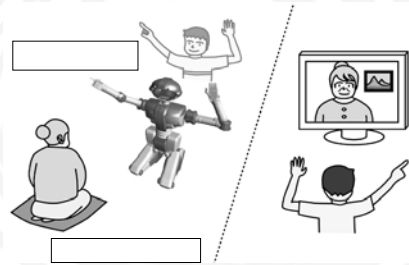


Recognition of In-Hand Manipulation along with Rolling Contact using Orbital Motion of Contact Points on Object Surface

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Support by robots at ubiquitous network society



Communication and remote medical care through humanoid

Purpose of research

Dexterous manipulation by multi-fingered robot hand

- Intuitive input method by human hand motion
- Precise reproduction of manipulation by multi-fingered robot hand



Execution of simple tasks by the NAIST-hand

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In-hand manipulation

Change in object position/orientation by using only finger movement

Example: grasping of tools which has two or more functions

Nail hammer



Mobile phone



Target Task:

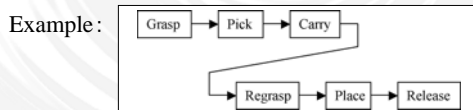
In-hand manipulation of an object using only one hand

Manipulation recognition

- Problem in the tele-operation of in-hand manipulation
There is a structural difference between the operator's and the robot's hands.
The difference have to be interpolated.

Common solution

Recognition of manipulation as primitives



□ Primitives of manipulation (abstract expression) ⁵

Conventional recognition method

Information used by recognition

- Joint angle (data glove)
- Fingertip force (FSR)
- Position / orientation of hand / object (camera)



Problem of these methods

Difficulty obtaining contact state on object surface

↓
Difficulty finding binding state of object

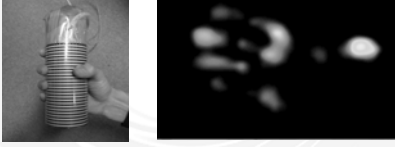
These methods only recognize simple tasks using easy information

(Pick and place / peg in hole) ⁶

Approach of this research

Manipulation recognition using contact information on an object

Contact information is obtained by attaching a sensor directly

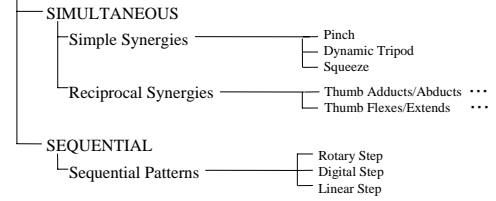


- Classification of in-hand manipulation using Elliott taxonomy
- Recognition of manipulation with rolling contact using orbital motion of contact points

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In-hand manipulation taxonomy by Elliott

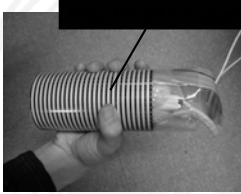
In-hand manipulation



Manipulations are classified into these categories

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Measurement of contact information on object



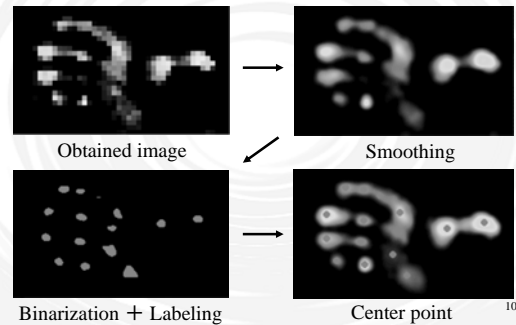
- Cylinder made from acrylic
Diameter 7cm Length 13cm
- Pressure distribution sensor
Nitta BIGMAT quarter
Spatial resolution 5 × 5mm
Measurement range 2~20KPa

- Constrained condition
 - The cylindrical form of the manipulated object is fixed
 - The hand gets contact only with the lateral side of the cylinder

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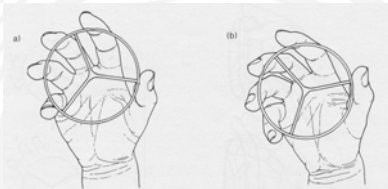
Pressure distribution image

Center point for each contact is obtained by calculating local maximum



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Recognition of manipulation with rolling contact by fingertips



(Elliott et al. 1984)

Rolling contact caused by finger motion makes slight change of contact point

Manipulation is recognized by orbital motion of contact point

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Orbital motion of contact point

Orbital motion is drawn by calculating the distance between the current and the previous image



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Detection of grasping direction

Grasping class changes according to the grasping direction
These classes are distinguished.



Prismatic Grasp

Circular Grasp

Grasping direction is recognized by the scale of a polygon made from all contact points

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Three manipulation primitives



Full Roll

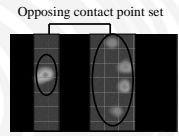


Rock



Pinch

Example: Rock

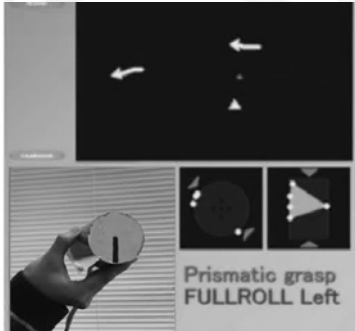


Prismatic Grasp



Circular Grasp₄

Recognition experiment



Characteristics of manipulation are obtained using contact information on object surface

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Conclusion

- We proposed a recognition method using contact information on object surface
- In-hand manipulation with rolling contact is recognized using orbital motion

Future works

- Recognition experiment conducted by plural subjects and evaluation of recognition rate
- Recognition of manipulation with finger gaiting on object

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