Inverse Kinematics

2021.5.4

Outline

- Demo
- Project overview
- Scoring criteria
- Objective and explanation
- Submission detail
- Hint and reminder

Demo

- Inverse Kinematics

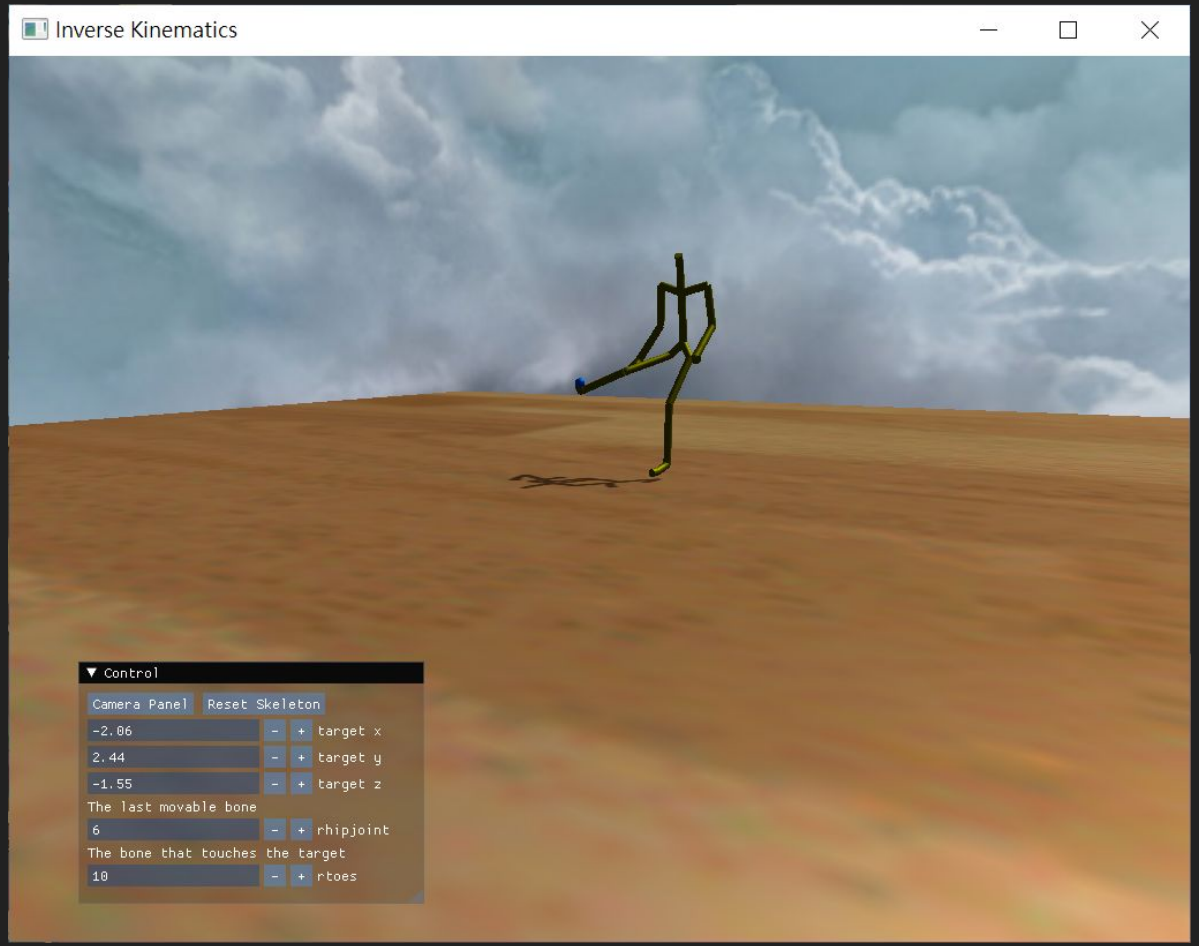
- Bone touch the target
  - rfingers (id=29)
- Last movable bone
  - lowerback (id=11)

Demo (cont.)

- When target is unreachable ...

Demo (cont.)

- Bone touch the ball
  - rtoes (id=10)
- Last movable bone
  - rhipjoint (id=6)



Project overview (Same as HW2)

- Solution layout
  - bin
  - assets
    - Shader and Texture
    - Acclaim - skeleton (asf) and motion (amc) files
  - src (source code)
  - include (header files for src)
  - extern (project dependencies)
  - InverseKinematics (Visual Studio project and main)

Project overview (cont.)

