

EECS 367 & ROB 320 Lab

KinEval IK control flow and parameters

Administrative

- Assignment #4: Robot FSM Dance Contest
 - Due tonight (Friday, March 11), 11:59pm
- Dance Contest-Demo
 - Next Wednesday, March 16th
 - During Interactive Session
 - Not additional feature points

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 Manipulator Jacobian

3 Gradient descent with Jacobian transpose

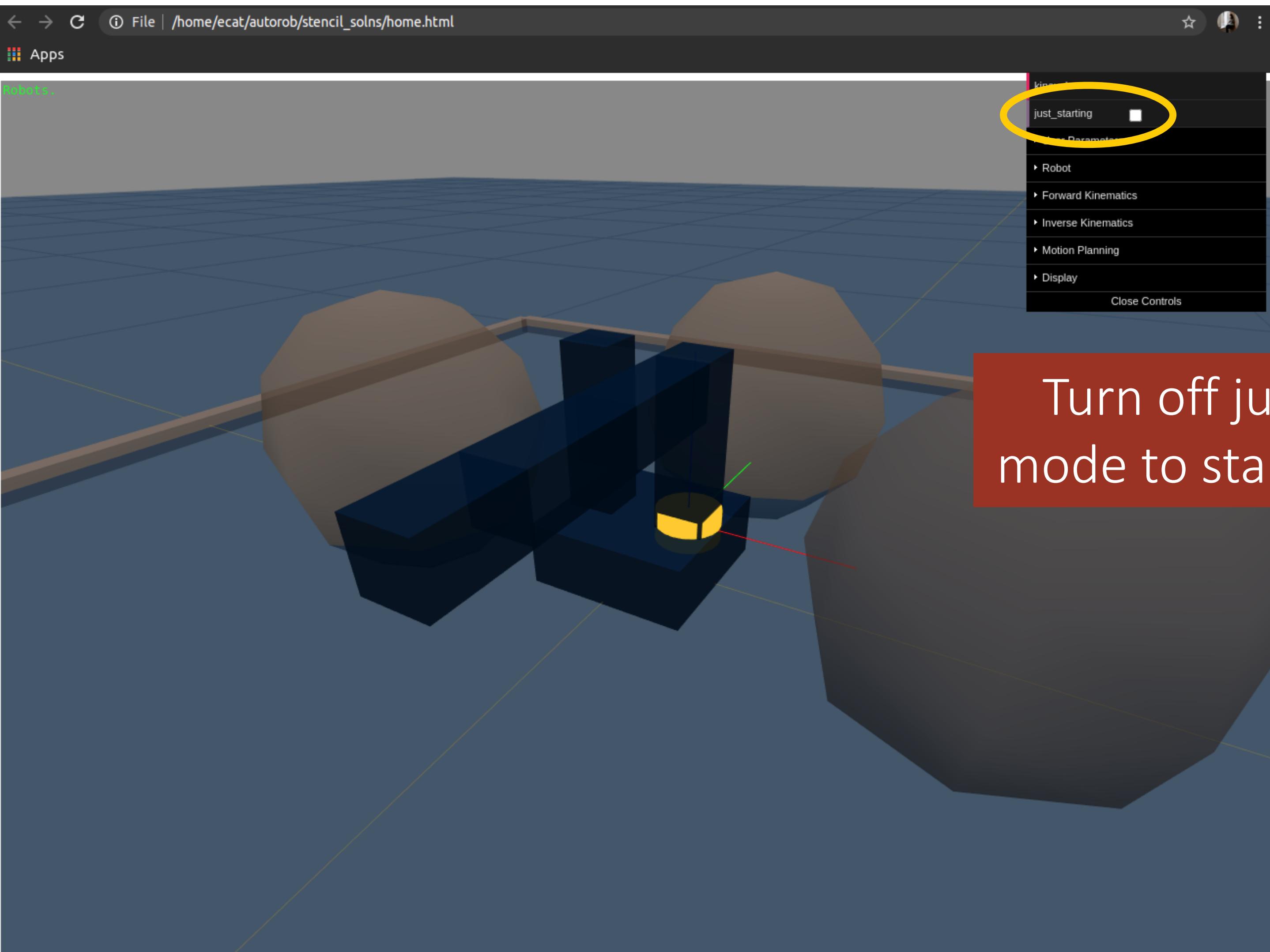
3 Jacobian pseudoinverse

Demo

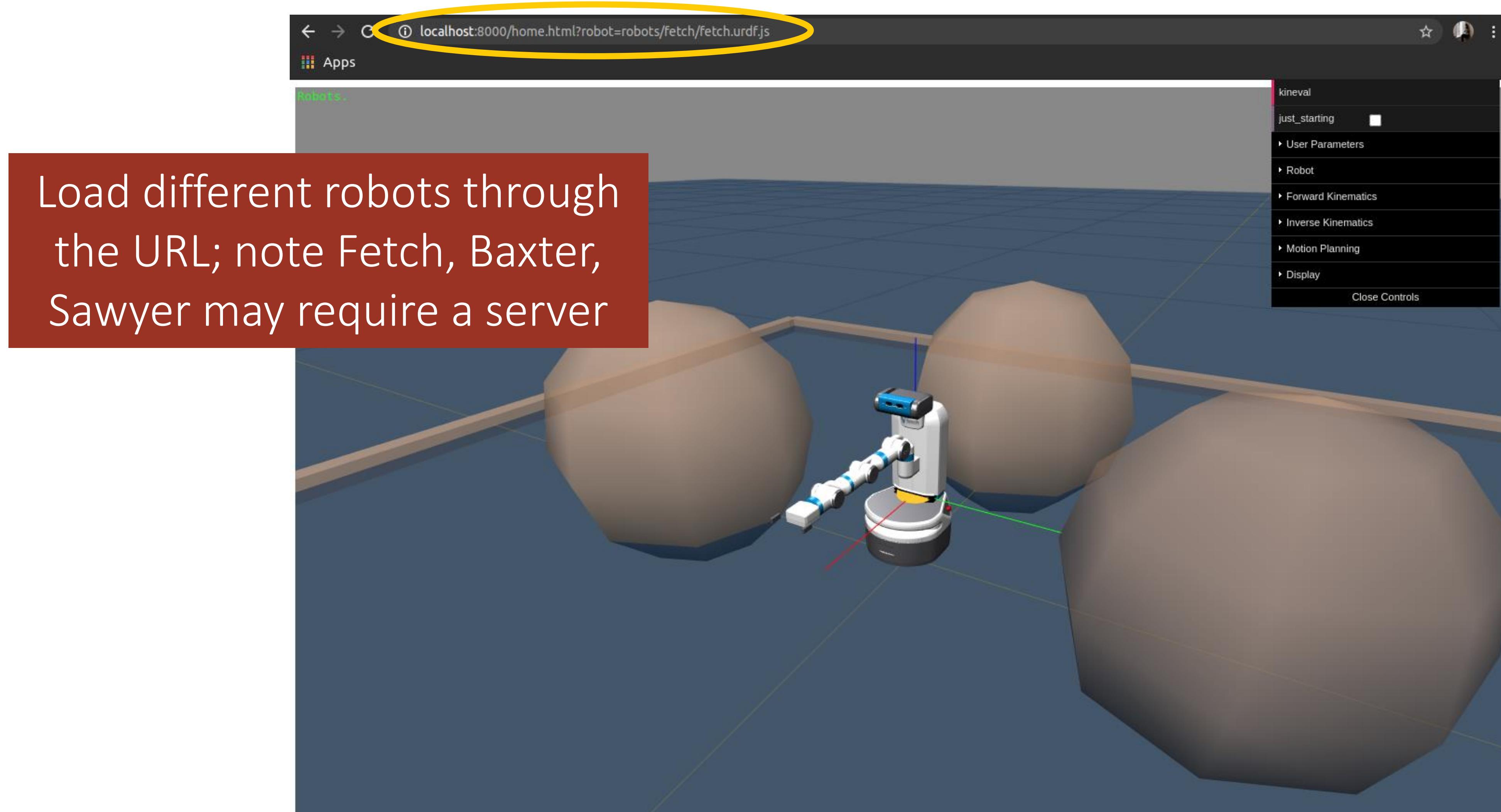
Running IK



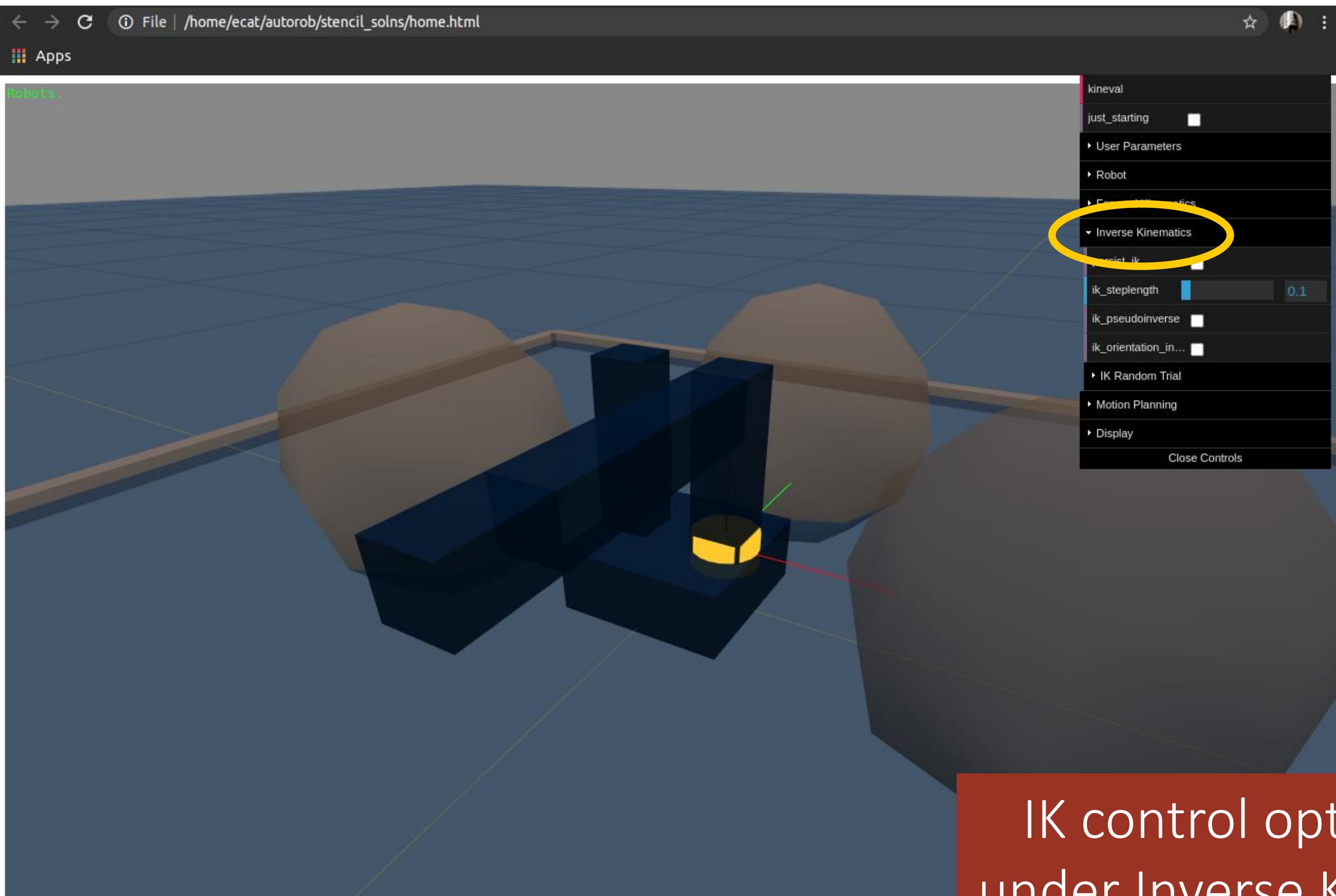
