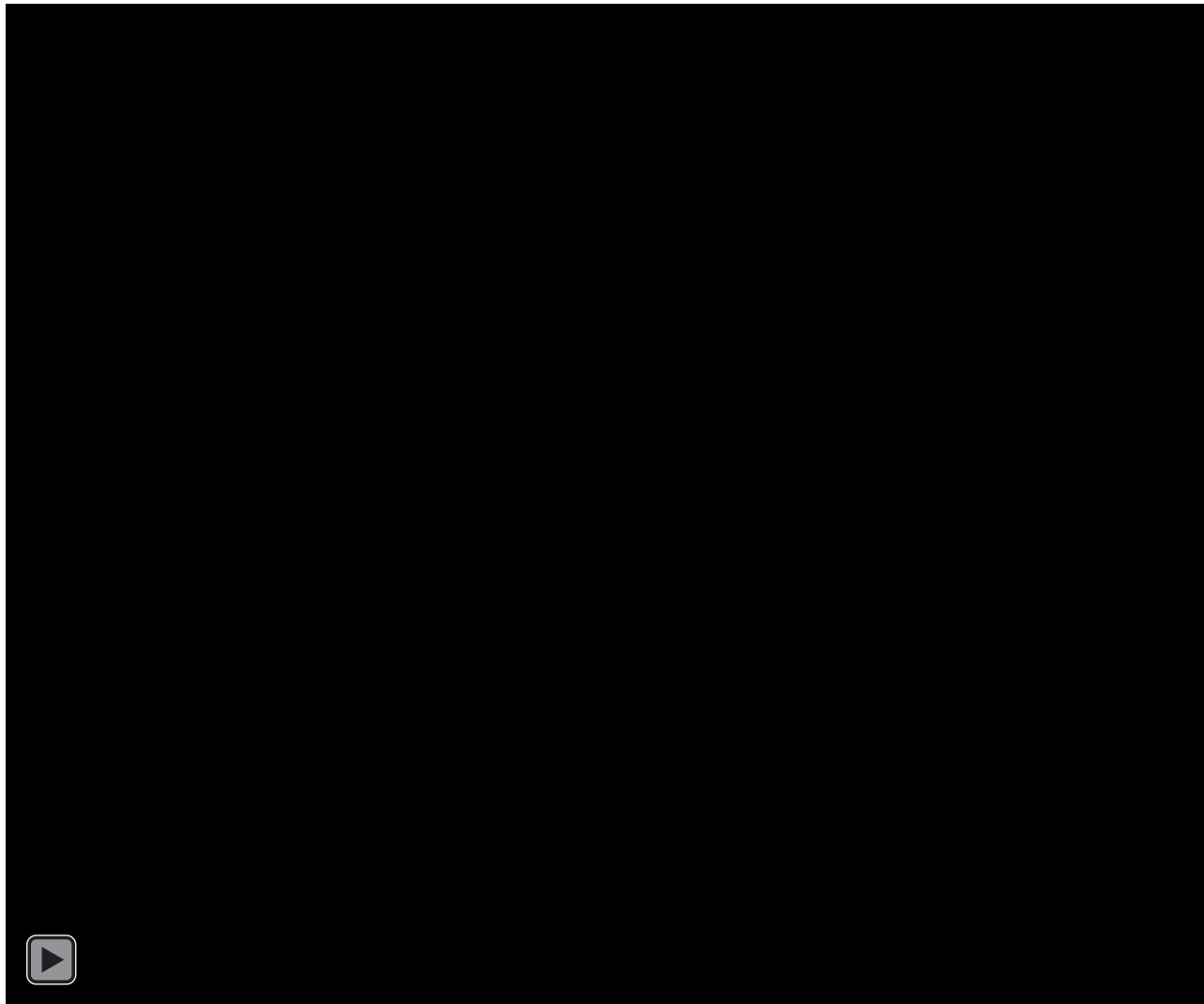


Morshidi and Tjahjadi (2012)

