

EECS 367 Lab

KinEval IK Control Flow and Parameters

Administrative

Assignment 5 released

Due Wednesday, November 11 at 11:59pm

Pull stencil update from upstream!

Lab Takeaways

1. Assignment 5 goals
 2. KinEval overview
 3. KinEval walkthrough
- How to start Assignment 5

Inverse Kinematics Overview

| Assignment 5: Inverse Kinematics | | | |
|----------------------------------|------|---|---|
| 6 | All | Manipulator Jacobian | } Features assigned to all sections |
| 3 | All | Gradient descent with Jacobian transpose* | |
| 3 | All | Jacobian pseudoinverse | |
| 6 | Grad | Euler angle conversion | } Feature assigned to grad section only |

* Undergrad section will implement gradient descent for **position only**, but grad section will implement gradient descent for **position and orientation**

Demo

KinEval Overview

autorob / **kineval-stencil** Watch 5 Star 9

<> Code Issues 1 Pull requests Actions Projects Wiki Security Insights

master kineval-stencil / kineval / Go to file Add file

zhezhou1993 Factorize kineval stencil for FK problems, fix bugs in previous version 70d8e4b 9 days ago History

| | | |
|-------------------------------|---|-------------|
| .. | | |
| kineval.js | initial commit Fall 2018 | 2 years ago |
| kineval_collision.js | initial commit Fall 2018 | 2 years ago |
| kineval_controls.js | initial commit Fall 2018 | 2 years ago |
| kineval_forward_kinematics.js | initial commit Fall 2018 | 2 years ago |
| kineval_inverse_kinematics.js | initial commit Fall 2018 | 2 years ago |
| kineval_matrix.js | Factorize kineval stencil for FK problems, fix bugs in previous version | 9 days ago |
| kineval_quaternion.js | Factorize kineval stencil for FK problems, fix bugs in previous version | 9 days ago |
| kineval_robot_init.js | Factorize kineval stencil for FK gradining | 9 days ago |
| kineval_robot_init_joints.js | Factorize kineval stencil for FK gradining | 9 days ago |
| kineval_rosbridge.js | initial commit Fall 2018 | 2 years ago |
| kineval_rrt_connect.js | initial commit Fall 2018 | 2 years ago |
| kineval_servo_control.js | initial commit Fall 2018 | 2 years ago |
| kineval_startingpoint.js | initial commit Fall 2018 | 2 years ago |
| kineval_threejs.js | initial commit Fall 2018 | 2 years ago |
| kineval_userinput.js | initial commit Fall 2018 | 2 years ago |

All code for assignment 4

kineval_inverse_kinematics.js

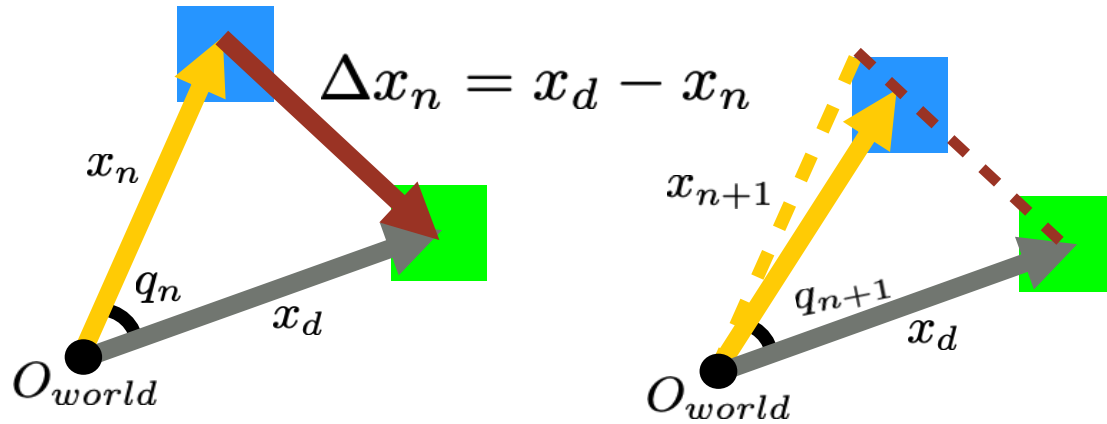
kineval_inverse_kinematics.js


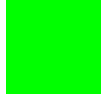
```
19 kineval.robotInverseKinematics = function robot_inverse_kinematics(endeffector_target_world, endeffector_joint, endeffector_position_local) {
20
21     // compute joint angle controls to move location on specified link to Cartesian location
22     if ((kineval.params.update_ik)||kineval.params.persist_ik) {
23         // if update requested, call ik iterator and show endeffector and target
24         kineval.iterateIK(endeffector_target_world, endeffector_joint, endeffector_position_local);
25         if (kineval.params.trial_ik_random.execute)
26             kineval.randomizeIKtrial();
27         else // KE: this use of start time assumes IK is invoked before trial
28             kineval.params.trial_ik_random.start = new Date();
29     }
30
31     kineval.params.update_ik = false; // clear IK request for next iteration
32 }
33
34 kineval.randomizeIKtrial = function randomIKtrial () {
35
36     // update time from start of trial
37     cur_time = new Date();
38     kineval.params.trial_ik_random.time = cur_time.getTime()-kineval.params.trial_ik_random.start.getTime();
39
40     // STENCIL: see instructor for random time trial code
41 }
42
43 kineval.iterateIK = function iterate_inverse_kinematics(endeffector_target_world, endeffector_joint, endeffector_position_local) {
44
45     // STENCIL: implement inverse kinematics iteration
46 }
```