Running IK



Running IK

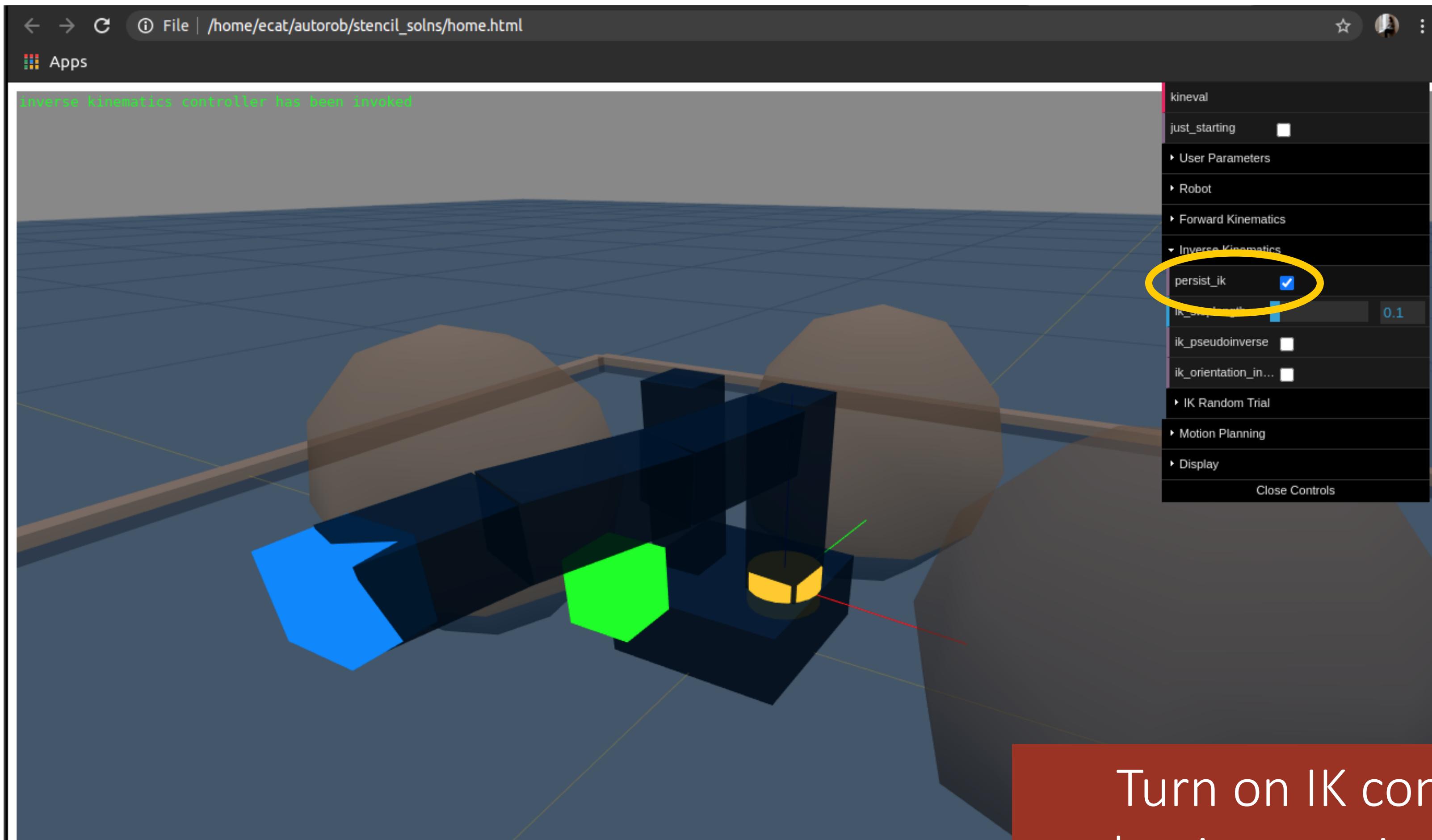


Running IK



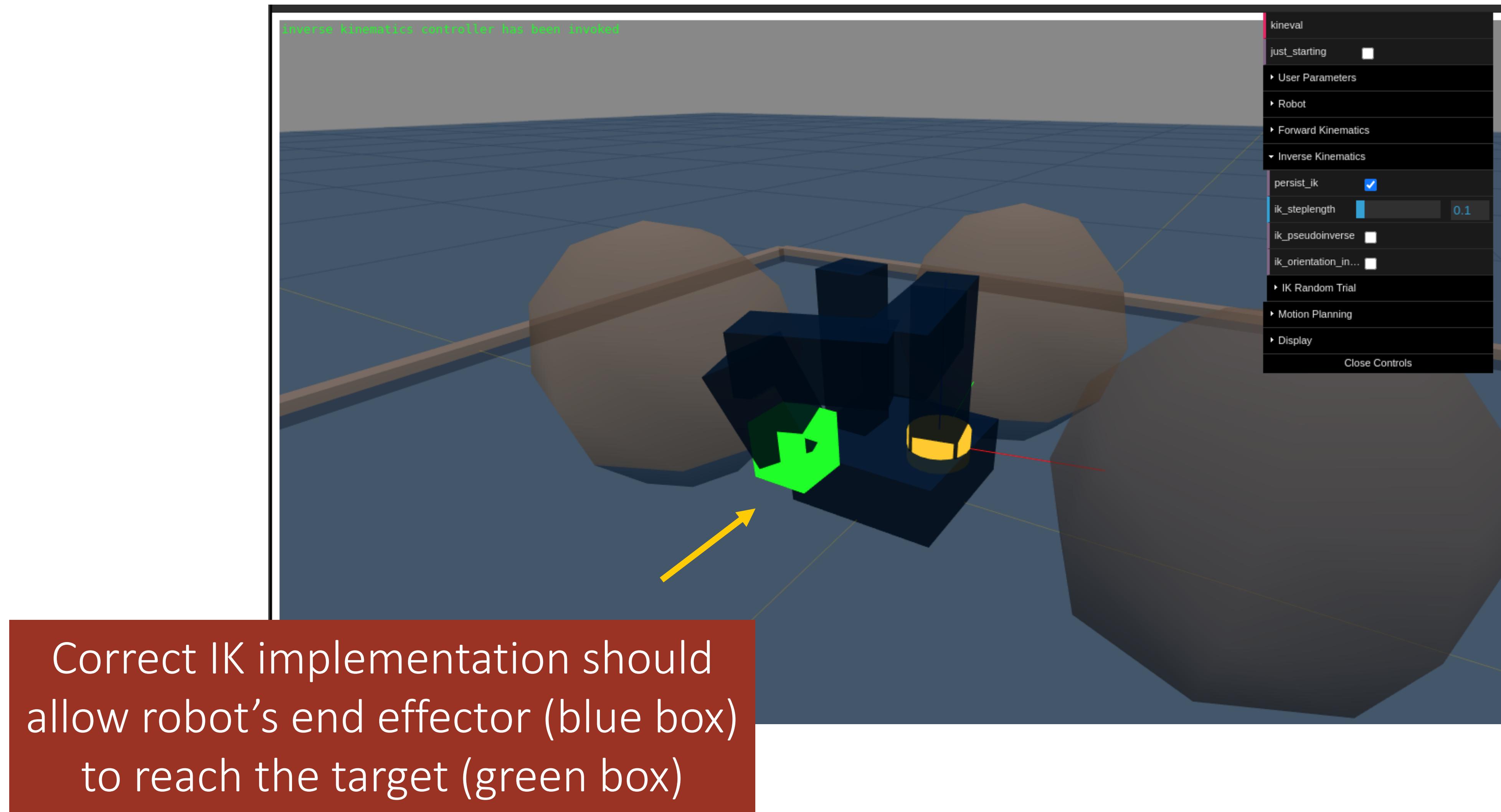
IK control options are
under Inverse Kinematics
in user interface

