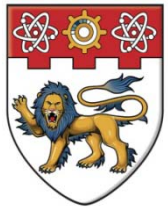

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Model-based Hand Tracking with the Kinect Sensor

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Supervisors:
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– *School of Electrical and Electronic Engineering.*
Prof. Daniel Thalmann
– *Institute for Media Innovation.*

Outline

- Introduction
- Related Work
- Objectives
- System Overview
- Future Work

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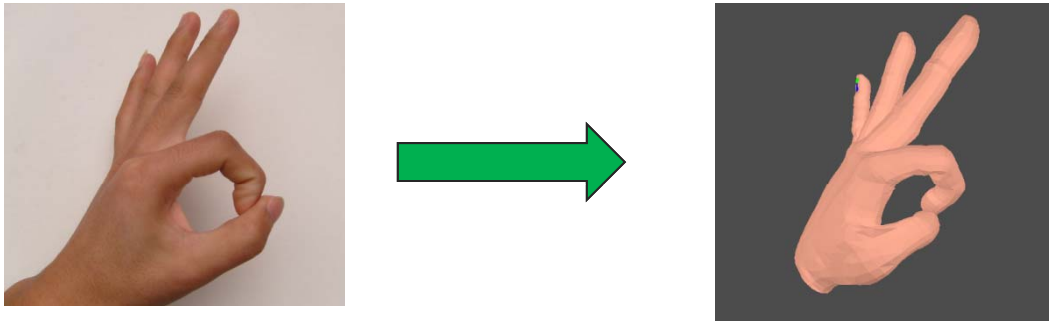
Introduction

- Restore 27 DOFs of hand motion from the input



- Applications
  - Human-Machine Interaction
  - Hand Gesture Recognition
  - Animation Synthesis

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Introduction

- Objectives
  - Speed
  - Accuracy

- Problem
  - High dimension space
  - Self-occlusion

Related Work – By Input

- Color Image Based Tracking [1] [2]
  - Chamfer distance, shape context, color likelihood
  - Limited accuracy
  - Require subsidiary techniques
- Depth Image Based Tracking [3] [4]
  - Robust
  - Restore more degrees of freedom
  - Hand segmentation needs to be refined

[1] Real-time hand tracking with a data glove, in SIGRAPH 2009 .

[2] Model-Based 3D Hand Pose Estimation from Monocular Video, in TPAMI 2011.

[3] Efficient model-based 3D tracking of hand articulations using Kinect, in BMVC 2011.

[4] A data-driven approach for real-time full body pose reconstruction from a depth camera, in ICCV 2011.

Related Work – By Methodology

- Template-Based Tracking [1] [5] [6]
  - Mapping from feature to pose
  - Quick and robust
  - Limited accuracy
- Model-Based Tracking [2] [3] [7] [8]
  - Enhanced accuracy
  - Slower
  - Sensitive to noisy data and fast motion

[5] Fast Pose Estimation with Parameter-Sensitive Hashing, in ICCV 2003.