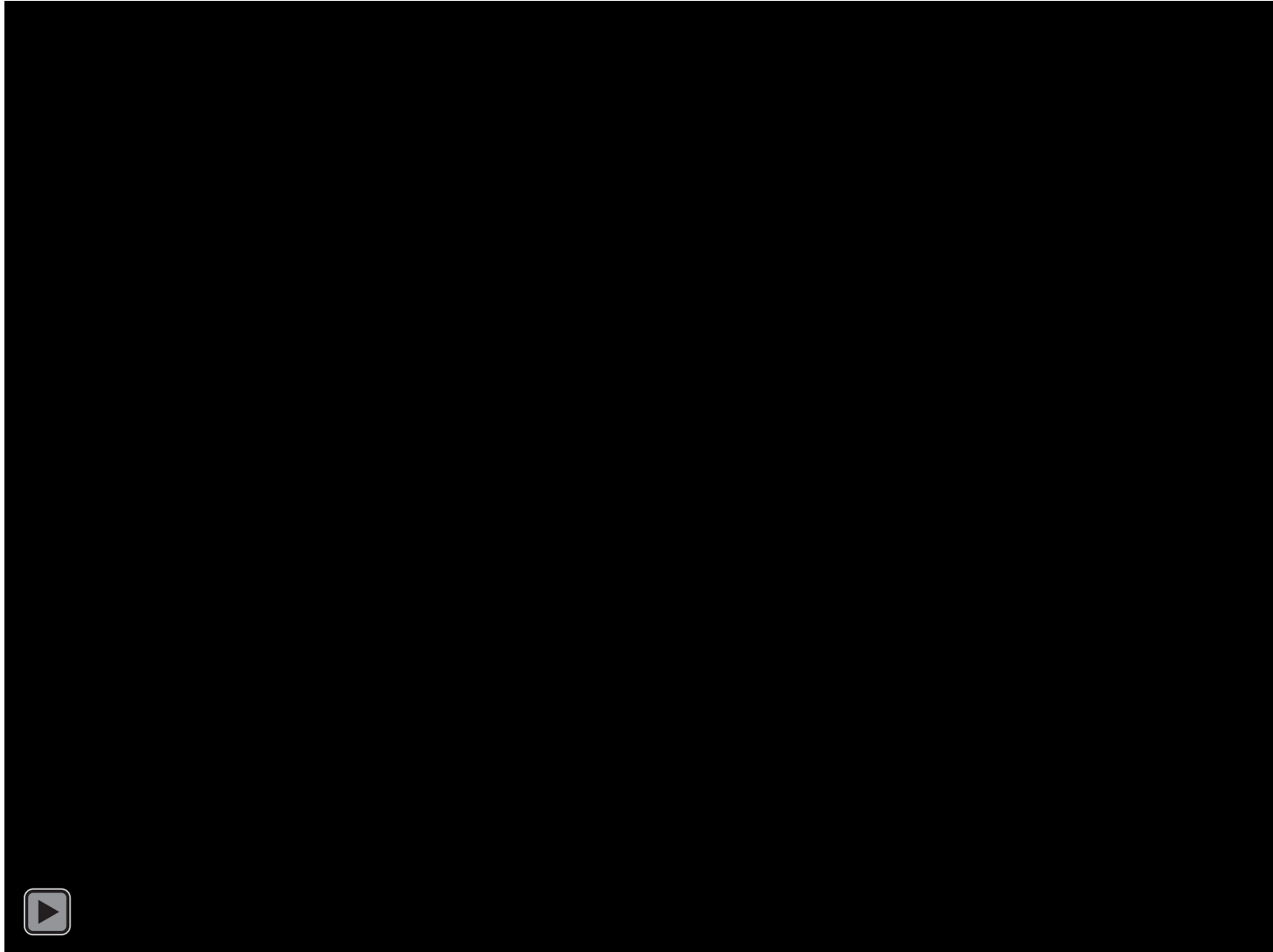
Model based Hand Tracking: 2D Video



Model based Hand Tracking: Point Cloud Data



Model based Hand Tracking: with an Object



손 추적 Algorithm: Model 기반(2/2)

