

Data Driven Computer Animation

HKU COMP 3360

Tutorial 3 - Animation Processing and Scripting

Prof. Taku Komura

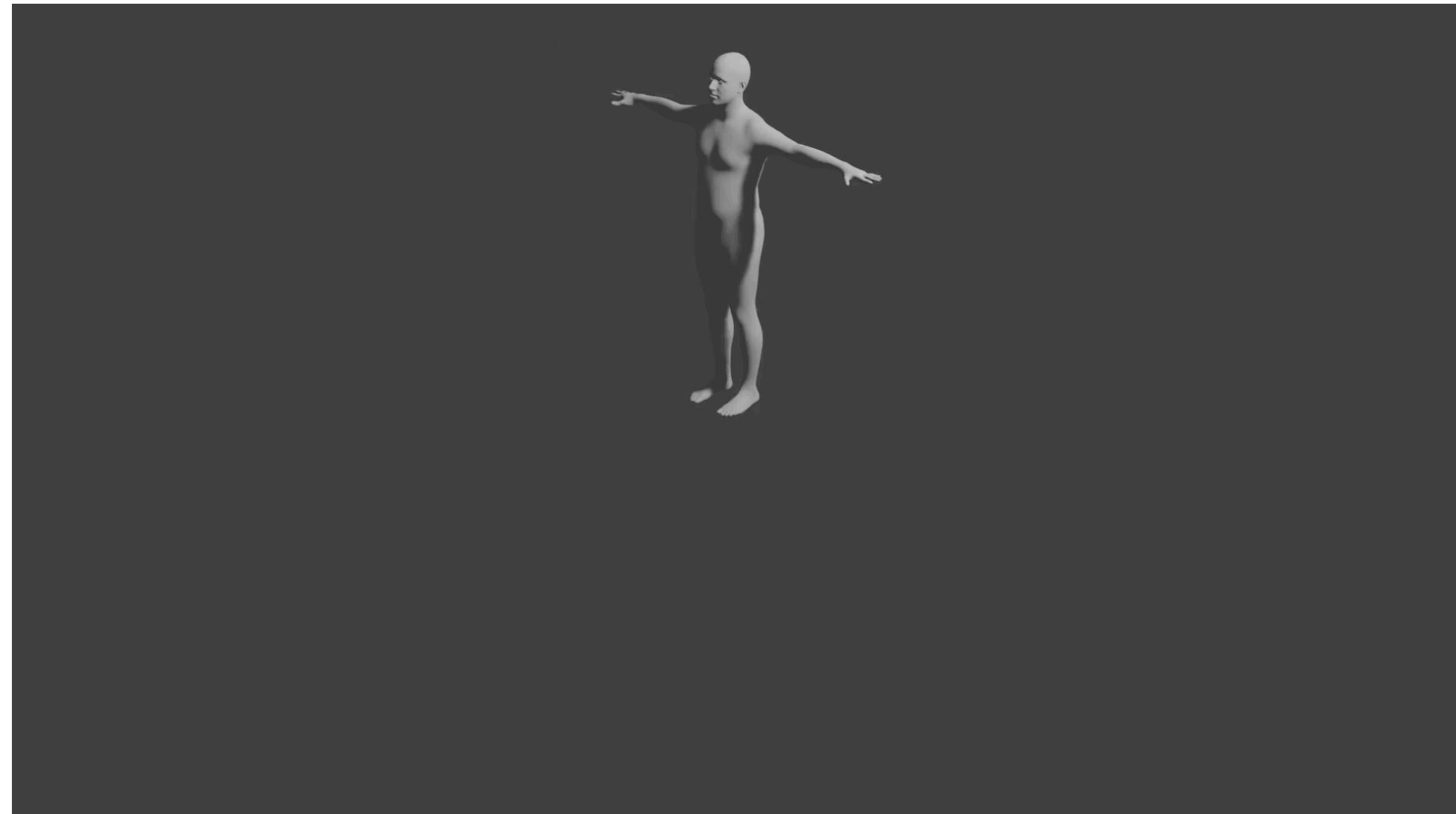
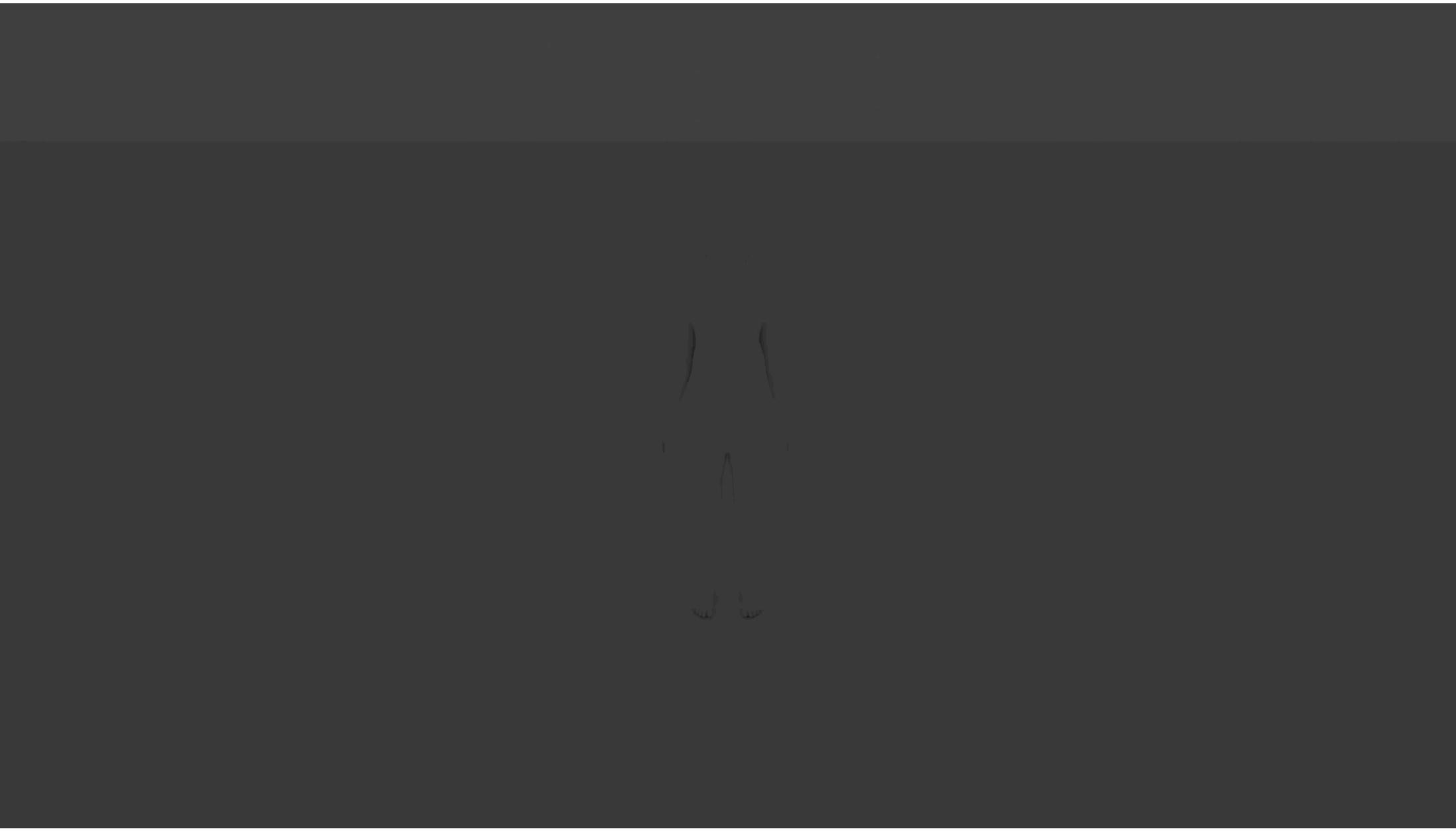
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SECTION 2A, 2023