Running IK

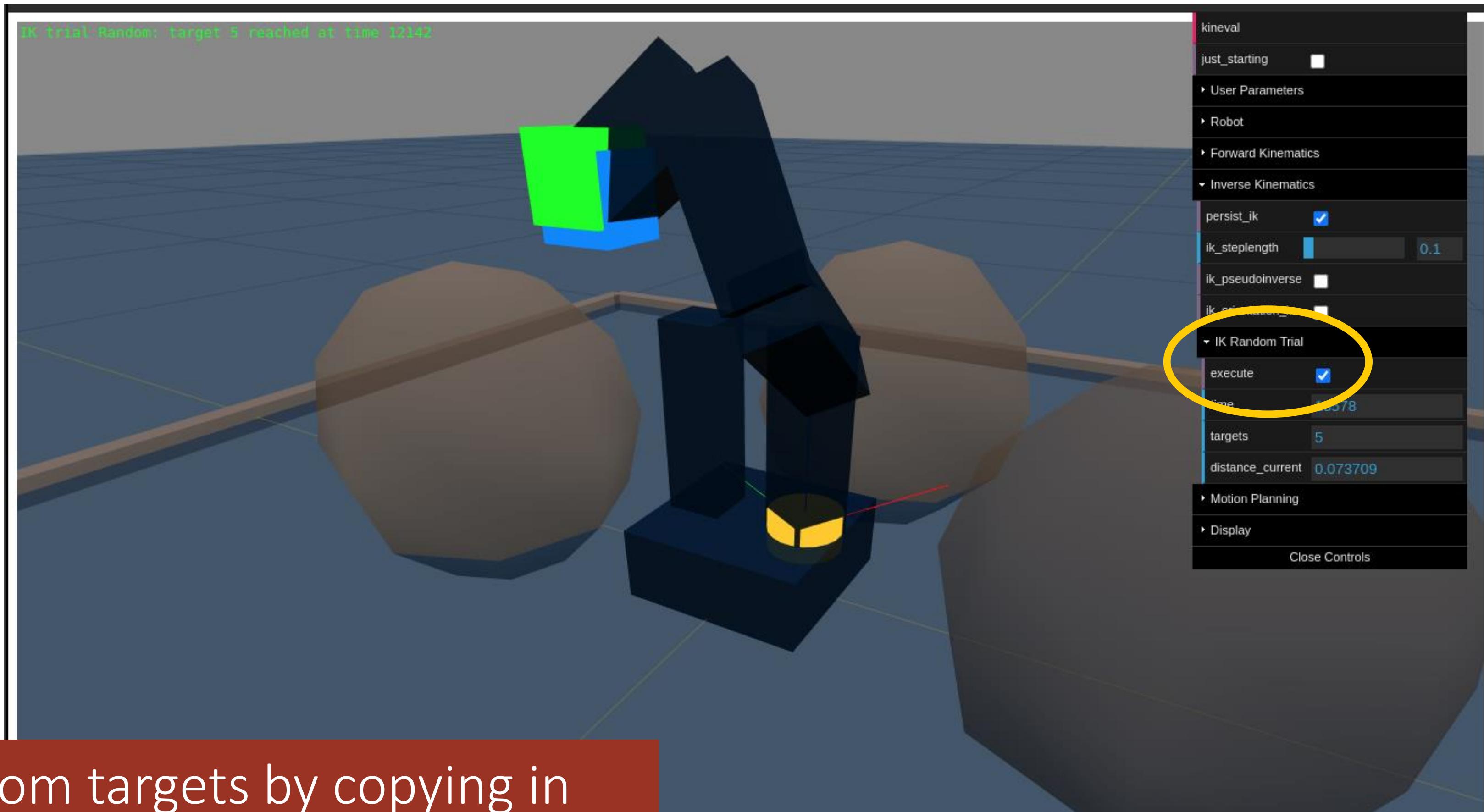


Turn on IK control by
selecting persist_ik OR by
holding down 'p' key

Running IK

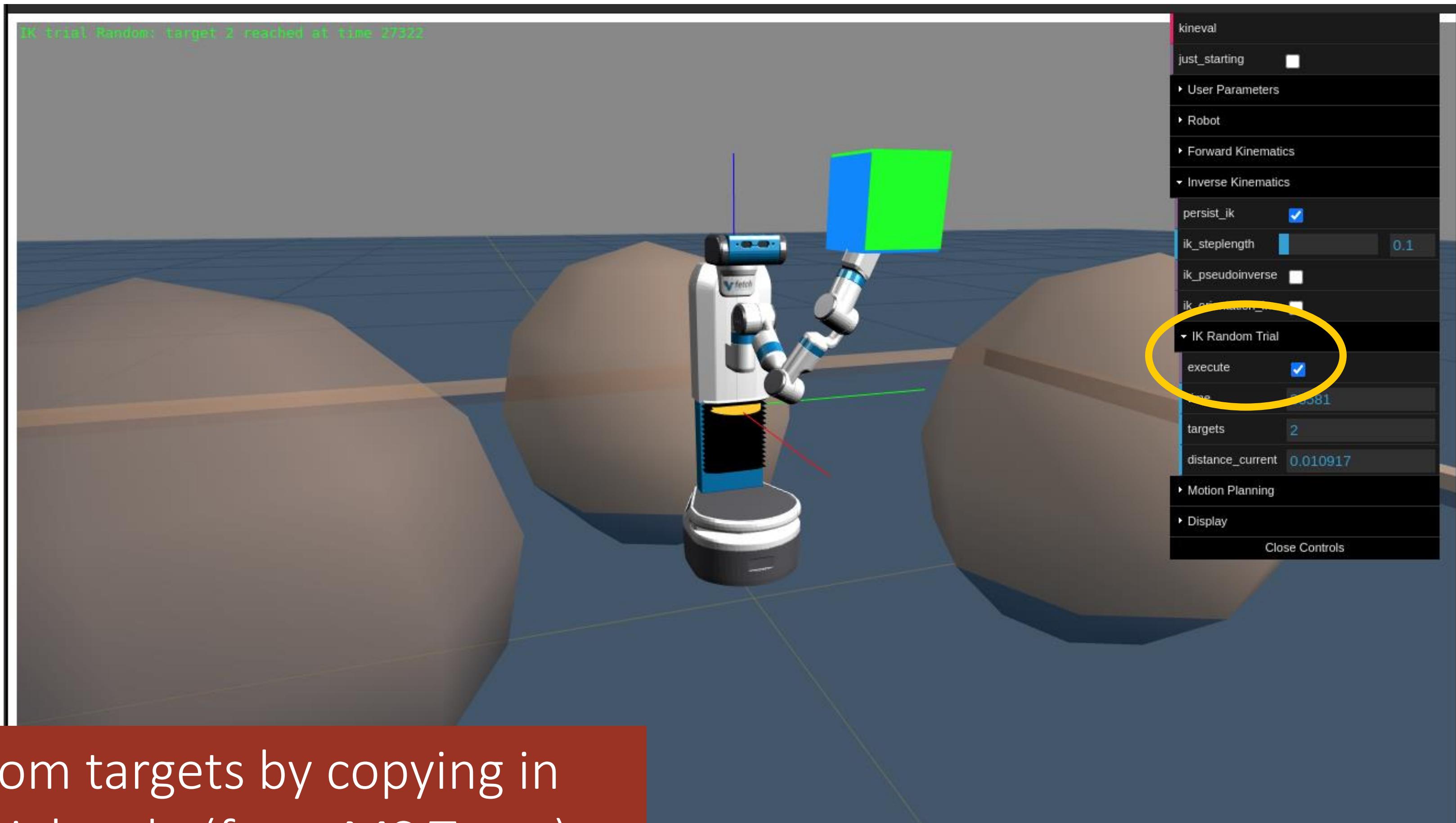


Running IK



Test random targets by copying in
random trial code (from MS Team)
then selecting Random Trial->execute

Running IK



Test random targets by copying in
random trial code (from MS Team)
then selecting Random Trial->execute

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

..

File	Commit Message	Time Ago
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	go
kineval_robot_init.js	Factorize kineval stencil for FK gradining	go
kineval_robot_init_joints.js	Factorize kineval stencil for FK gradining	go
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

