# Evaluating Human Hand Pose

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Project Progress Presentation

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# Overview

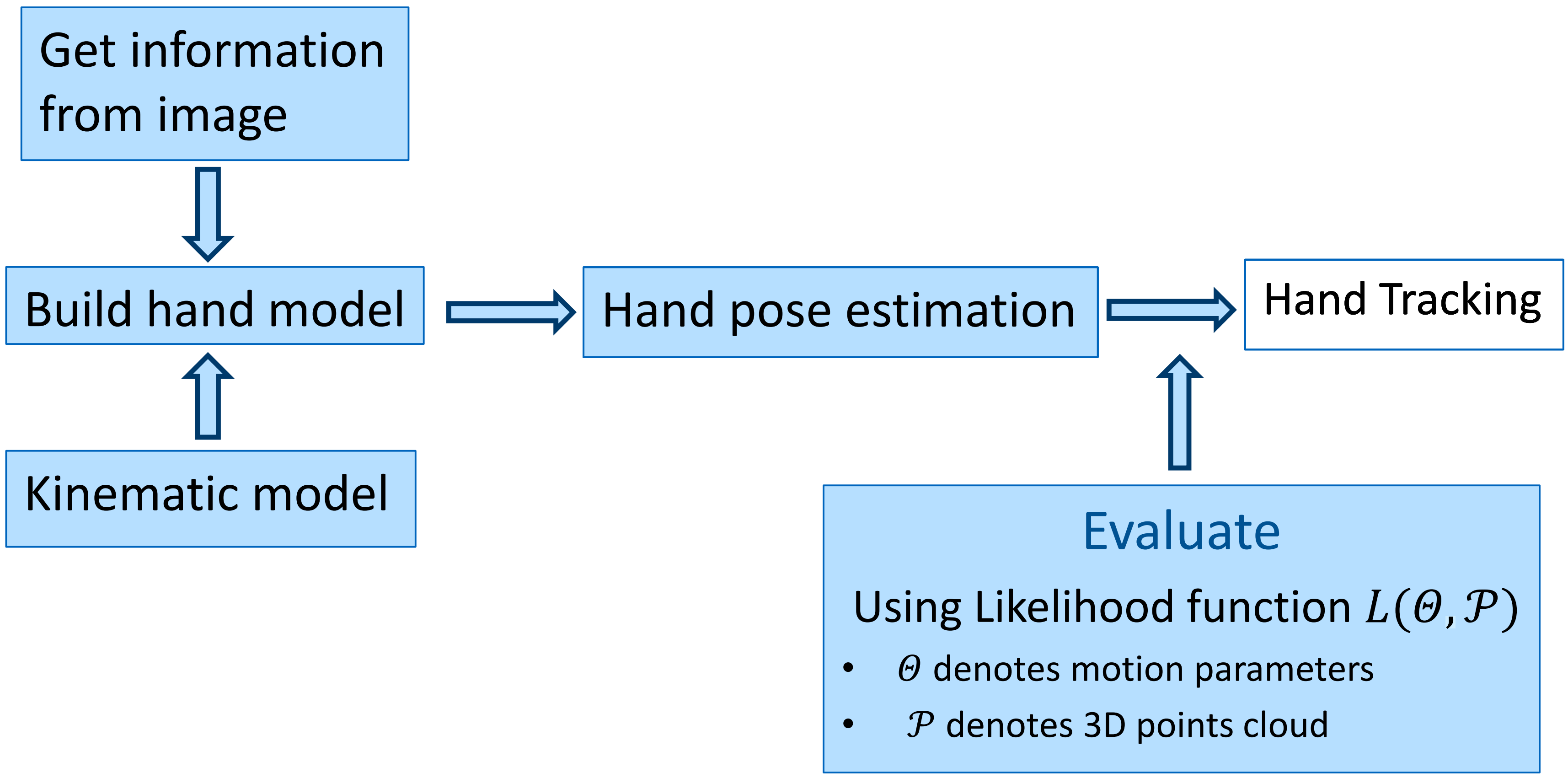
- Task introduction
- Project works
- Results and evaluations
- Future works