Review on Assignment 1

T-Pose

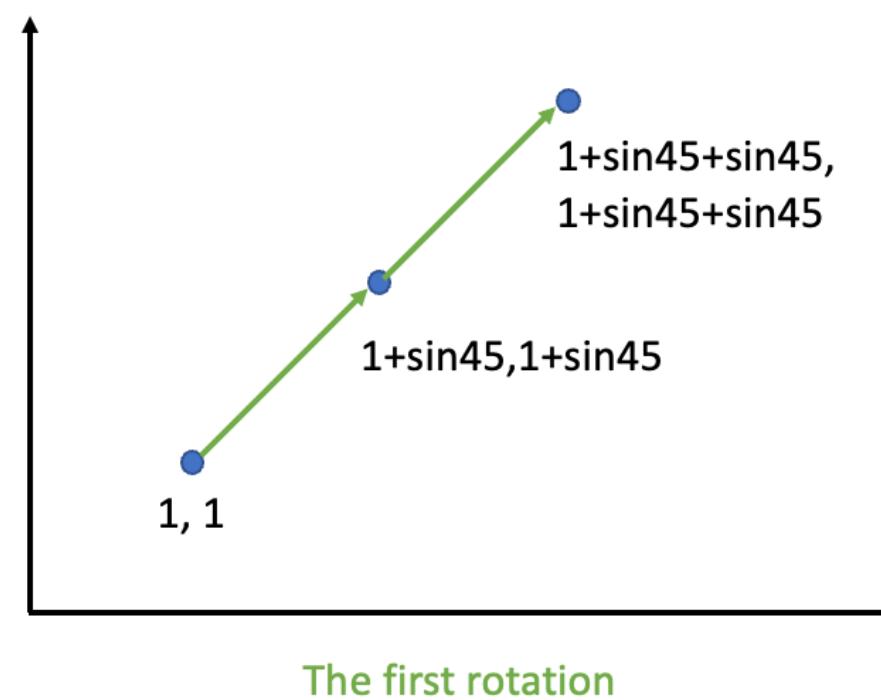
```
if parent_idx == -1:  
    global_joint_position[joint_idx] = joint_offsets[joint_idx]  
else:  
    global_joint_position[joint_idx] = global_joint_position[parent_idx] + joint_offsets[joint_idx]
```



- > The vector between two joints is known
- > make the vector align to its parent joint position

Review on Assignment 1

Method 1: Consider each rotation

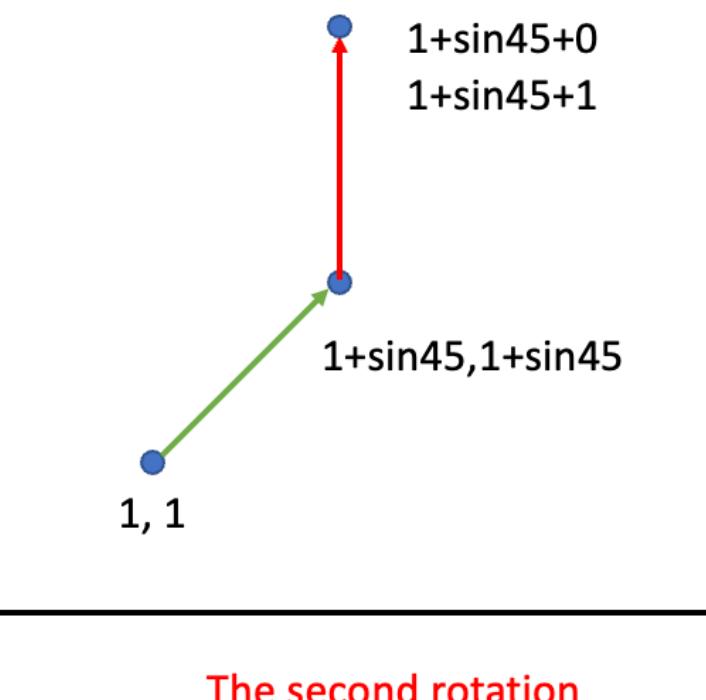


The first rotation

```
new_bone0 = bone0 @ 45 degree = (sin45, sin45)
new_bone1 = bone1 @ 45 degree = (sin45, sin45)
```

```
Joint 1: joint0.position + new_bone0
Joint 2: joint1.position(new) + new_bone1
```