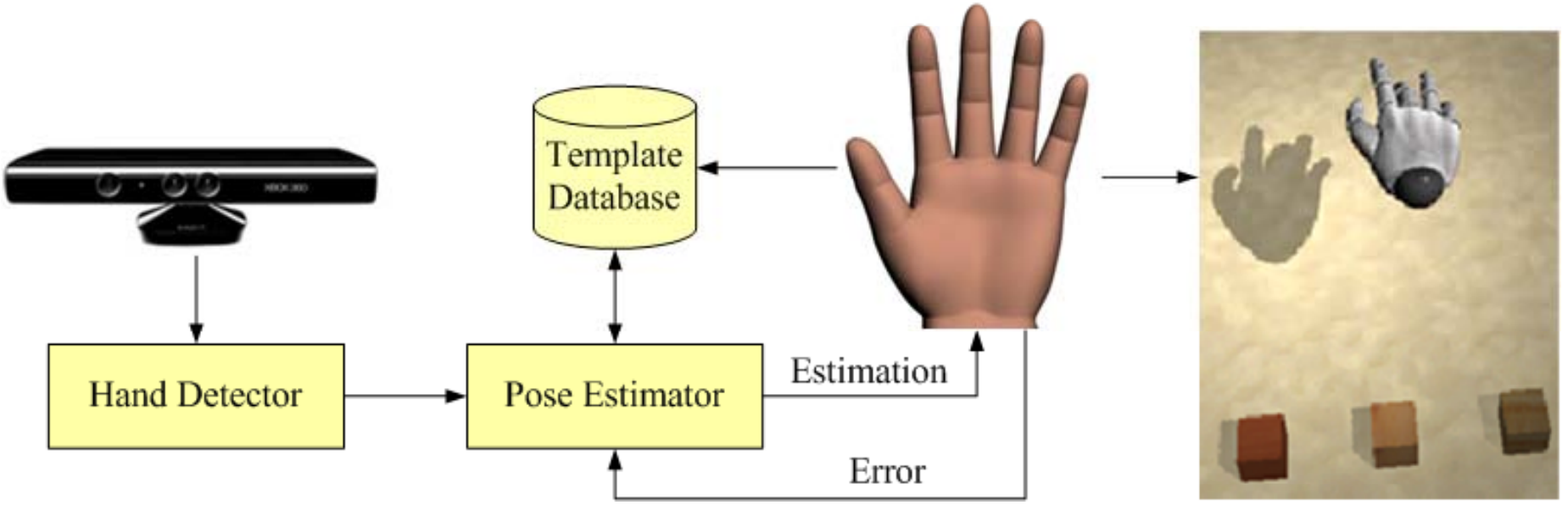
[6] Inferring Body Pose without Tracking Body Parts, in CVPR 2000.

[7] Model-Based Hand Tracking Using a Hierarchical Bayesian Filter, in TPAMI 2006.

[8] Model Based Hand Tracking by Chamfer Distance and Adaptive Color Learning Using Particle Filter, in EURASIP Journal on Image and Video Processing 2009.

Objectives

- Object manipulation task recognition
- Modeling of object manipulation in a Virtual Environment