Implement `iterateIK()` such that each joint along the end effector path gets an update to its `.control` term

Translating the IK Update

IK UPDATE PER JOINT



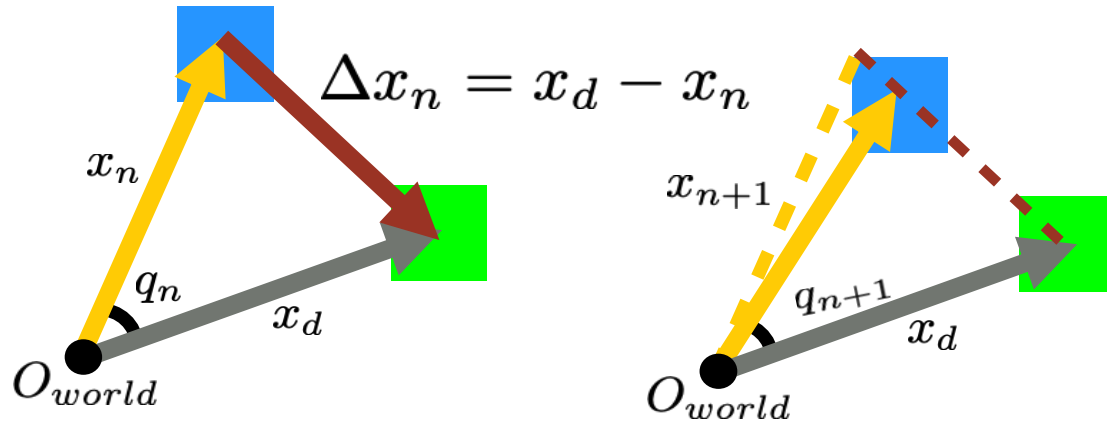
 = current end effector position
 = desired end effector position

GENERAL IK UPDATE PROCEDURE

$$\begin{aligned}\Delta x_n &= x_d - x_n \\ \Delta q_n &= J(q_n)^{-1} \Delta x_n \\ q_{n+1} &= q_n + \gamma \Delta q_n\end{aligned}$$

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IK UPDATE PER JOINT



GENERAL IK UPDATE PROCEDURE

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KINEVAL VARIABLES

$x_d \rightarrow$ endeffector_target_world

$q_n \rightarrow$ robot.joints[...].angle

$p^{x_n} \rightarrow$ endeffector_position_local

$x_n \rightarrow T_{x_n}^O p^{x_n}$

$T_{x_n}^O \rightarrow$ a .xform, calculated by FK

$\gamma \rightarrow$ kineval.params.ik_steplength

$\Delta x_n \rightarrow$ robot.dx

$J(q_n) \rightarrow$ robot.jacobian

$\Delta q_n \rightarrow$ robot.dq

} Necessary for
CI grader!

KinEval IK Parameters

Parameters of `iterate_inverse_kinematics` function:

`endeffector_target_world` – target pose of end effector for IK, has `.position` and `.orientation`

`endeffector_joint` – string name of joint connected to end effector

`endeffector_position_local` – position of end effector with respect to local frame

Global parameters that your code needs to check:

`kineval.params.ik_steplength` – size of step to take along configuration gradient when updating control

`kineval.params.ik_pseudoinverse` – Boolean flag denoting which method to use (Jacobian transpose vs pseudoinverse)

Performance Validation

`kineval.randomizeIKTrial()`

Source code will be provided on assignment 5 channel in MS Team

Graduate extension points for reaching at least 100 targets in 60 seconds

Inverse kinematics will react in real time

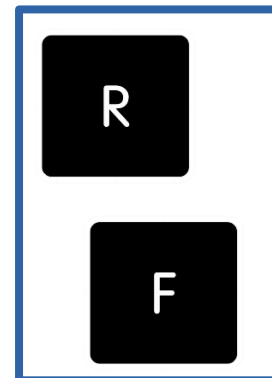
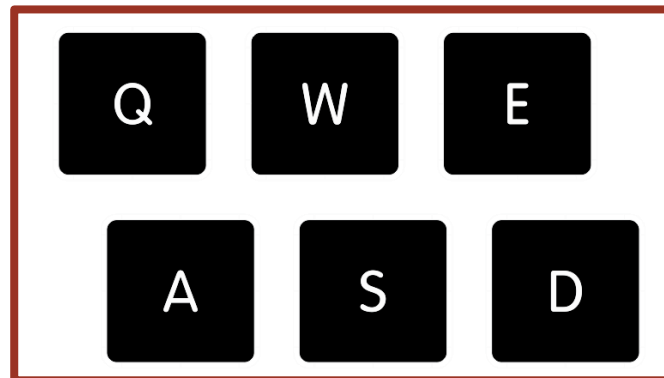
Turn on `persist_ik` in the GUI menu or hold down 'p' key to turn on

IK will account for manual adjustments to robot base or joint angles

Also will react to any modification of the end effector target

Keyboard controls

Base Controls



End Effector
Target Controls



IK Toggle