The location of joints will be changed $n \cdot \log(n)$ times

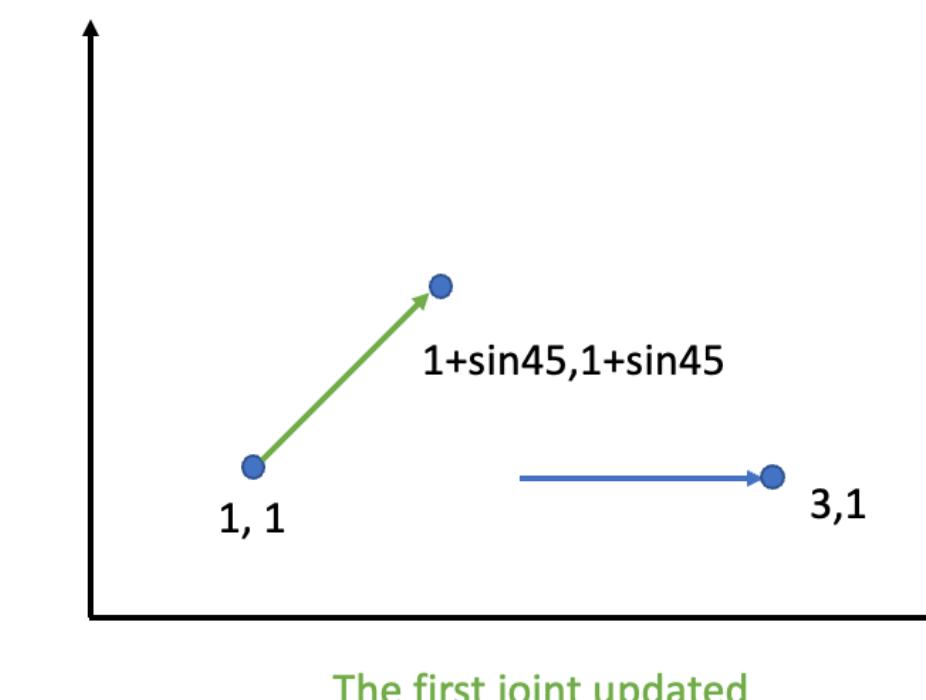


The second rotation

```
new_new_bone1 = new_bone1 @ 45 degree
= (0, 1)
```

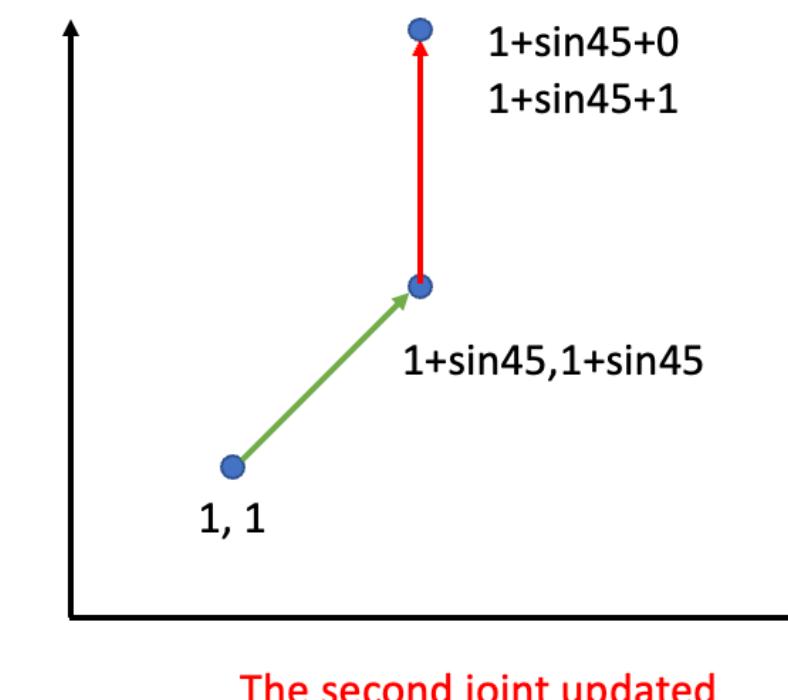
```
Joint 2: joint1.position(new) + new_new_bone1
```

Method 2: Consider each bone



The first joint updated

```
new_bone0 = bone0 @ 45 degree = (sin45, sin45)
Joint 1: joint0.position + new_bone0
= 1+sin45,1+sin45
```



The second joint updated

```
new_joint1_rotation = 45 + 45 = 90
new_bone1 = bone1 @ 90 degree
= (0, 1)
```

```
Joint 2: joint1.position(new) + new_bone1
```

The location of joints will be changed n times

FK

```
for joint_idx, parent_idx in enumerate(joint_parents):
    parent_orientation = R.from_quat(global_joint_orientations[:, parent_idx, :])
    rotated_vector = parent_orientation.apply(joint_positions[:, joint_idx, :])
    global_joint_positions[:, joint_idx, :] = global_joint_positions[:, parent_idx, :] + rotated_vector
    global_joint_orientations[:, joint_idx, :] = (parent_orientation * R.from_quat(joint_rotations[:, joint_idx, :])).as_quat()
```