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System Overview

- 3D hand model
- Hand detector
- Pose estimator

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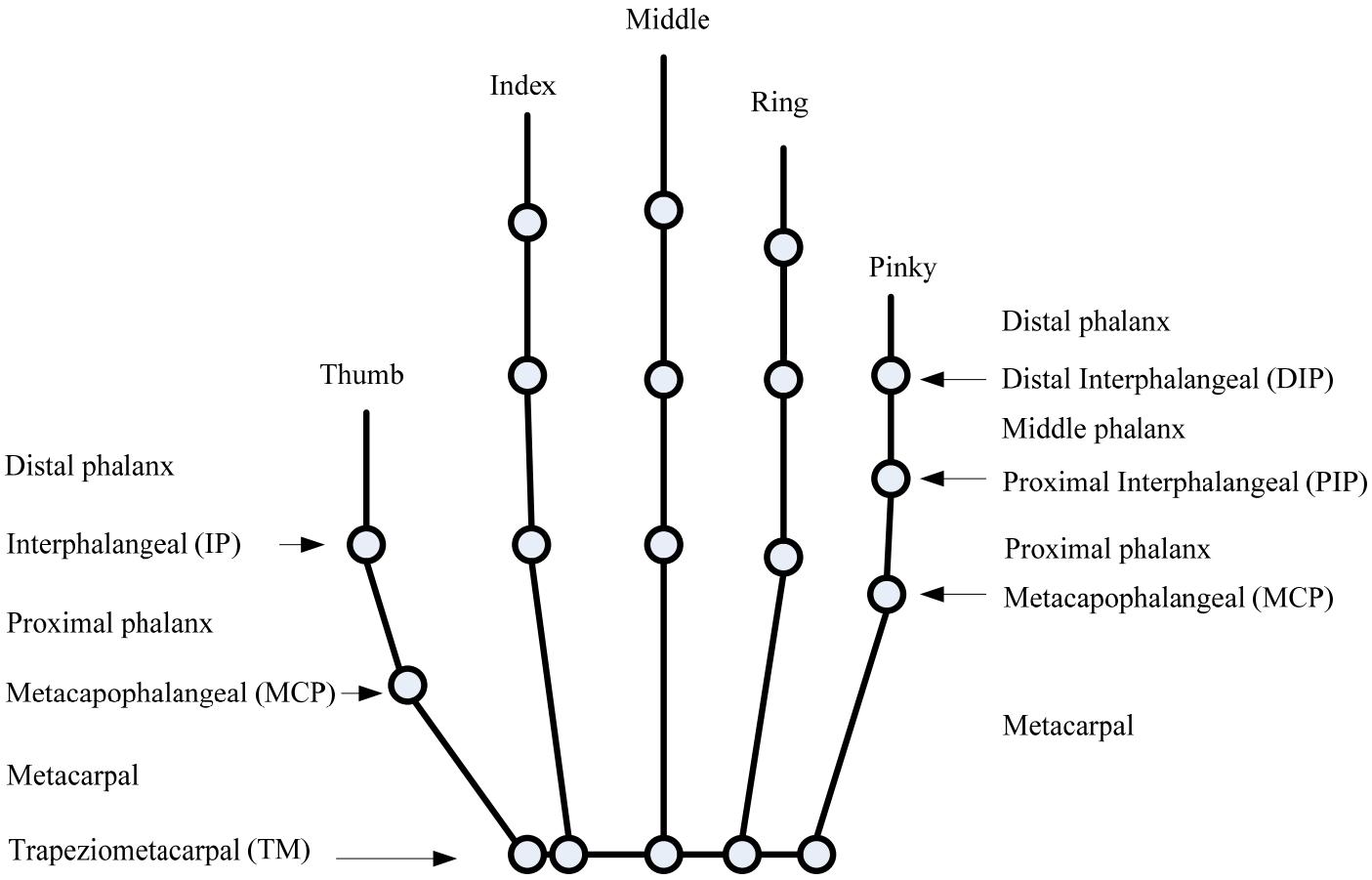
3D Hand Model



