

Gesture Interface

A Naive Framework

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Table of Contents

1. Introduction
2. Inverse Kinematics
3. Learning Methods

Introduction

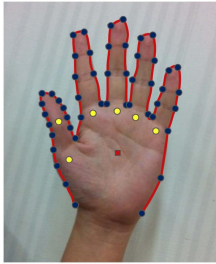


Figure 1: Example of Hand Gesture.

Color Based Method

The above picture is an example of color based gesture recognition. Color based algorithms are normally heavily relying on background color.

Spatial Motions

Swipe, tracking, clapping...

Finger Motions

Grabbing, rub, pointing and etc.

Muscles and Other Biosignals

All Involves hardwares.

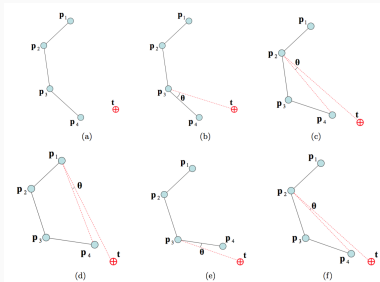
Note

Naive camera based gestures are used.

Inverse Kinematics

- Cyclic Coordinate Descent
- Jacobian Transpose
- FABRIK
- Neural Network

Cyclic Coordinate Descent



Basic Idea

- Greedy
- Iterative
- Does not care whether the target is within range

Why

WangXin made the CCD work.

Jacobian Transpose

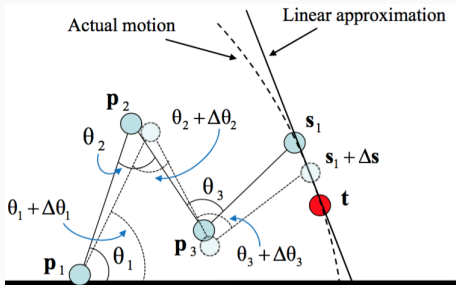


Figure 2: Jacobian Transpose

Definitions

J Partial Derivation of the entire chain system.

θ Vector of θ values.

s Vector of end effectors.

p_j Position of the joints.

Jacobian Matrix

$$J(\theta_{ij}) = \left(\frac{\partial s_i}{\partial \theta_j} \right)_{ij}$$

Where $i = 1, \dots, k$ and $j = 1, \dots, n$.

In this case $k = 1$ and $n = 3$.

Jacobian Transpose

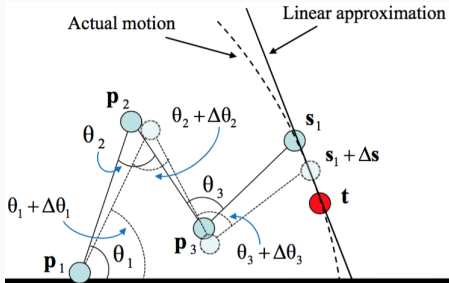


Figure 2: Jacobian Transpose

Jacobian Transpose

Jacobian Transpose is to move the angles with a step of

$$\Delta\theta = \alpha J^T \vec{e}$$

Where \vec{e} is the vector of direction of the step and α is the selected step size.

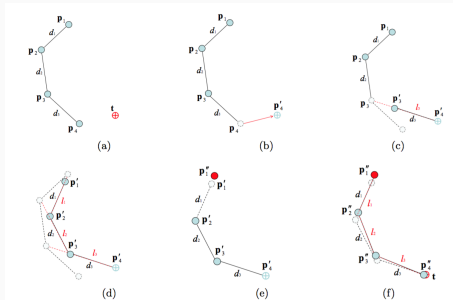


Figure 3: FABRIK

FABRIK

Stands for Forward And Backward Reaching Inverse Kinematics.

Definitions

\mathbf{t} Vector of targets.

d_i Distance between each joint $d_i = \|\mathbf{p}_{i+1} - \mathbf{p}_i\|$

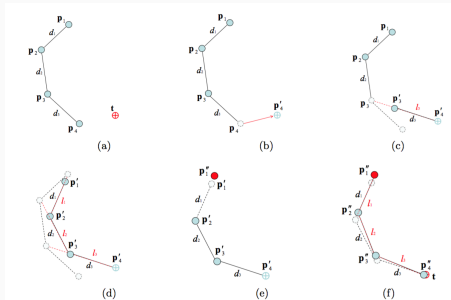


Figure 3: FABRIK

Data: d, t, p

Result: The new joint positions p
initialization;

if Target is not within range then

point directly to the target and return;

else

$b = p_1$ and $dif_A = |p_n - t|$;

while $dif_A > tolerance$ do

$p_n = t$;

for $i = n - 1, \dots, 1$ do

$r_i = |p_{i+1} - p_i|$;

$\lambda_i = \frac{d_i}{r_i}$;

