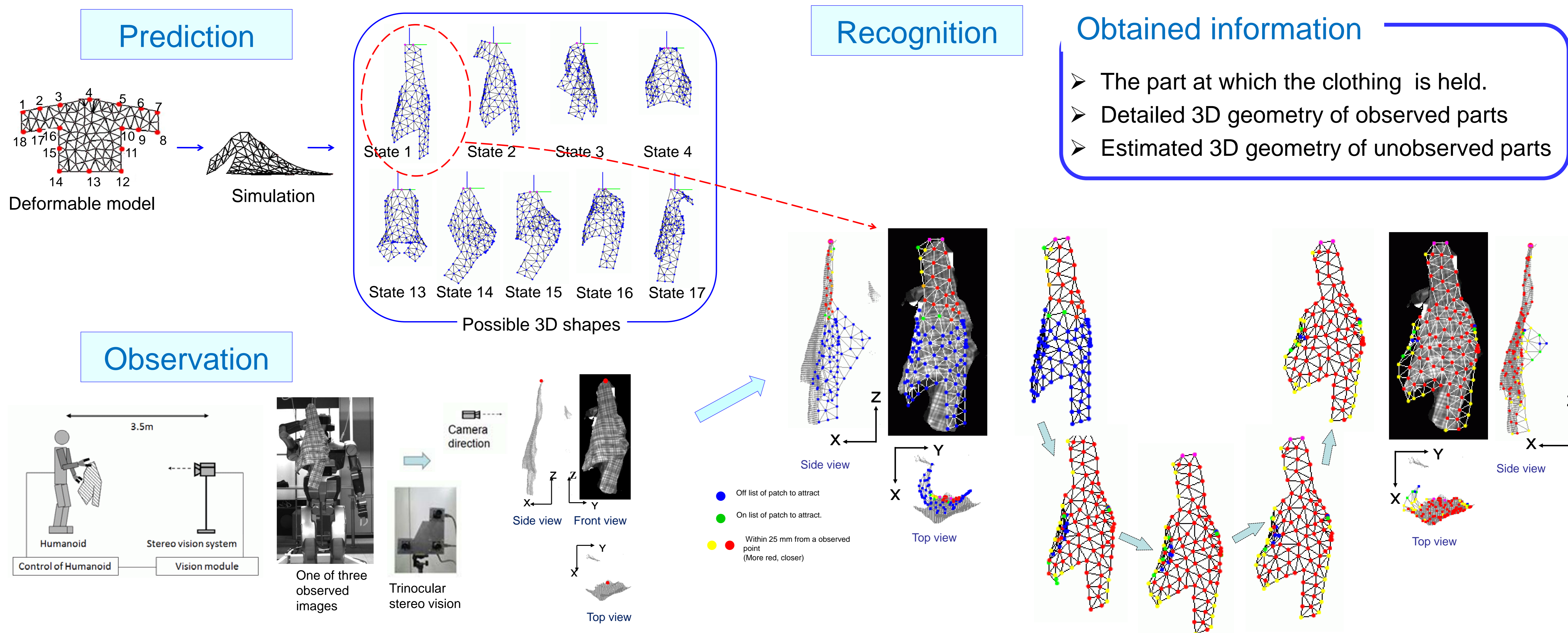# Deformable-model driven visual recognition for handling clothes by humanoid robots
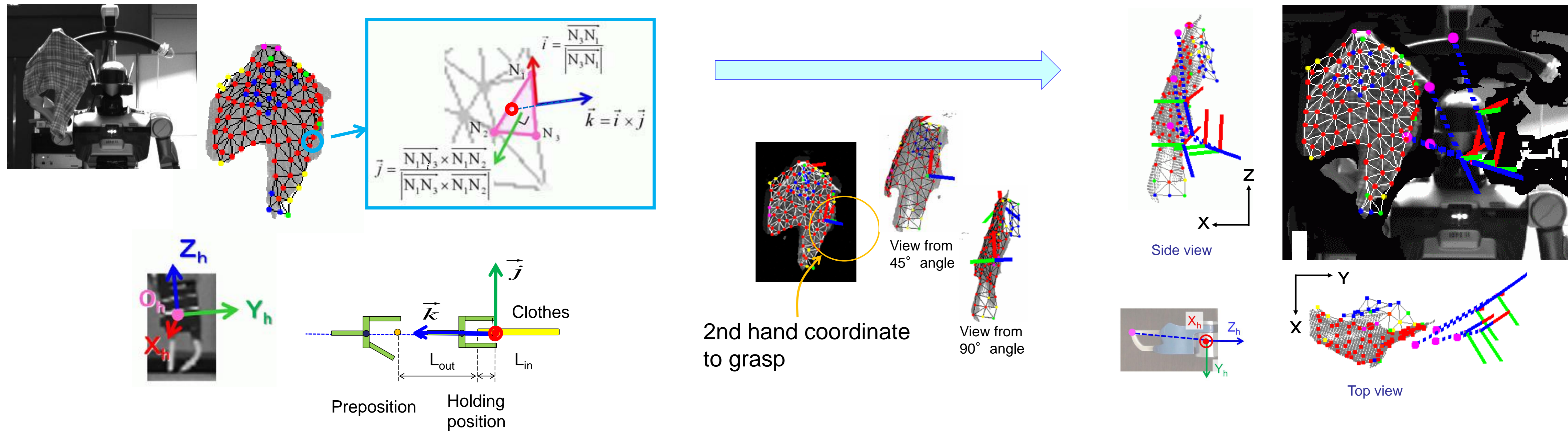
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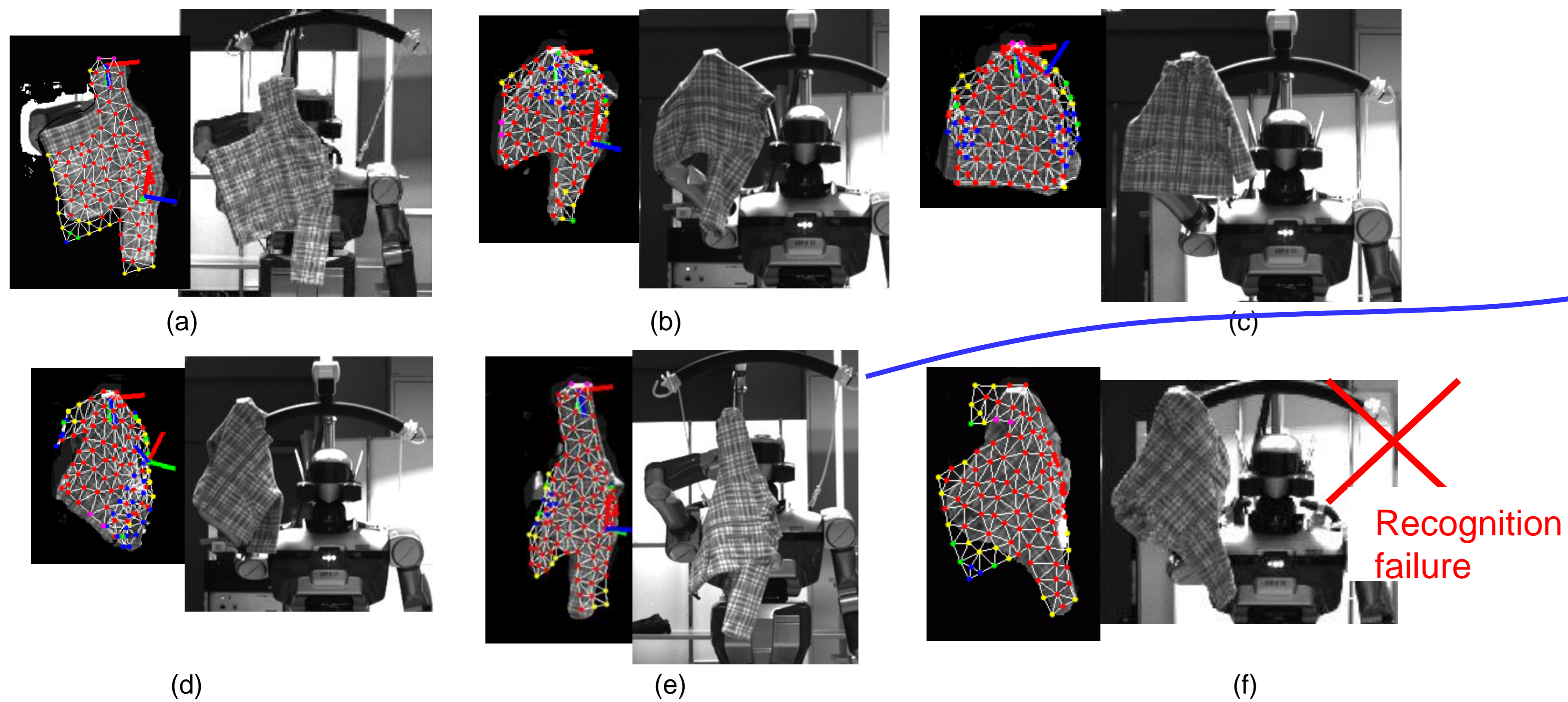National Institute of Advanced Industrial Science and Technology (AIST)