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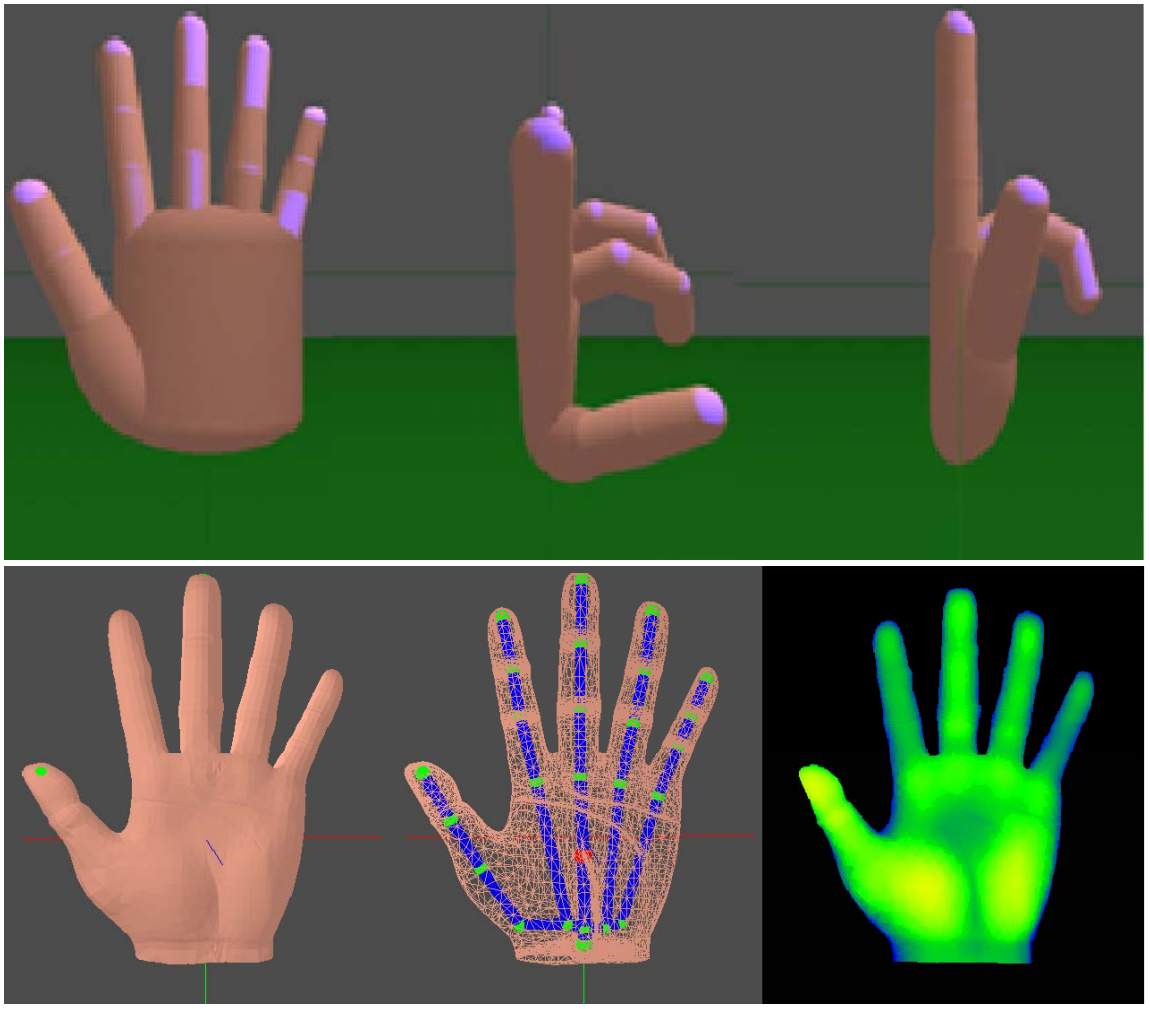
3D Hand Model



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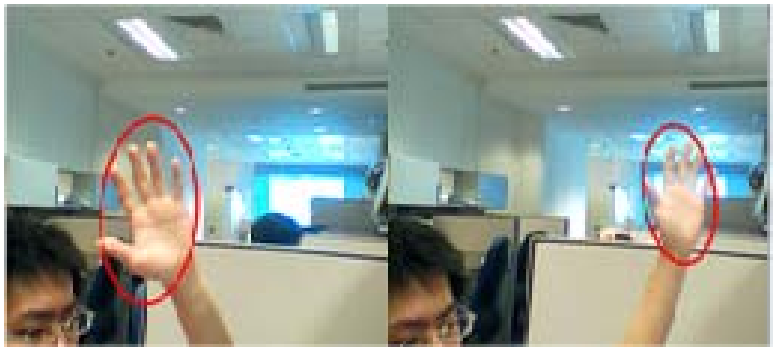
Hand Detector – Color based