- Environment
  - IDE: Visual studio 2017 / 2019
  - Platform: Windows

  - Graphics API: OpenGL
  - OpenGL Loading Library: glad2
  - OpenGL Toolkit: glfw
  - UI Library: dear imgui

  - Math Library: Eigen

Project overview (cont.)

- src
  - acclaim (code for parsing acclaim files)
  - grahpics (code for rendering geometries)
  - simulation (code for running simulation)
  - util (utilities)

- Everything you need to implement is in the simulation folder

Scoring Criteria

- Inverse kinematics - 80%
  - Pseudoinverse - 20%
  - Related Implementation - 60%
- Report - 20%
- Bonus - 5%

Objective and explanation

- pseudoInverseLinearSolver(Jacobian, target)
  - Find solution of linear least squares system
  - i.e. find x which min(|Jacobian * x - target|)
- inverseJacobianIKSolver(target_pos, start_bone, end_bone, posture)
  - Solve inverse kinematics using **inverse jacobian method**.
  - Return true if IK is stable, false otherwise (Bonus)

Objective and explanation (cont.)

- Report (below is a suggested outline)
  - Introduction/Motivation
  - Fundamentals
  - Implementation
  - Result and Discussion
    - How different step and epsilon affect the result
  - Conclusion

Submission detail

- Compress required files into a .zip file
  - Naming rule: CA3_StudentID.zip
    - e.g., CA3_309553010.zip

- Your zip file should contain following components
  - simulation/kinematics.cpp
  - Report in **PDF** format, no more than 10 pages
  - **DO NOT** include whole project

Submission detail (cont.)

- Upload all your materials to new E3
  - No limit to the number of times of upload
  - The latest version is your final submission

Submission detail (cont.)

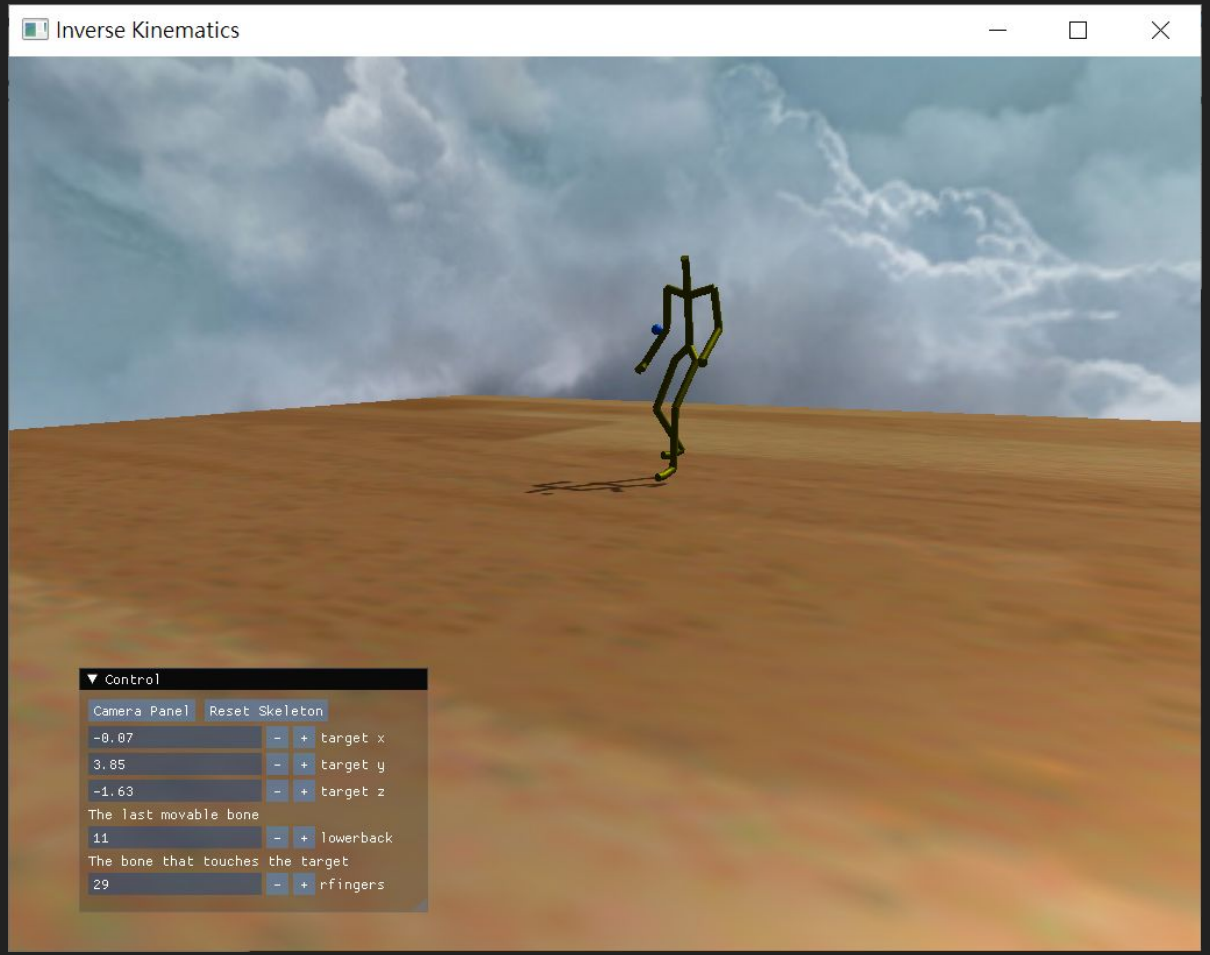
- Late policies
  - Penalty of 10 points on each day after deadline
- Cheating policies
  - 0 points for any cheating on assignments
  - Allowing another student to examine your code is also considered as cheating
- Deadline
  - Monday, 2021/05/24, 23:55