# Motivation

Hand Pose Estimation

➢ One of the most crucial parts in hand tracking technique

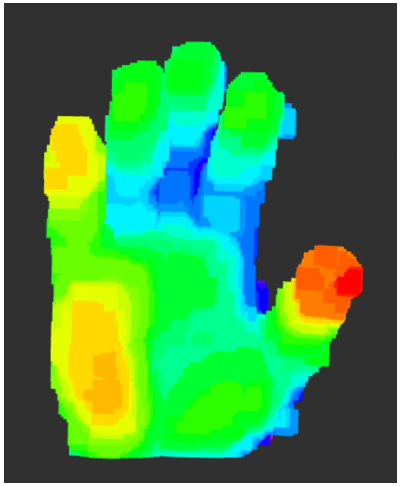
# Motivation

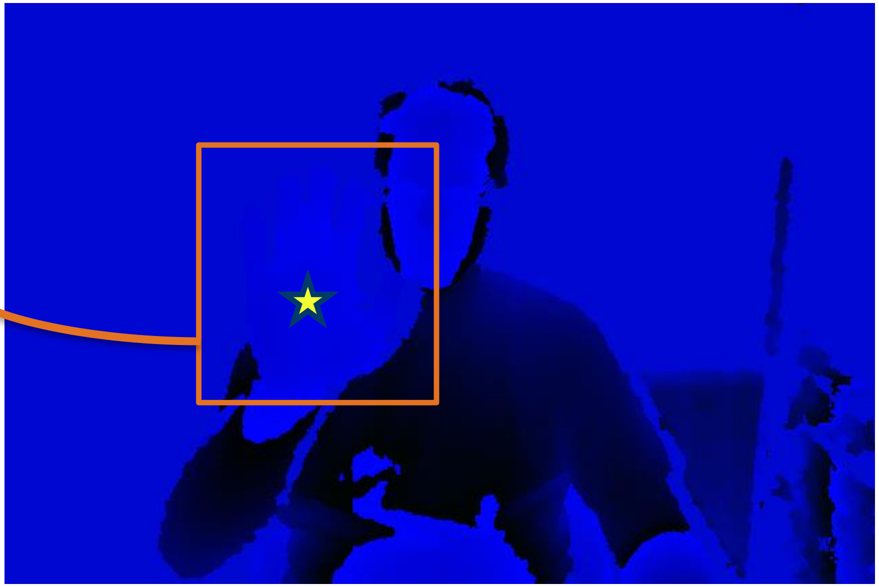

Get information from image
Build hand model
Kinematic model
Hand pose estimation
Hand Tracking
Evaluate
Using Likelihood function $L(\Theta, \mathcal{P})$
• $\Theta$ denotes motion parameters
• $\mathcal{P}$ denotes 3D points cloud

# Tasks

- Convert depth image into 3D points cloud
- Build Kinematic hand model
- Define sphere based likelihood function
- Evaluation

# Hand segmentation and data set conversion

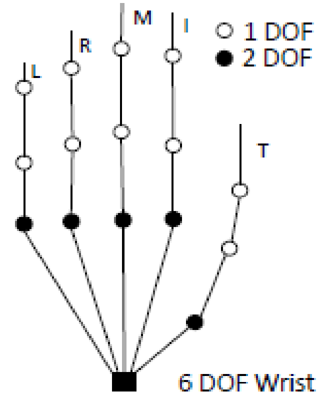




- Crop desired hand region from the depth image.
(Hand center and hand frame boundary are given)
- Convert depth image segmentation into 3D points cloud.