Review on Assignment 1

CCD-IK

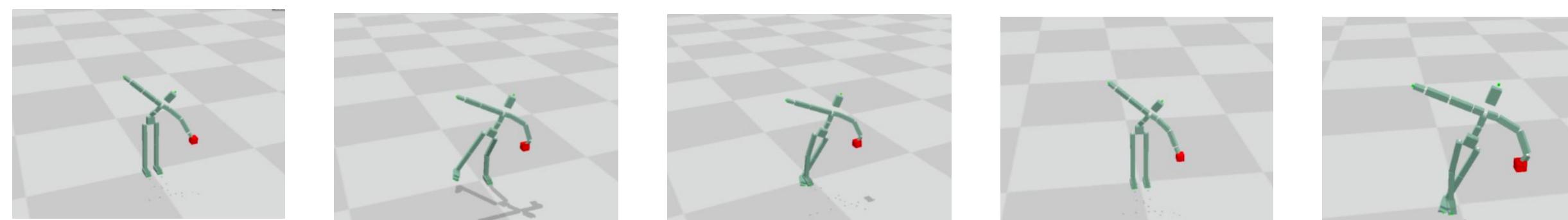
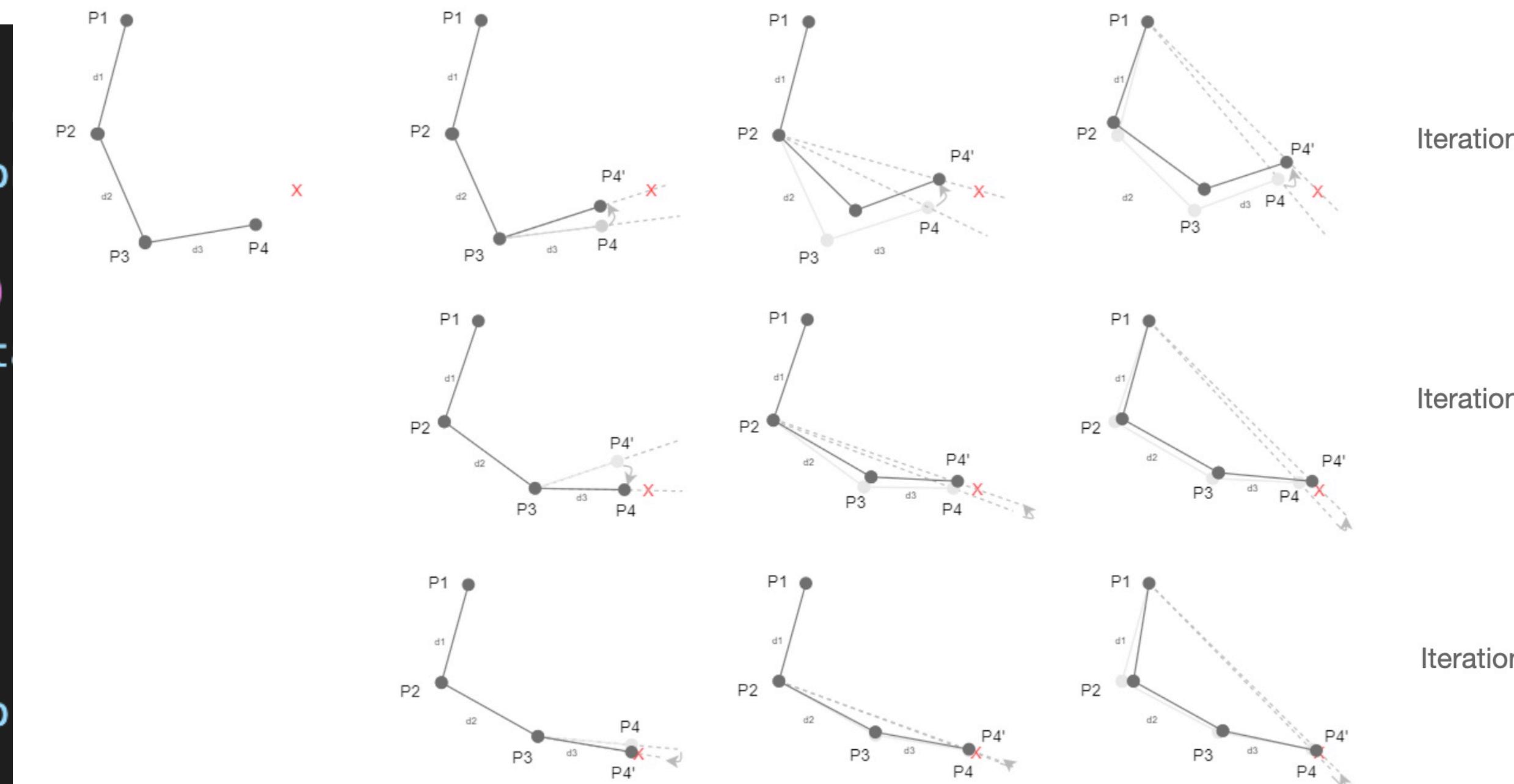
```
##### Code Start #####
vec_cur2end = norm(chain_positions[end_idx] -
vec_cur2tar = norm(target_pose - chain_positio

axis = norm(np.cross(vec_cur2end, vec_cur2tar)
rot = np.arccos(np.vdot(vec_cur2end, vec_cur2t

if np.isnan(rot):
    continue

rotate_vector = R.from_rotvec(rot * axis)
chain_orientations[current_idx] = rotate_vector
##### Code End #####