Hint and Reminder

- Hint: course materials
  - Inverse Kinematics
    - Review "Kinematics.pptx" from p.20 - p.50
    - Review "acclaim_FK_IKnote.pdf" Inverse Kinematics part
- You need to implement Inverse-Jacobain method in this homework.

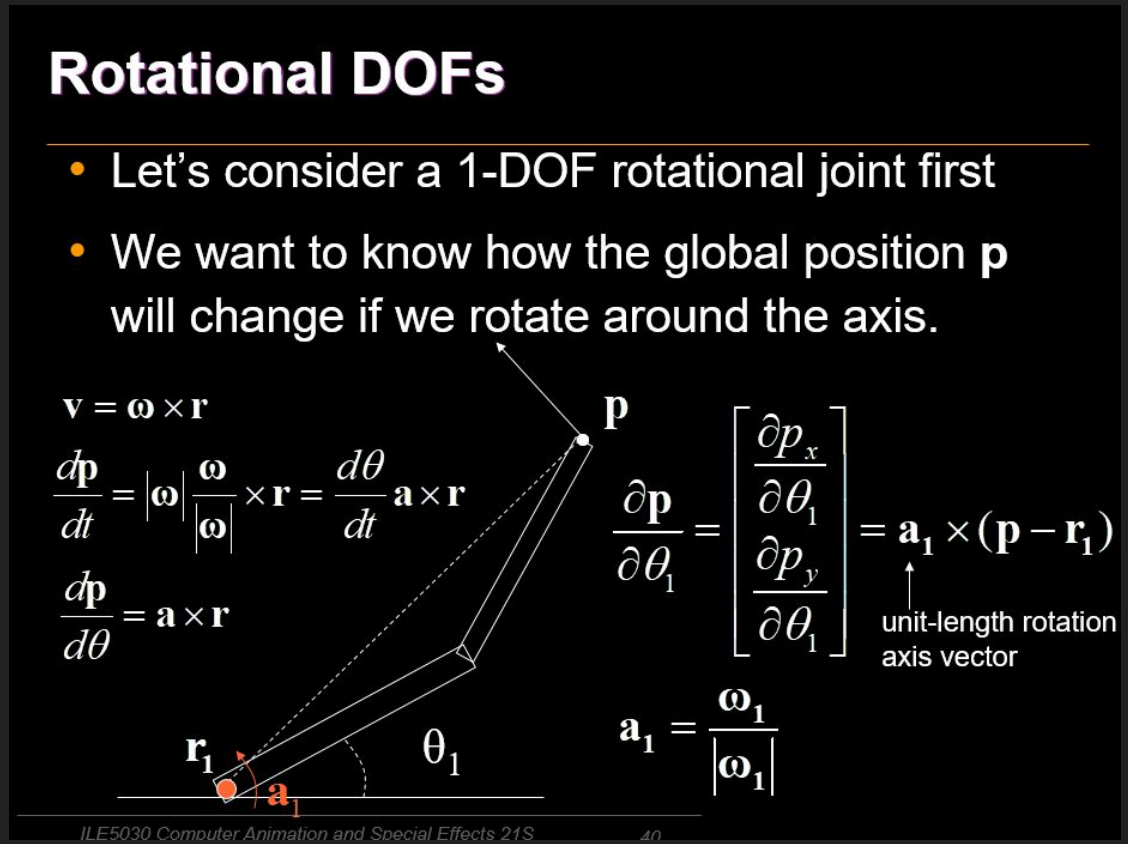
Hint and Reminder

- Blank template:



Hint and Reminder (cont.)

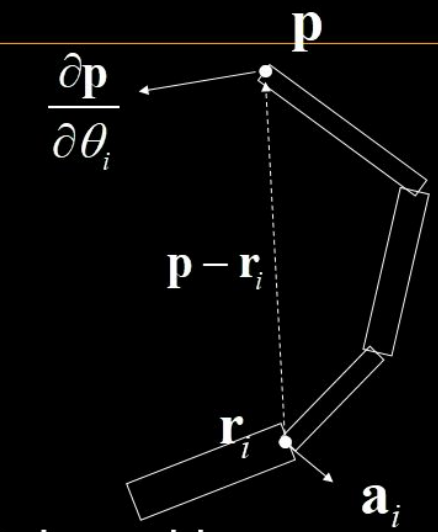
- Computing Jacobian geometrically



Hint and Reminder (cont.)

Rotational DOFs

$$\frac{\partial \mathbf{p}}{\partial \theta_i} = \mathbf{a}_i \times (\mathbf{p} - \mathbf{r}_i)$$



$\mathbf{a}_i$: unit length rotation axis in world space

$\mathbf{r}_i$: position of joint pivot in world space

$\mathbf{p}$: end effector position in world space

Hint and Reminder (cont.)

Iterative IK Using Inverse Jacobian

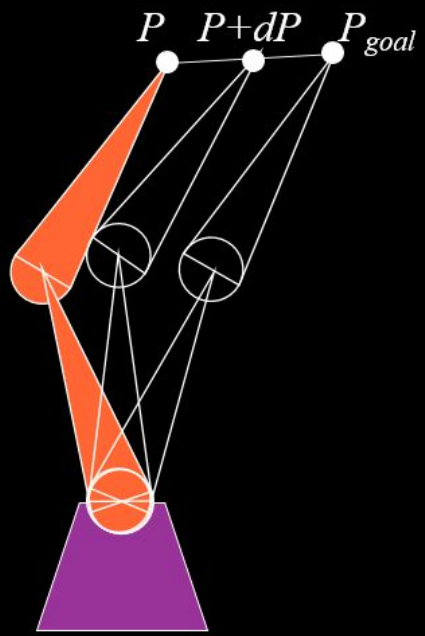
$$\theta = f^{-1}(P)$$

$$V = J(\theta)\dot{\theta}$$

$$\dot{\theta} = J^{-1}(\theta)V$$

$$\theta_{k+1} = \theta_k + \Delta t J^{-1}(\theta_k)V$$

- Linearize about θ_k locally
- Small increments



Hint and Reminder (cont.)

- What is Eigen::Matrix4Xd?
  - A matrix that has 4 rows, but unknown columns
  - e.g. Eigen::Matrix4Xd a(4, 30); // a has 4 rows, 30 columns of doubles.
- What is Eigen::VectorXd?
  - A vector with unknown size.
  - e.g. Eigen::VectorXd b(30); // b has 30 doubles
- Target position change too slow!
  - Hold ctrl when you press + or -
- What is "last movable bone"?
  - While you are traversing parents of "touch target bone", you should stop at this bone.

Hint and Reminder (cont.)

- How to contact TA?
  - Please ask your question on new E3 forum. (recommend)
    - Questions are similar, you can find answer easier.
    - If you cannot ask question without providing your code
      - You are probably asking TA debug your code.
    - Send email to **BOTH** TAs via new E3 if you think the question is personal.
  - If you need to ask question face-to-face, please send email for appointment.

  - IMPORTANT: please sort out and arrange your question, so we can help you without wasting time on trivial matters.