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1. Recognition of clothing states using deformable clothing models

Prediction

1 2 3 4 5 6 7
18 17 16 10 9 8
15 11
14 13 12

Deformable model → Simulation →

State 1　State 2　State 3　State 4

State 13　State 14　State 15　State 16　State 17

Possible 3D shapes

Recognition

Obtained information

➢ The part at which the clothing is held.
➢ Detailed 3D geometry of observed parts
➢ Estimated 3D geometry of unobserved parts

Observation

3.5m

Humanoid　　　Stereo vision system

Control of Humanoid → Vision module

One of three observed images

Trinocular stereo vision

Camera direction

Side view　Front view

Top view

Side view

Top view

● Off list of patch to attract.
● On list of patch to attract.
● ● Within 25 mm from a observed point (More red, closer)

Side view

Top view

2. Derivation of actions for handling a specific part of the clothes

$$\vec{i} = \frac{\overrightarrow{N_3 N_1}}{|\overrightarrow{N_3 N_1}|}$$

$$\vec{k} = \vec{i} \times \vec{j}$$

$$\vec{j} = \frac{\overrightarrow{N_1 N_3} \times \overrightarrow{N_1 N_2}}{|\overrightarrow{N_1 N_3} \times \overrightarrow{N_1 N_2}|}$$

N_1 N_2 N_3

Z_h O_h Y_h X_h

$\vec{j}$ $\vec{k}$ Clothes

L_{out} L_{in}

Preposition Holding position

2nd hand coordinate to grasp

View from 45° angle

View from 90° angle

Side view

Top view

Z X

X Y

X_h Z_h Y_h

3. Experimental results using HRP2

Grasping action carried out for (e)

(a)

(b)

(c)

(d)

(e)

(f)

Recognition failure