- 제품을 파지한 자세를 분석하기 위해서는 **다방면에서 촬영한 3차원 형상 필요**
- **빠른 조작 상황에 대한 분석**은 높은 computing power를 요구함

Hand poses without a product



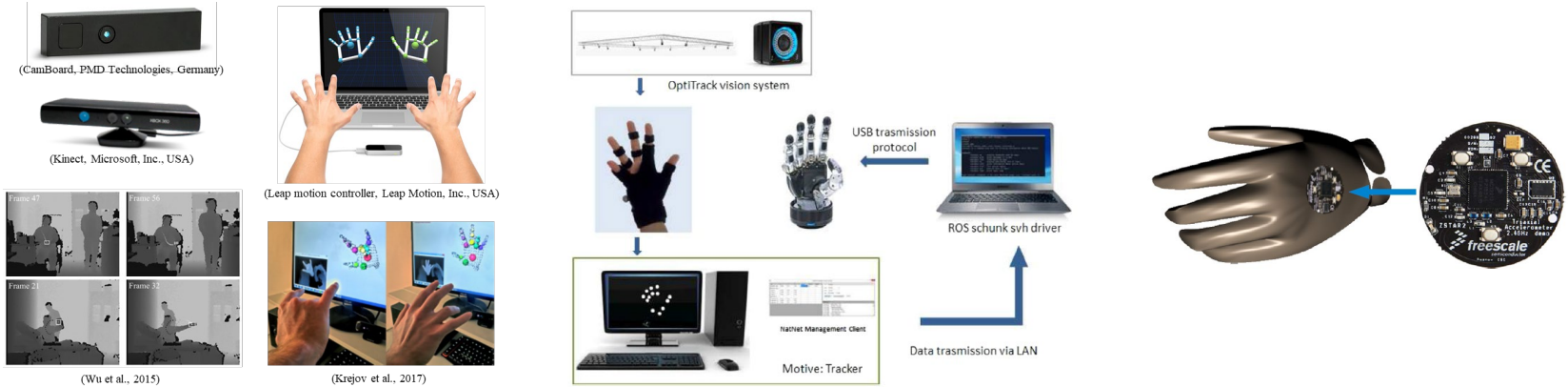
Hand poses with a product



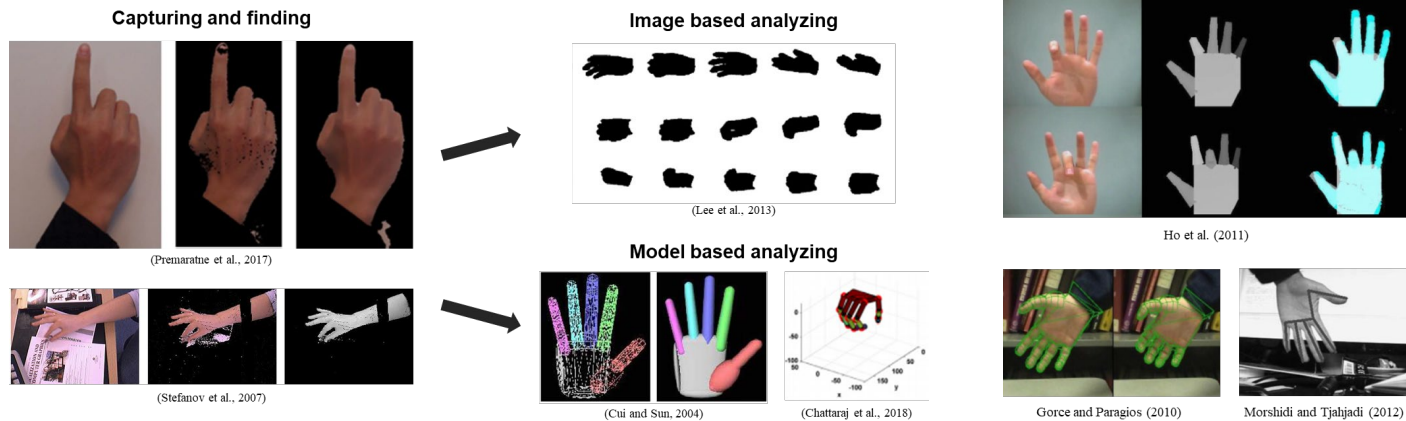
토의(1/3)