The screenshot shows a GitHub repository page for 'autorob / kineval-stencil'. The 'Code' tab is selected. A commit by 'zhezhou1993' is highlighted, showing the message 'Factorize kineval stencil for FK problems, fix bugs in previous version' and the commit hash '70d8e4b' from 9 days ago. Two specific files in this commit are highlighted with red boxes and arrows pointing to a large red callout box: 'kineval_matrix.js' and 'kineval_inverse_kinematics.js'. The callout box contains the text 'All code for assignment 4'. The rest of the commit history shows other files like 'kineval.js', 'kineval_forward_kinematics.js', etc., with their respective commit messages and dates.

kineval_inverse_kinematics.js

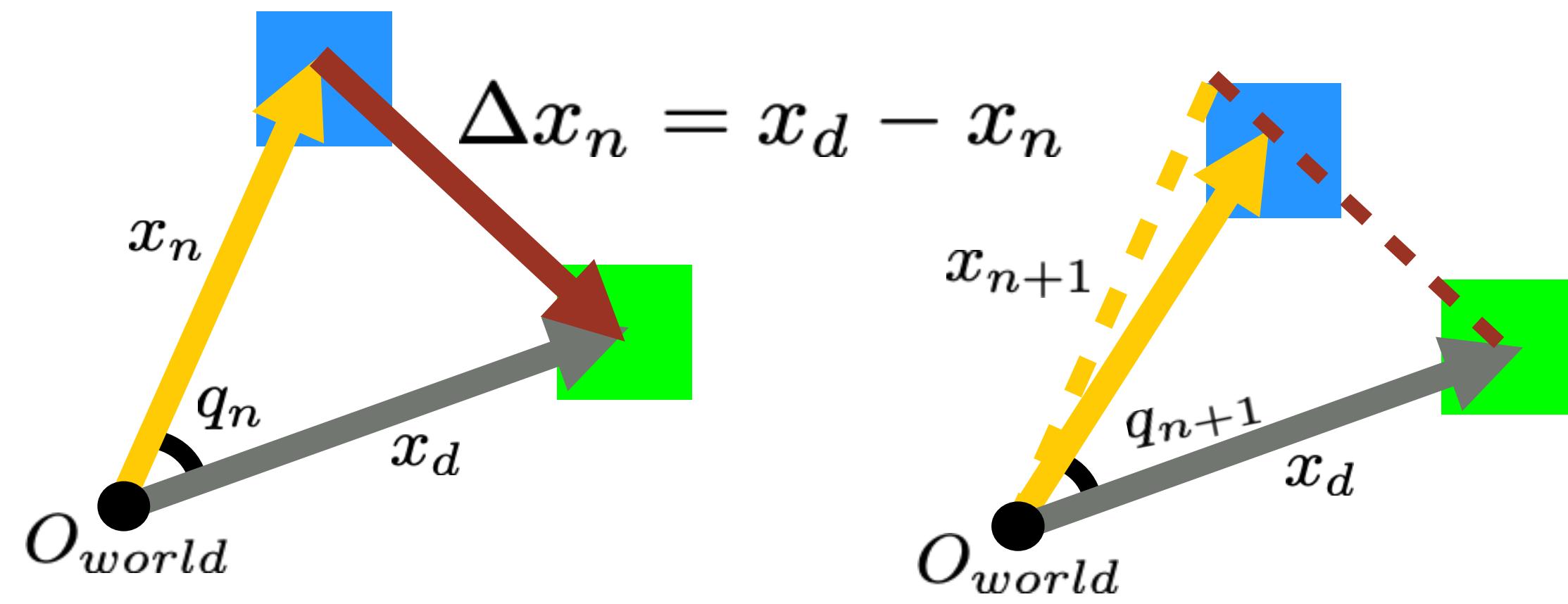
kineval_inverse_kinematics.js

```
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
```