# Build hand model skeleton

**Hand model skeleton**

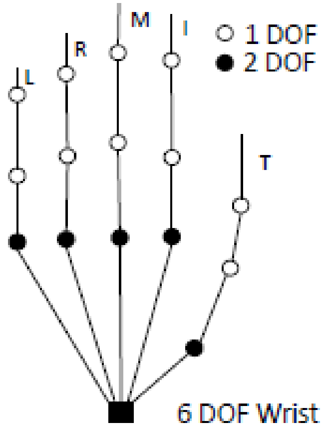



【Chen et al., CVPR14】

- Assume each finger as one chain
- Define chain pose using DH parameter

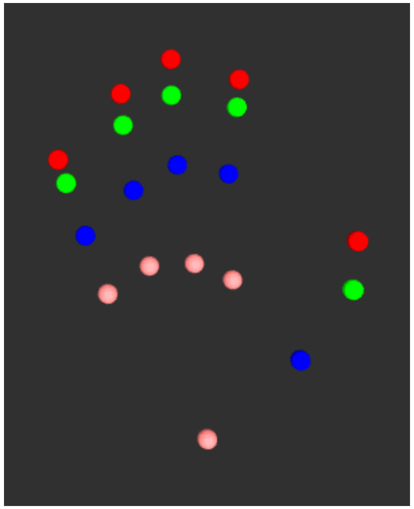
# Build hand model skeleton

**Hand model skeleton**




【Chen et al., CVPR14】

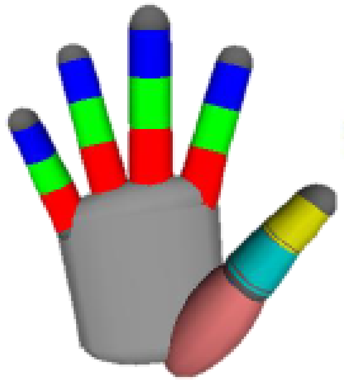
**Hand skeleton visualized in rviz**



- Define 26 degrees of freedom hand motion model
- Use 26 spheres
- Build forward kinematic hand model skeleton.

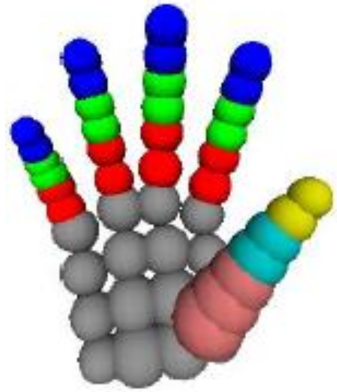
# Construction of sphere hand model

**Cylinder hand model**



【Chen et al., CVPR14】

**Sphere hand model**

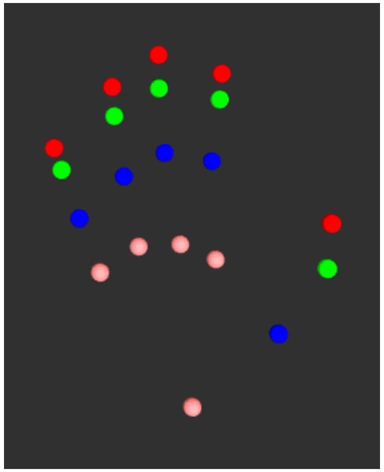


【Chen et al., CVPR14】

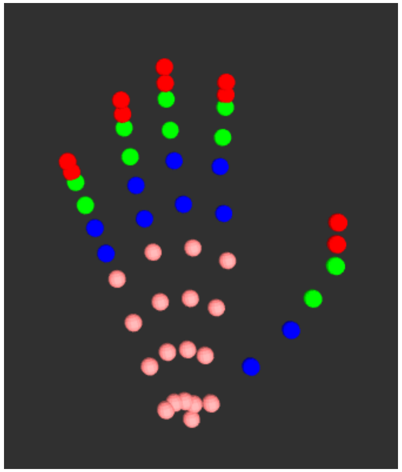
- Inspired by cylinder hand model, The sphere model is denoted as $\mathcal{M}(\Theta) = \{s_i\}_{i=1}^{48}$ , each sphere $s = \{c(\Theta), r\}$ has center $c(\Theta)$ and radius $r$ .
- The radius $r$ are different

# Construction of sphere hand model

**Hand skeleton visualized in rviz**



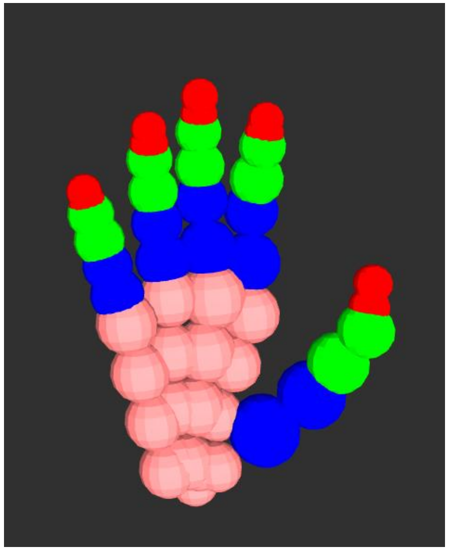
**Sphere hand model visualized in rviz**



Model the other 22 spheres into the skeleton.