$p_i = (i - \lambda_i)p_{i+1} - \lambda_i p_i$;

end

$p_1 = b$;

for $i = 1, \dots, n - 1$ do

$r_i = |p_{i+1} - p_i|$;

$\lambda_i = \frac{d_i}{r_i}$;

$p_i = (i - \lambda_i)p_{i+1} - \lambda_i p_i$;

end

end

end

FABRIK Constraints

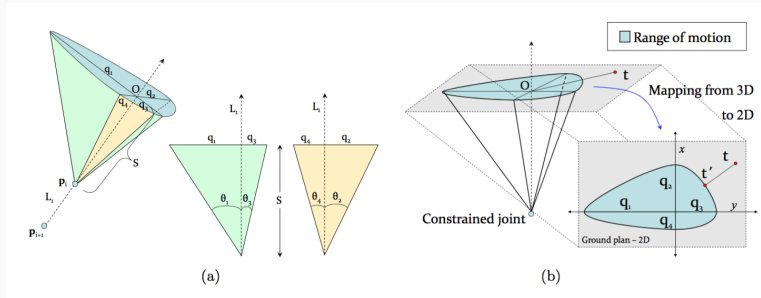


Figure 4: Example of Constraints in a Joint System

Reachable Space

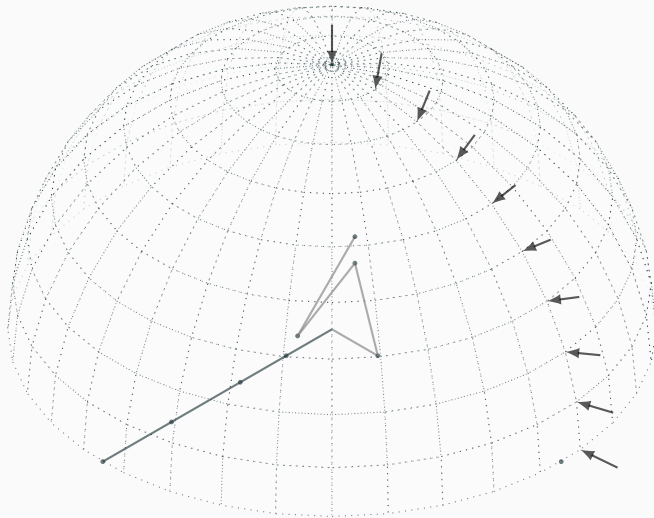


Figure 5: Reachable Space of a Fully Free Robot Arm

Reachable Space for UR10

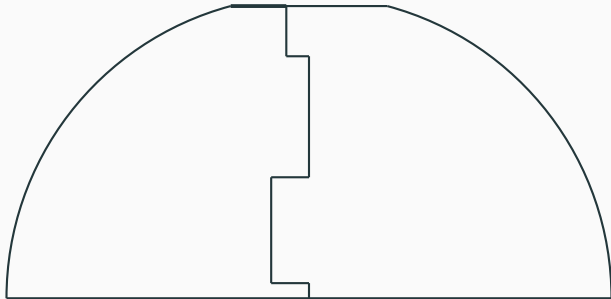
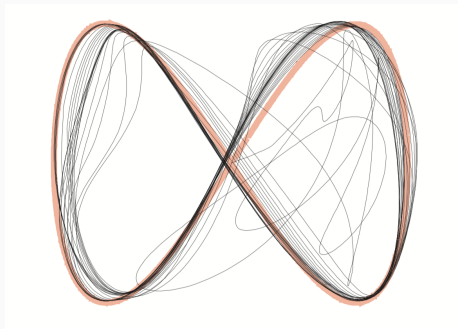


Figure 6: Reachable Space for UR10

Learning Methods

Actions(Scenarios)



Natural Gesture of a Robot

Unpredictability

Robustness

Gesture when reaching the end effector

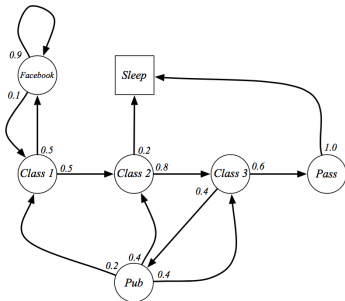
Learning Method

Monte Carlo(policy search)

Dynamic Programming(value function)

Neural Network

Model



$$\mathcal{P} = \begin{matrix} & \begin{matrix} C1 & C2 & C3 & Pass & Pub & FB & Sleep \end{matrix} \\ \begin{matrix} C1 \\ C2 \\ C3 \\ Pass \\ Pub \\ FB \\ Sleep \end{matrix} & \begin{bmatrix} & & & & & 0.5 & \\ & 0.5 & & & & & 0.2 \\ & & 0.8 & & & & \\ & & & 0.6 & 0.4 & & \\ 0.2 & 0.4 & 0.4 & & & & 1.0 \\ 0.1 & & & & & 0.9 & \\ & & & & & & 1 \end{bmatrix} \end{matrix}$$