RGB

HSV

YCbCr



MeanShift

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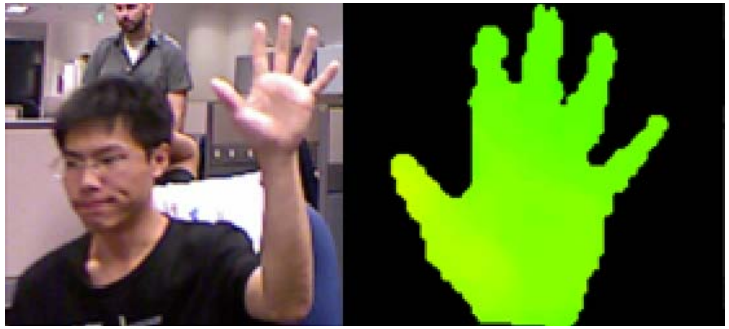
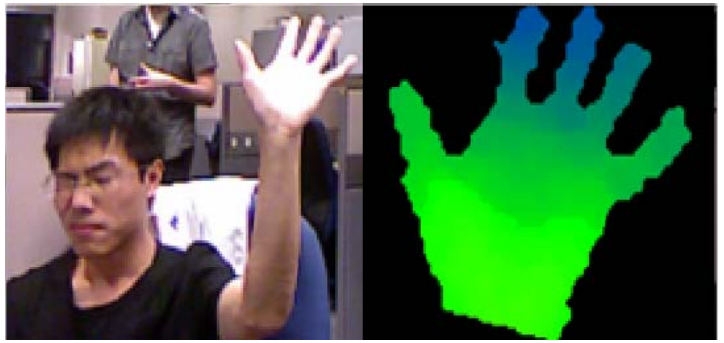
Hand Detector – Depth based



(1)

(2)

(3)



(4)

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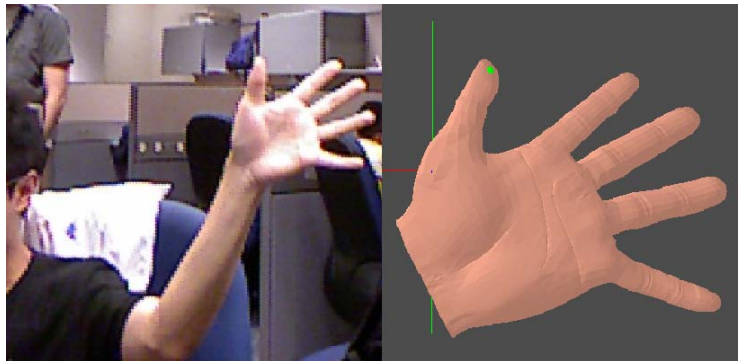
Pose Estimation

- Global Motion
  - 3D Global Translation and Rotation
  - Basis for local hand pose estimation
- Local Hand Pose
  - 15 Degrees of Freedom
  - Objective Function Minimization
  - Initial Estimation
  - Local Optimization

Global Rotation

(1)



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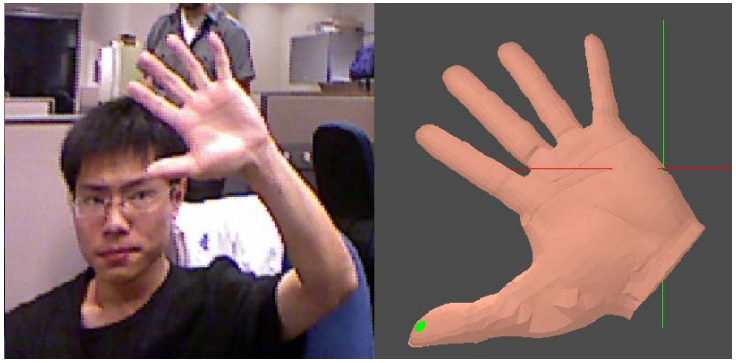

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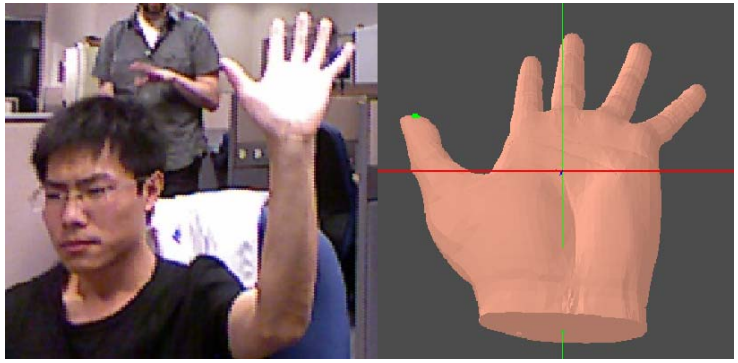