# Adjustment of hand spheres

**Calibrated sphere hand model visualized in rviz**



Calibrate value of each sphere radius

# Definition of sphere based likelihood function

$$D(p, s) = abs(||p - c||_2 - r)$$ 【Chen et al., CVPR14】

- $D(\bullet)$ denotes the Euclidean distance from point p to its closest sphere surface
- $c$ is the sphere center and $r$ is the sphere radius.
- Define $D(\bullet)$ as one point cost value

# Definition of sphere based likelihood function

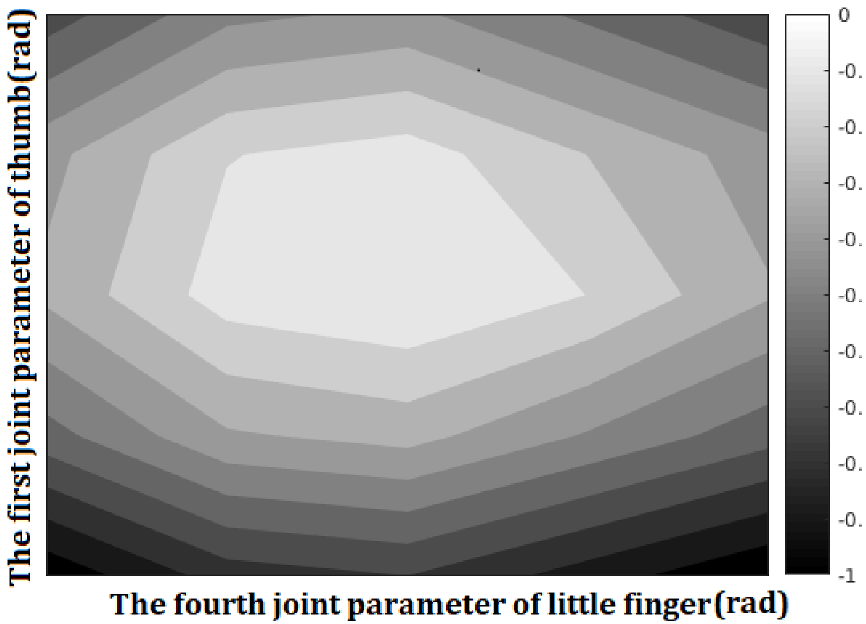
$$L(\Theta, \mathcal{P}) = \sum_{p \in sub(\mathcal{P})} D(p, s_{x(p)})^2$$ 【Chen et al., CVPR14】

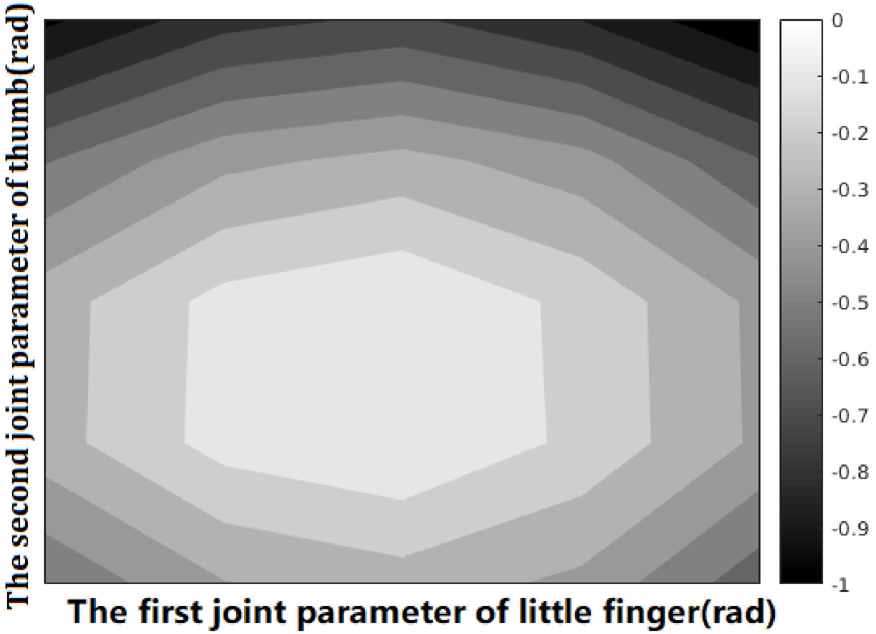
- Define $L(\bullet)$ as cost value function, $\Theta$ denotes motion parameters and $\mathcal{P}$ denotes 3D points cloud
- Cost value indicates the difference between hand pose estimation and the given hand pose from image.
- The minimal cost value indicates the optimal pose estimation which has largest likelihood

# Evaluation of the sphere hand model

- For further evaluation, vary the ground truth of two randomly dimension
- Vary the joint parameters in the range of $[-10^o,\ 10^o]$
- Vary the coordinate parameters in the range of [-0.4m, 0.4m]