```



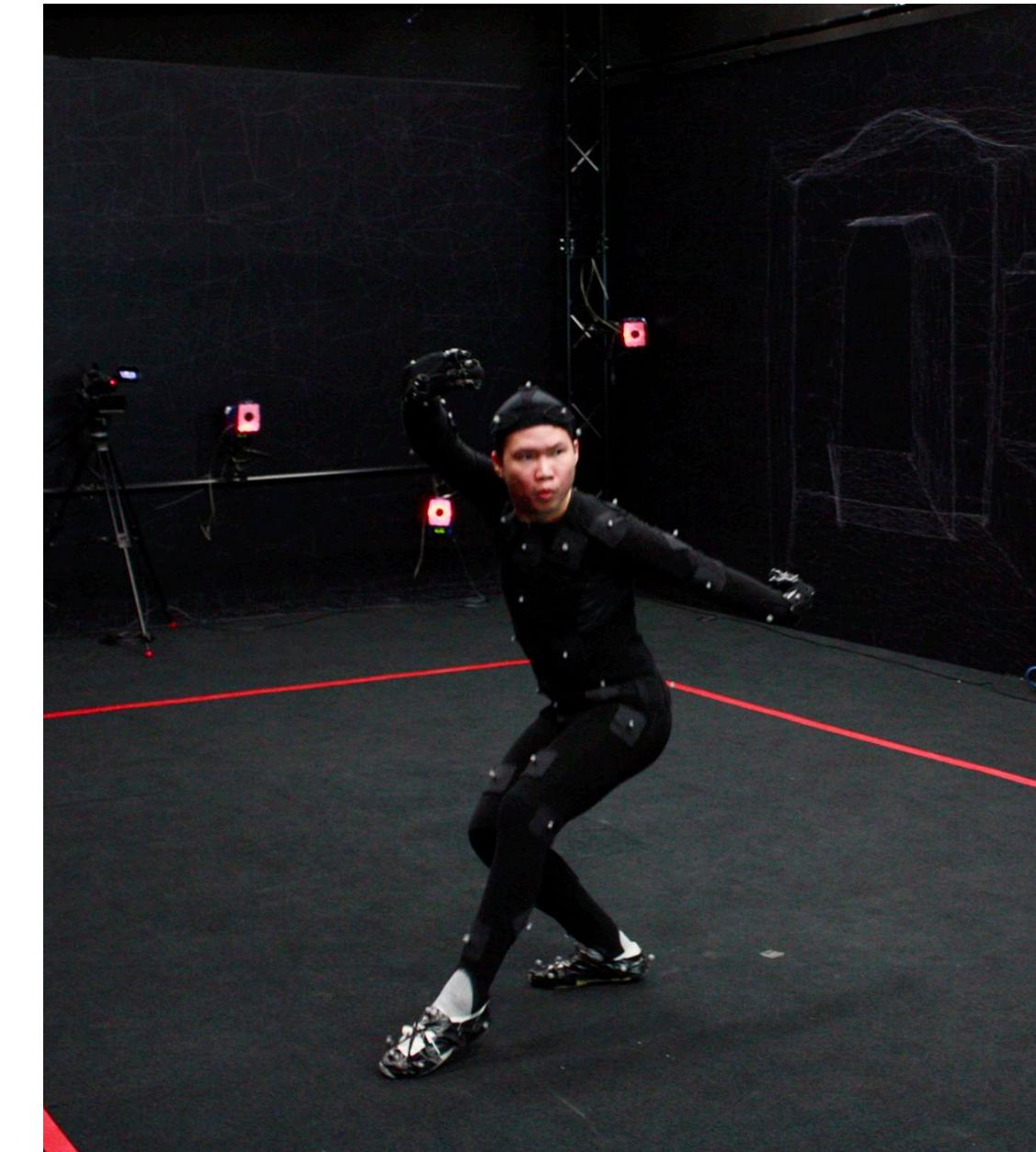
Review on Assignment 1

By the experiment of Keyframe Animation and IK, you might find:

1. Some poses look unrealistic
2. It requires lots of experiences to produce high quality animation
3. IK makes problems also (sometimes)