(4)

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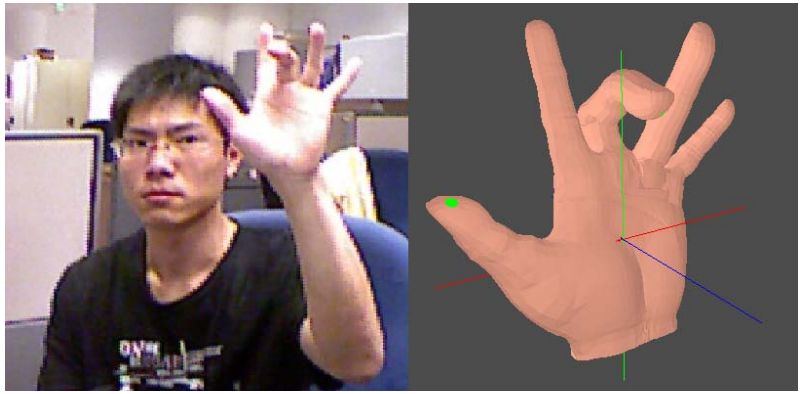
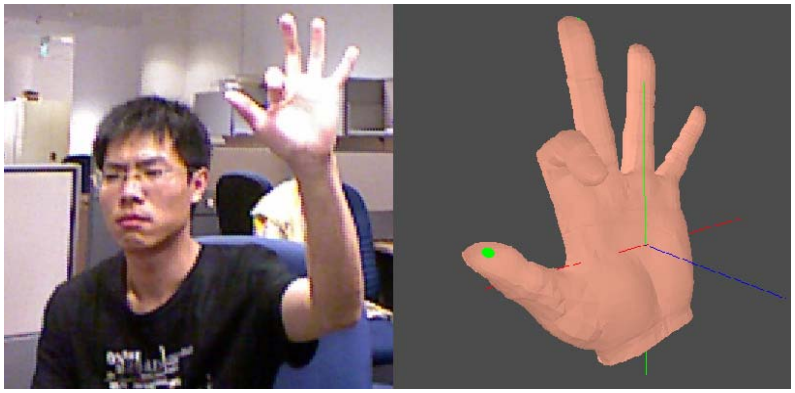
Local Motion – Initial Estimation



(1)



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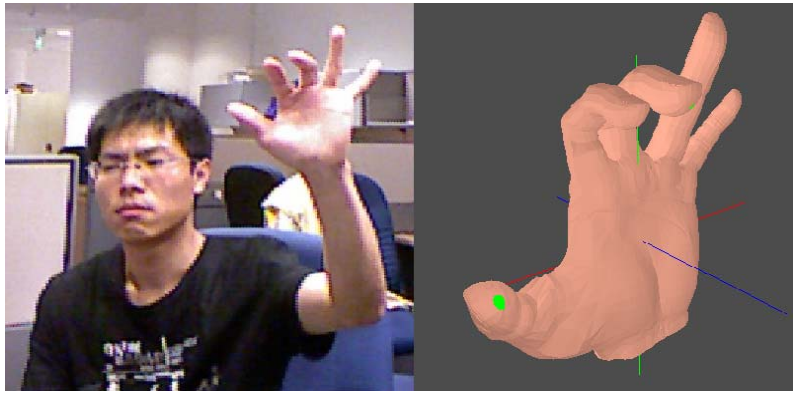