손 추적 기술에 대한 기술 현황 파악

활용 가능한 측정 장비

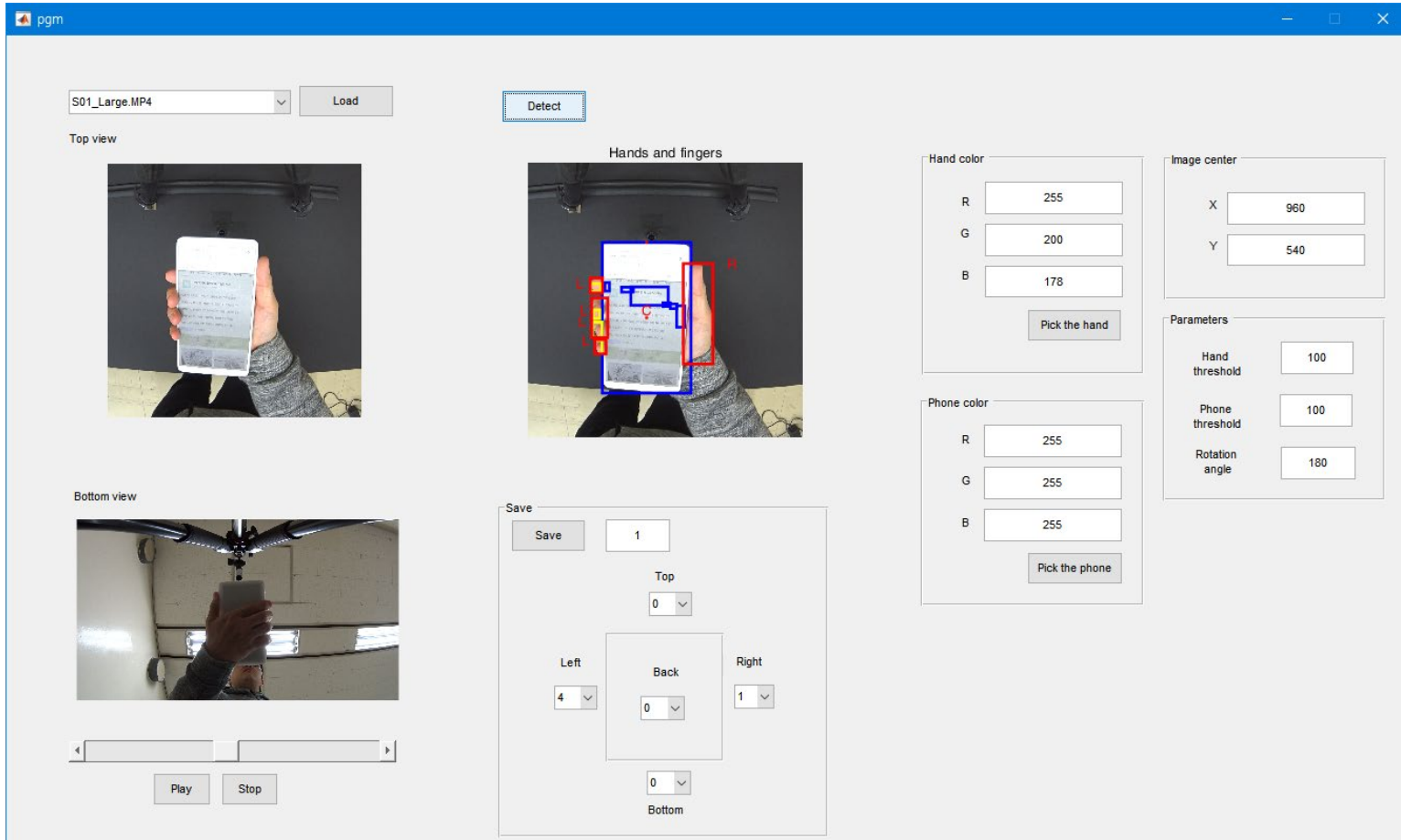


손 추적 algorithm



토의(2/3)

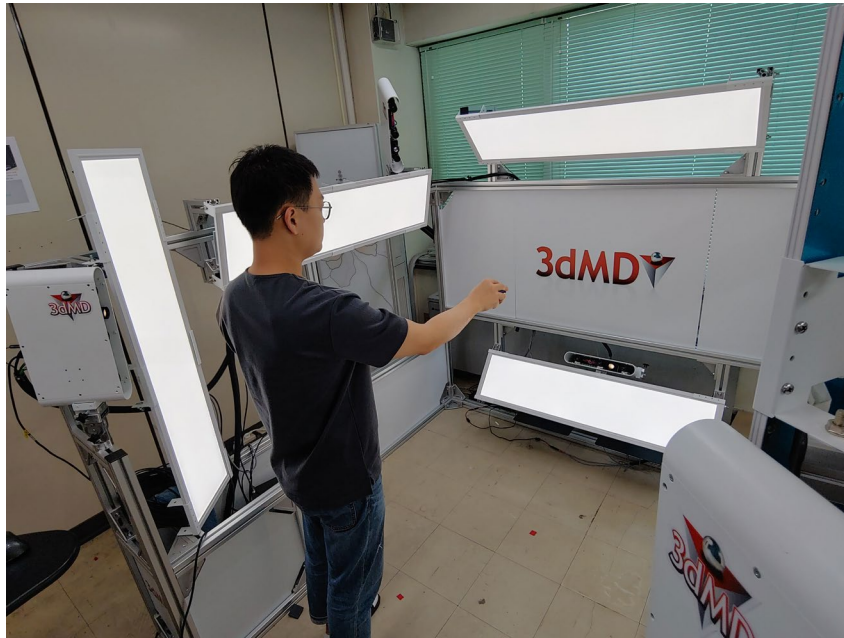
- Image 기반 hand tracking 알고리즘을 적용해보았으나 **제품에 의해 손이 가리는 경우 분석에 어려움이 있음**