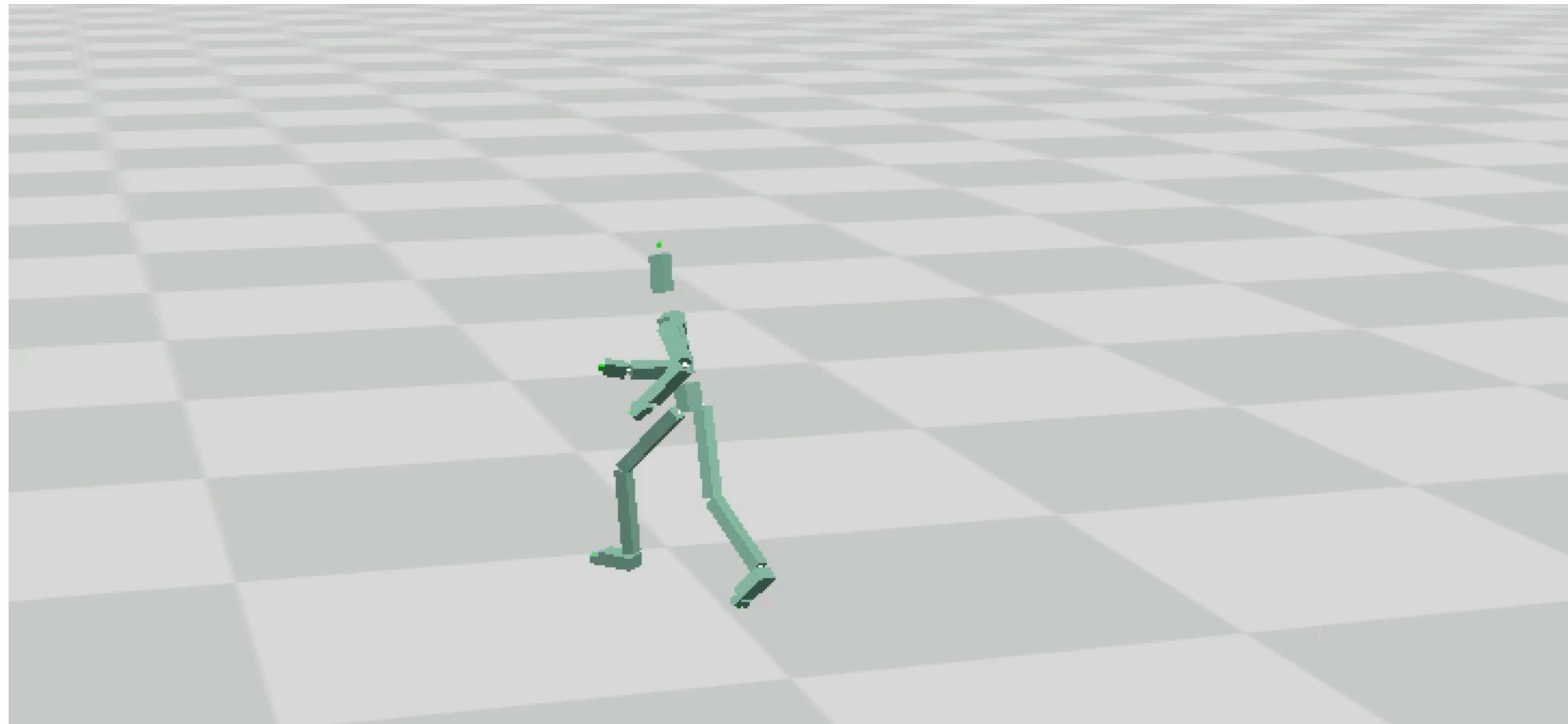
We are trying to improve it

But we still need Motion Capture



Tutorial 3 - Agenda

- Basic properties for the motion data
- Implement the Temporal Editing of motion data (30%)
- Implement a simple Motion Blending (35%)



(Under python and panda3D environment)

Motion Features

- Frametime = $1 / \text{fps}$
- Joint Velocity: $\text{delta_}(jointPosition) / \text{delta_}(t)$
- Joint Angular Velocity $\text{delta_}(jointRotation) / \text{delta_}(t)$
- Predicted(future) joint position/rotation: $\text{current_position} + \text{velocity} * \text{time}$

AS2 Task 1: Temporal Editing

- Given a motion data with 120 frames, 30 fps (4s)
- Downsampling: take frame 0, 2, 4, 6... 120. Keep 15 fps, 4s
- Upsampling: use 120 frames to do the interpolation for generating 240 frames, keep same time duration -> 60 fps
- Change the frame number, but use different fps

What is Interpolation

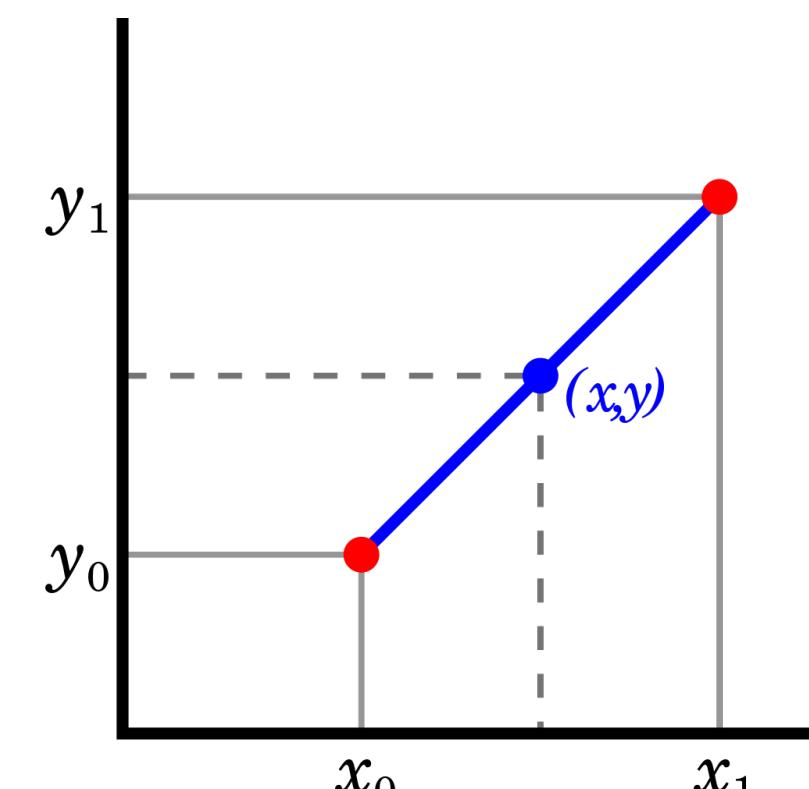
- 1, 2, 3, 4, 5, 6, ?, ?, ?, 10, 11 can we fill it?

- 1, ?, ?, ?, ?, ?, ?, ?, ?, 11 can we fill it?