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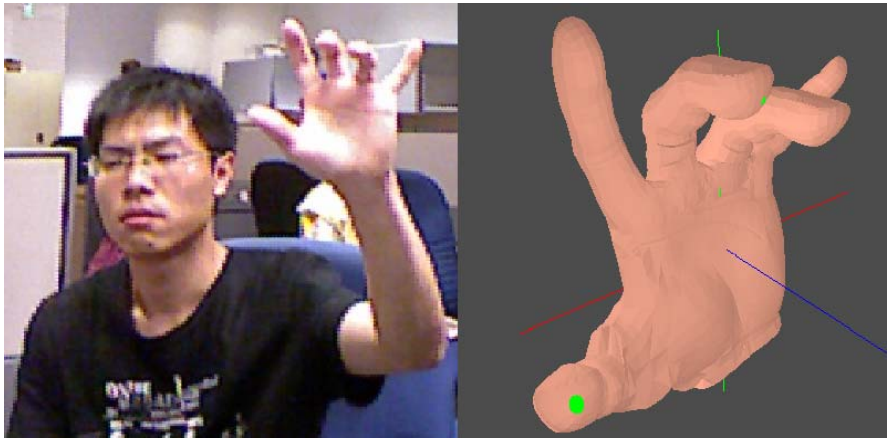
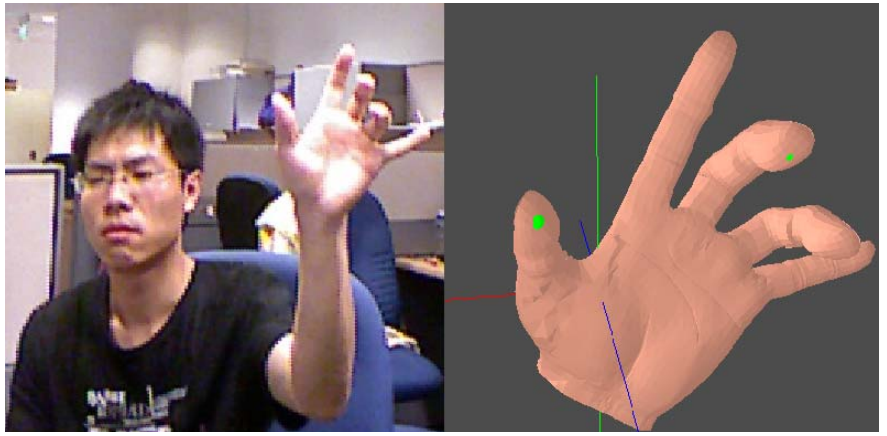
Local Motion – Initial Estimation



(5)



(6)

Local Motion – Local Optimization

- Objective Function
  - Silhouette
  - Depth

$$f_C(\theta) = \lambda \frac{|A_I - A_H|}{\max(A_H, A_I)} + (1-\lambda)\frac{1}{z_M A_O} \sum_{z_n, z_h \in A_O} \min(|z_n - z_h|, z_M)$$

- Optimization Methods
  - Nelder-Mead Simplex
  - Genetic Algorithm

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Local Motion – Local Optimization

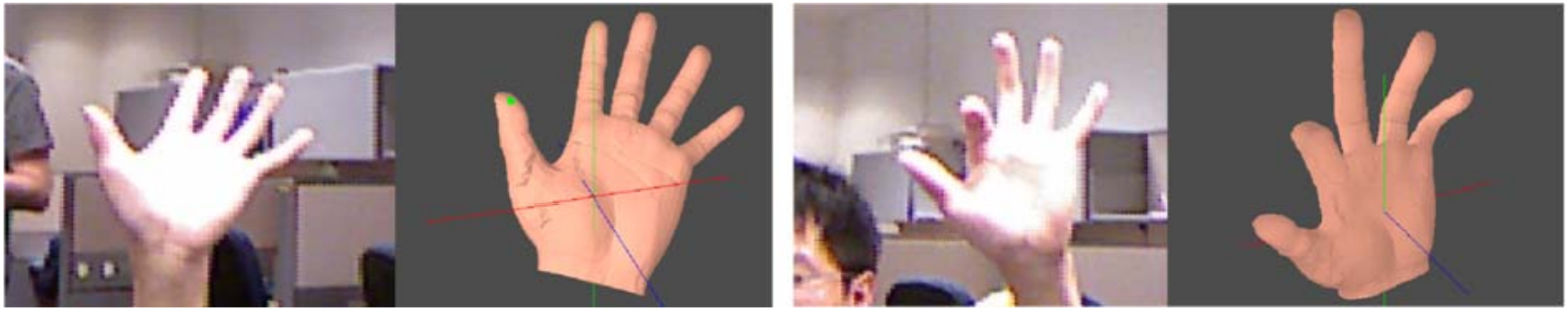
- Some Previous Results
  - Optimization using Silhouette difference
  - Simplex Search and Genetic Algorithm