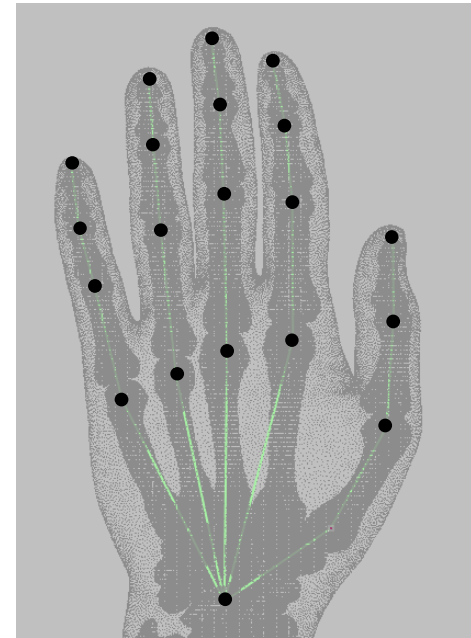
□ 제품 파지 시의 손 자세를 파악하기 위해서는 기술 보완이 필요할 것으로 사료됨

- **Dynamic 3D scanner 활용**
- **Model 기반 hand tracking algorithm을 적용**

Dynamic 3D scanner 활용 예



Hand model 개발 예



Thank you
for your attention!