Definitions

π Policy: mapping from states to actions

S A set of States

A A set of Actions

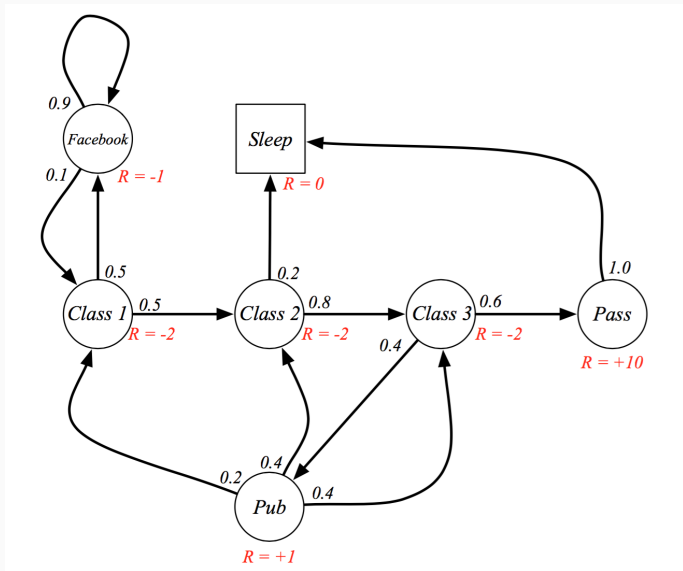
R Reward Function

P State transition function

$v(s)$ State Value Function of a MRP

γ Discount Function, $\gamma \in [0, 1]$

Model



Goal

Discover an optimal policy that maximizes:

$$J = E\{\sum_{h=0}^H R_h\}$$

Where H is the steps the algorithm takes

Expanding

Expanding the above with reward settings:

$$\max_{\pi} J(\pi) = \sum_{s,a} \mu^{\pi}(s) \pi(s, a) R(s, a)$$

$$s.t. \mu^{\pi} = \sum_{s,a} \mu^{\pi}(s) \pi(s, a) T(s, a, s'), \forall s' \in S,$$

$$1 = \sum_{s,a} \mu^{\pi}(s) \pi(s, a)$$

$$\pi(s, a) \geq 0, \forall s \in S, a \in A$$

Where μ is the distribution of states.

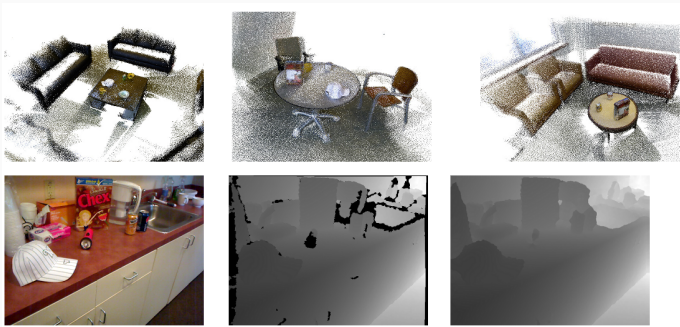
Methods

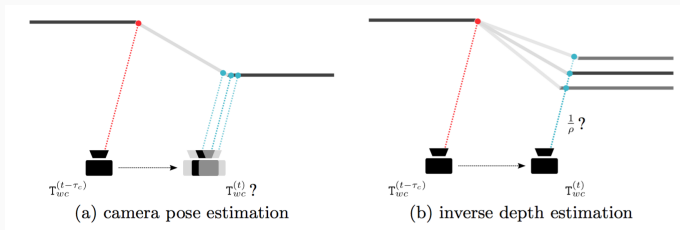
- Video Stream
- Depth Camera Stream
- 3D Reconstruction(Event Camera)

Methods

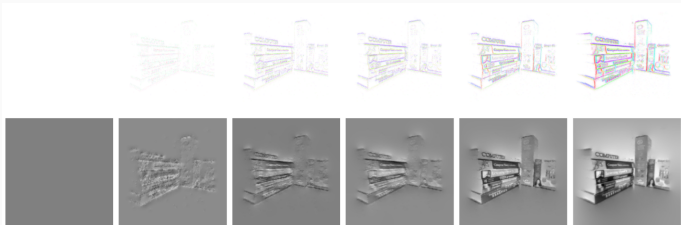


Methods





Methods



Methods



Questions?

Backup slides

Sometimes, it is useful to add slides at the end of your presentation to refer to during audience questions.

The best way to do this is to include the `appendixnumberbeamer` package in your preamble and call `\appendix` before your backup slides.

metropolis will automatically turn off slide numbering and progress bars for slides in the appendix.



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