Nelder-Mead Simplex

Genetic Algorithm

Local Motion – Local Optimization

- Some Preliminary Results
  - Simplex Search
  - Silhouette and Depth



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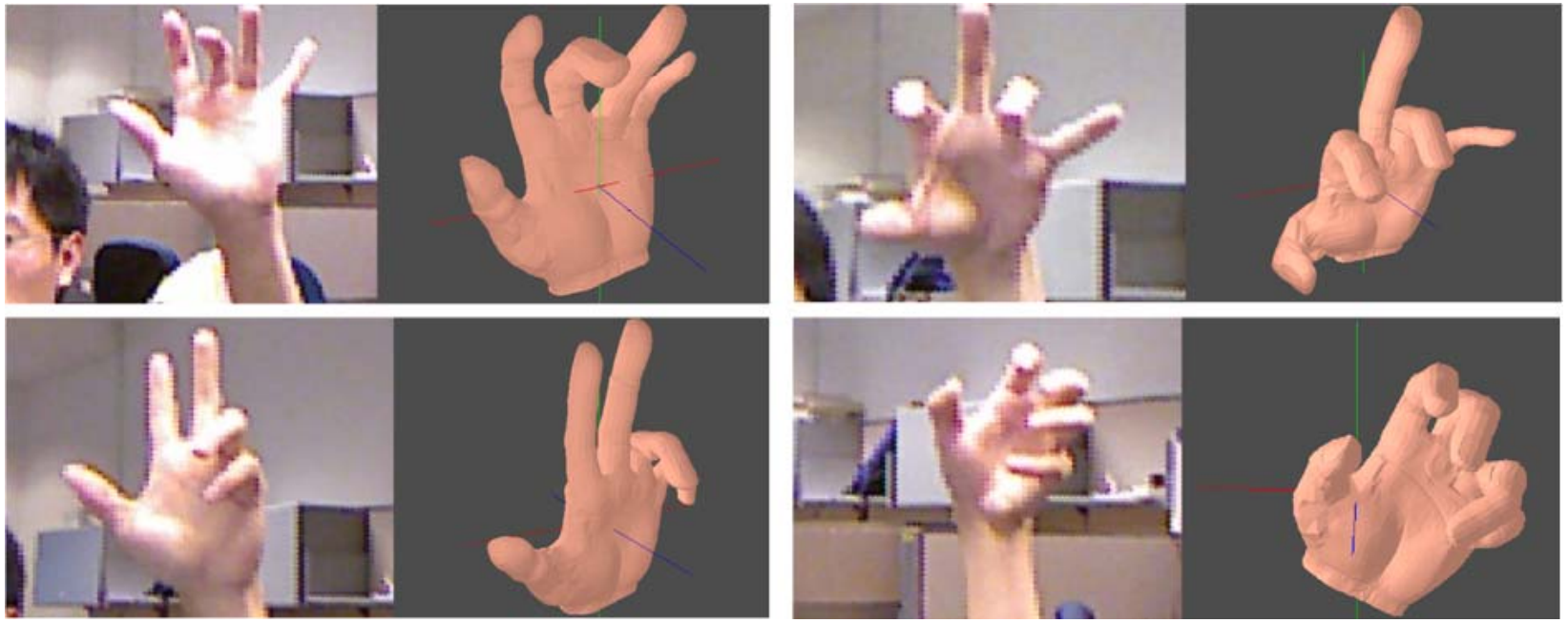
Local Motion – Local Optimization



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Future Work

- Dimension reduction
- Particle filter
- Extended to multi-cameras

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Thank You!