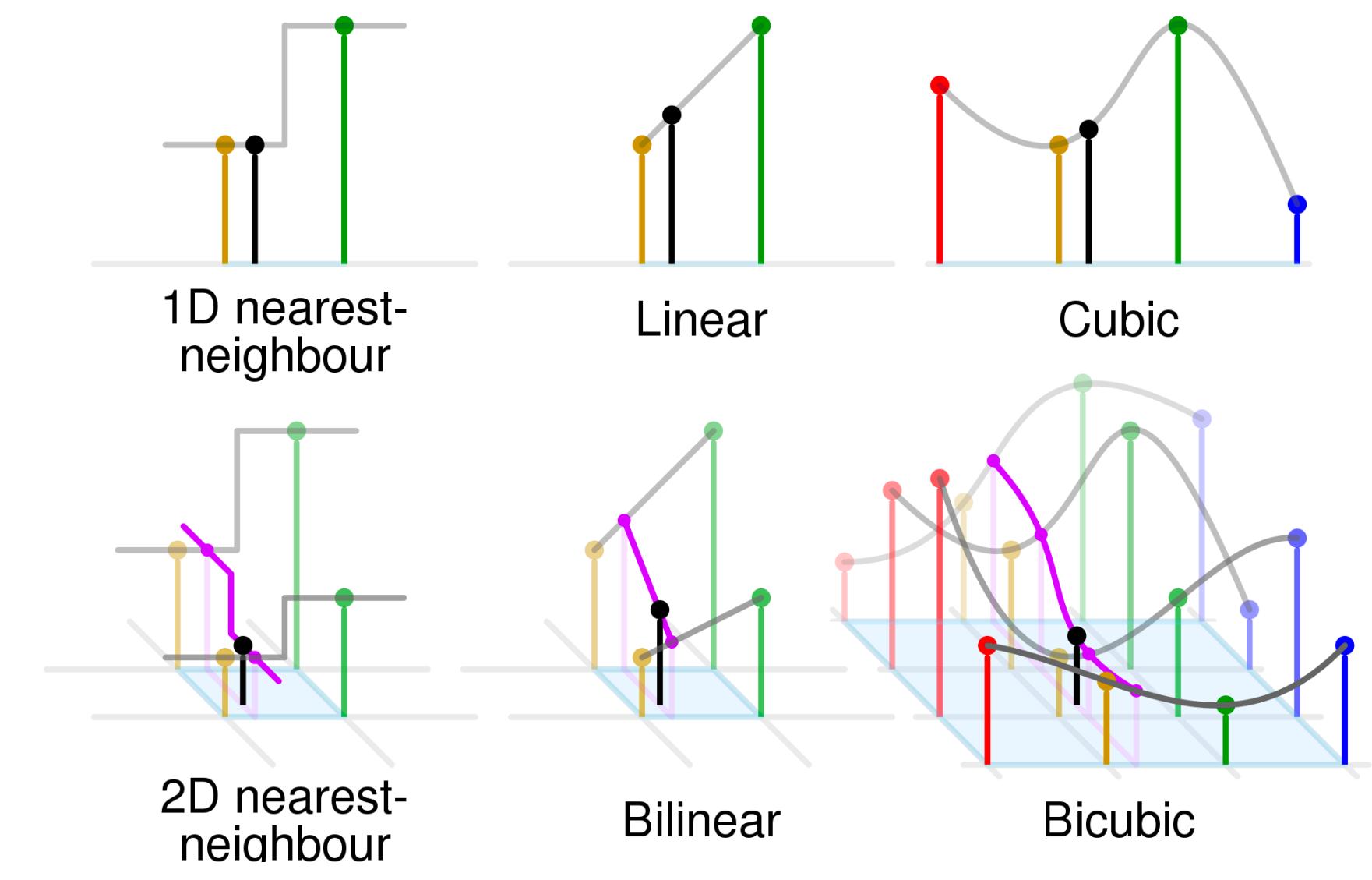
$$\text{offset} = 11 - 1 = 10$$

$$\text{per_item_offset} = 10 / 10 = 1$$

$$\text{results} = [1 + i * 1] \text{ for } i \text{ in range}(0, 10)$$