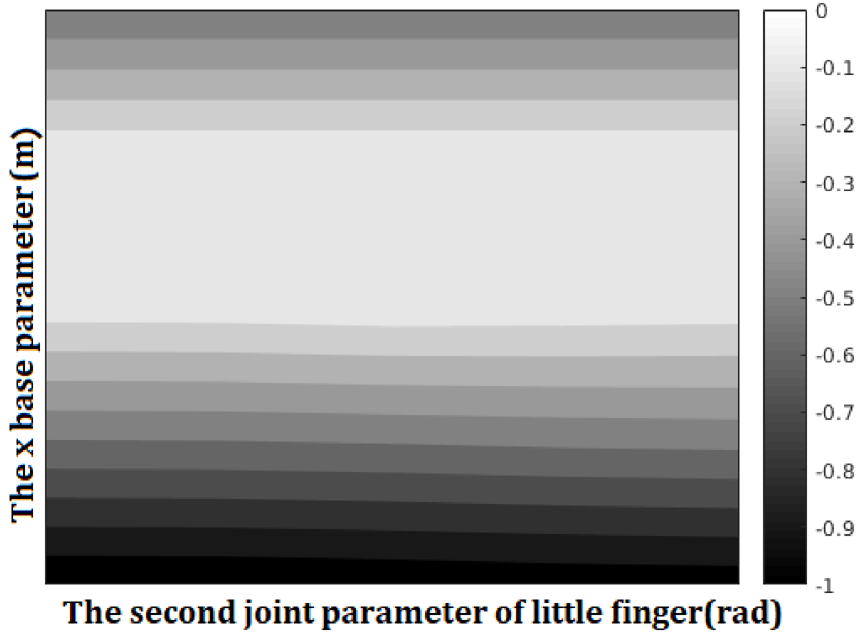
# Evaluation of the sphere hand model

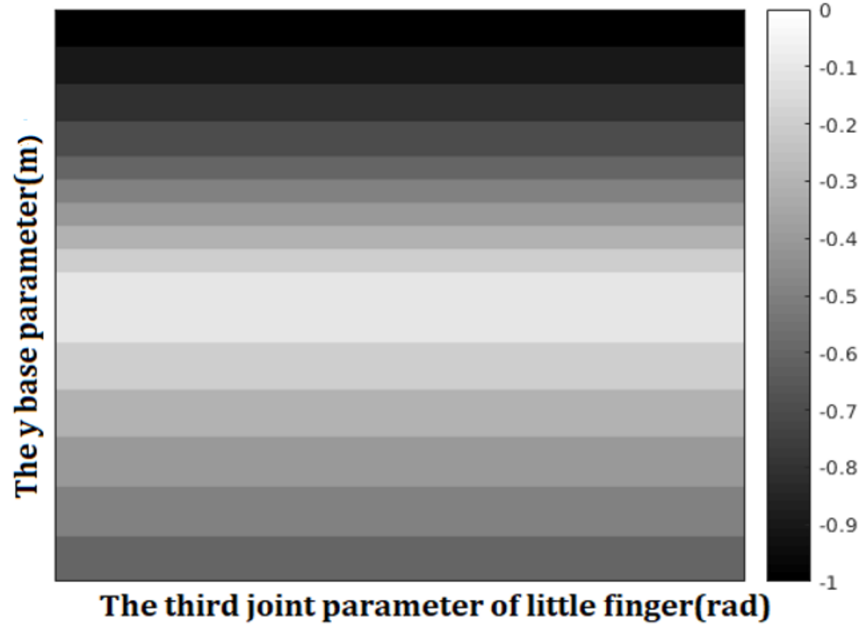



- The brightest region indicates the local minima of the cost function

# Evaluation of the sphere hand model




In all situations, cost value converge to the local minima at the ground truth

# Conclusion

- From the evaluation results, the sphere hand model is successfully implemented

- Sphere based cost function is successfully implemented to evaluate the hand model

# Future works

- There will be collisions in penetration of the two finger.
    - ➢ Additional penalization norms

# Reference


- QIAN, Chen, et al. Realtime and robust hand tracking from depth. In: *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*. 2014. S. 1106-1113.

- TOMPSON, Jonathan, et al. Real-time continuous pose recovery of human hands using convolutional networks. *ACM Transactions on Graphics (ToG)*, 2014, 33. Jg., Nr. 5, S. 169.