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



GENERAL IK UPDATE PROCEDURE

$$\Delta x_n = x_d - x_n$$

$$\Delta q_n = J(q_n)^{-1} \Delta x_n$$

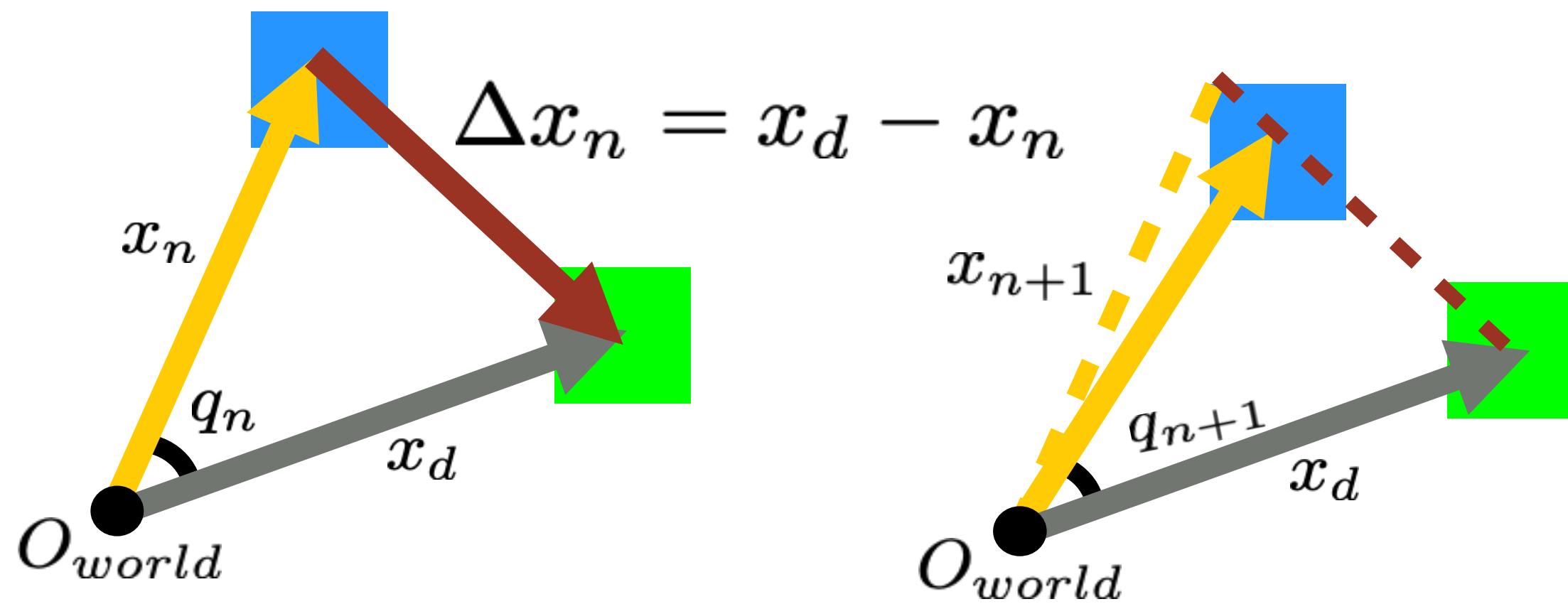
$$q_{n+1} = q_n + \gamma \Delta q_n$$

= current end effector position

= desired end effector position

Translating the IK Update

IK UPDATE PER JOINT



GENERAL IK UPDATE PROCEDURE

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

KINEVAL VARIABLES

$x_d \rightarrow \text{endeffector_target_world}$

$q_n \rightarrow \text{robot.joints[...].angle}$

$p^{x_n} \rightarrow \text{endeffector_position_local}$

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

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

$\gamma \rightarrow \text{kineval.params.ik_stepLength}$

$\Delta x_n \rightarrow \text{robot.dx}$

$J(q_n) \rightarrow \text{robot.jacobian}$

$\Delta q_n \rightarrow \text{robot.dq}$

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_stelength` – 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

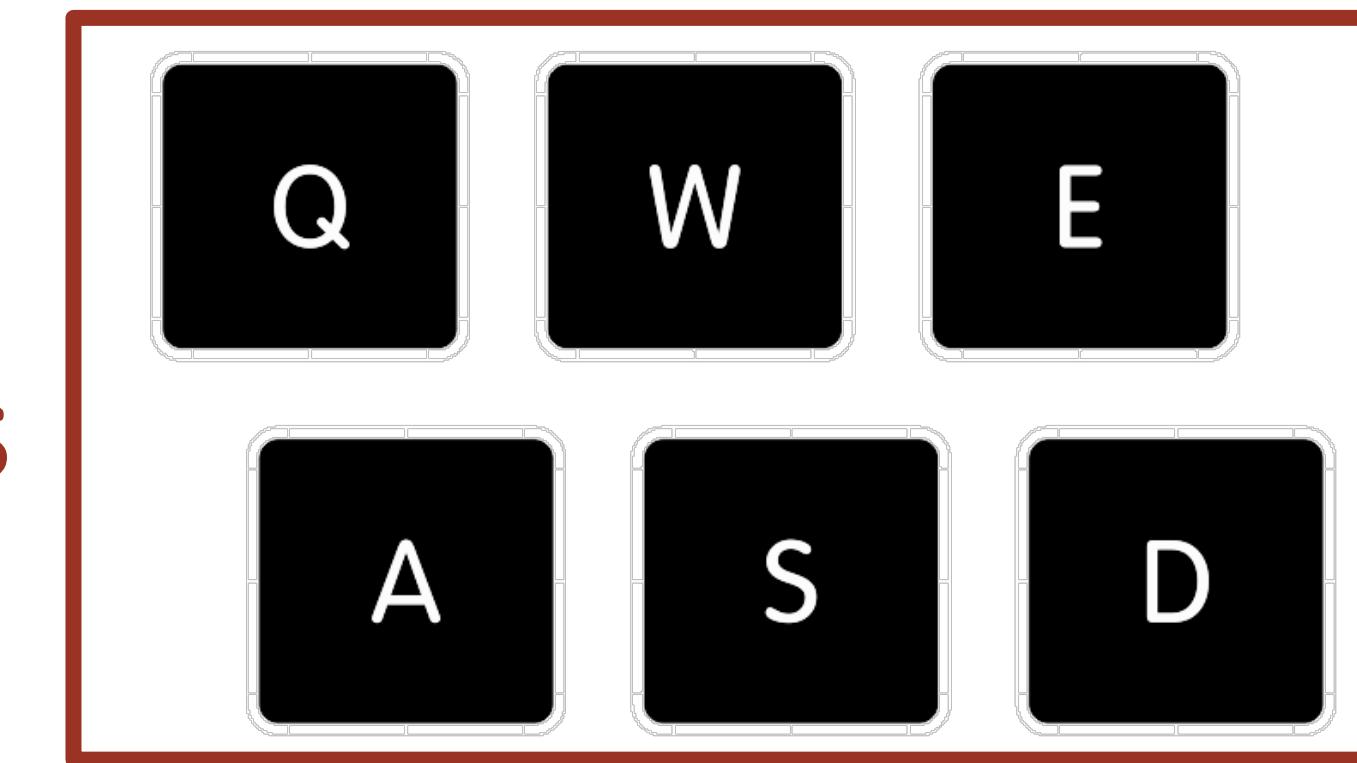
Inverse kinematics will react in real time

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

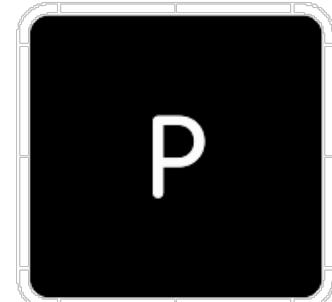
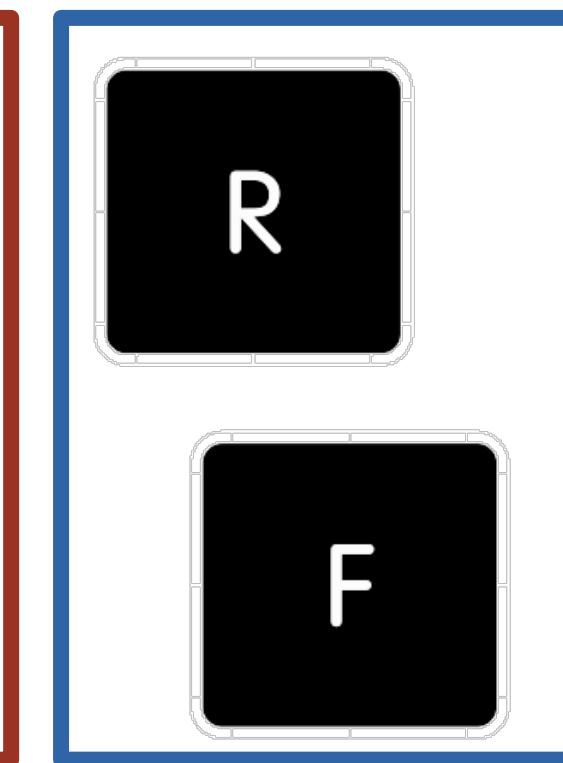
IK will account for manual adjustments to robot base or joint angles

Also will react to any modification of the end effector target

Keyboard controls



Base Controls



IK Toggle

**End Effector
Target Controls**