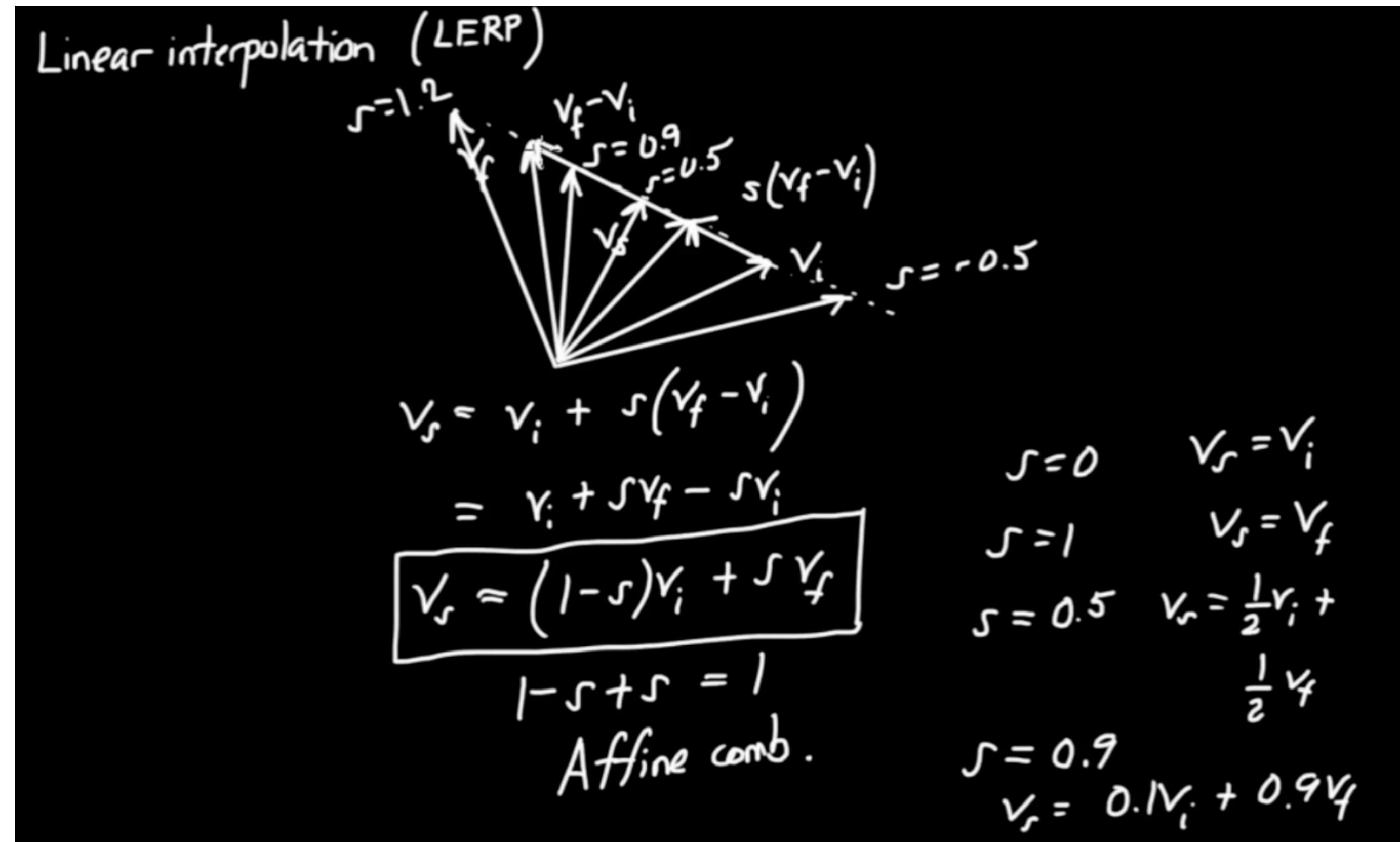


Linear interpolation, refer to [wiki](#)



The zoo of interpolation method

Linear Interpolation for vector

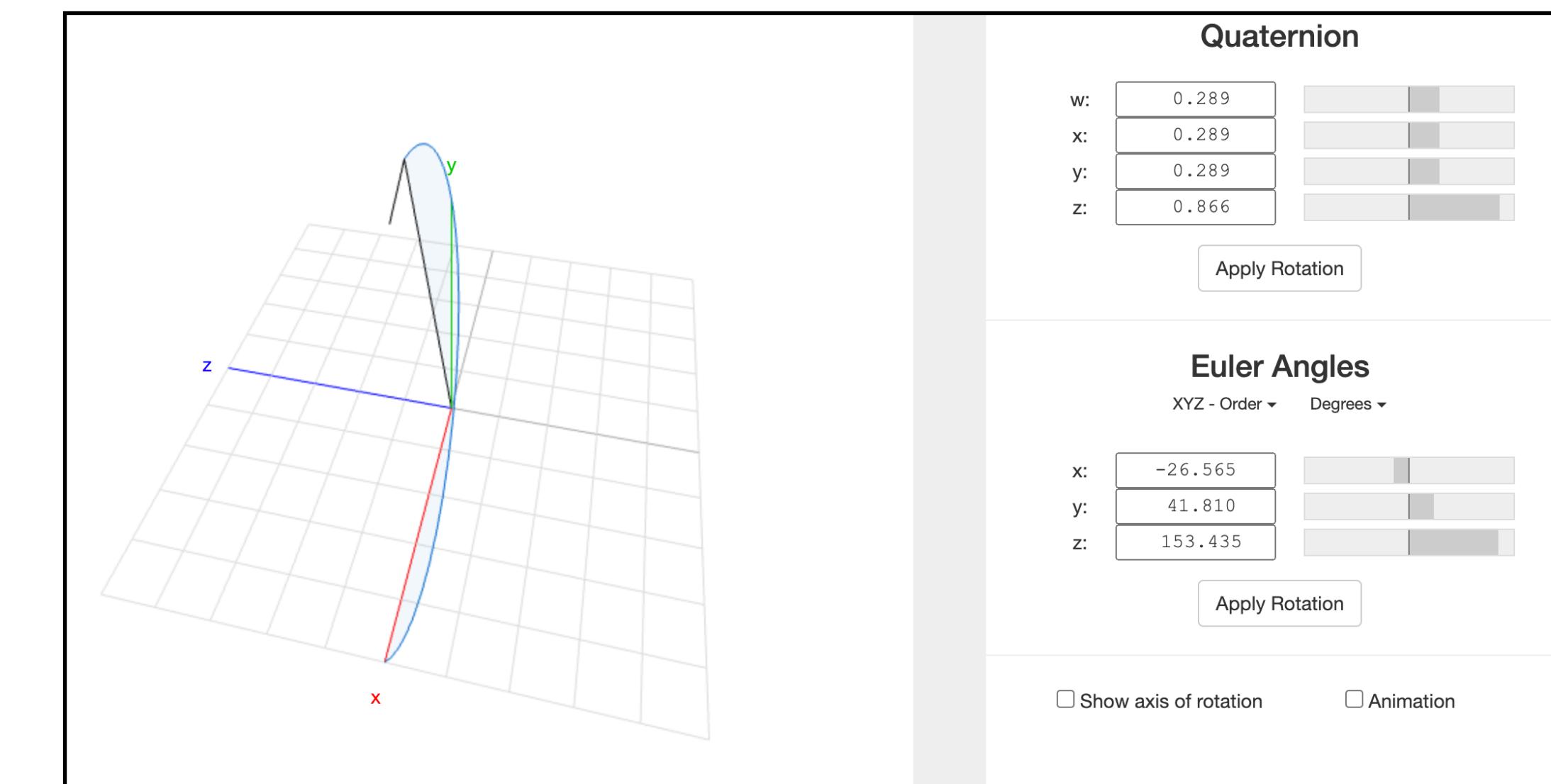
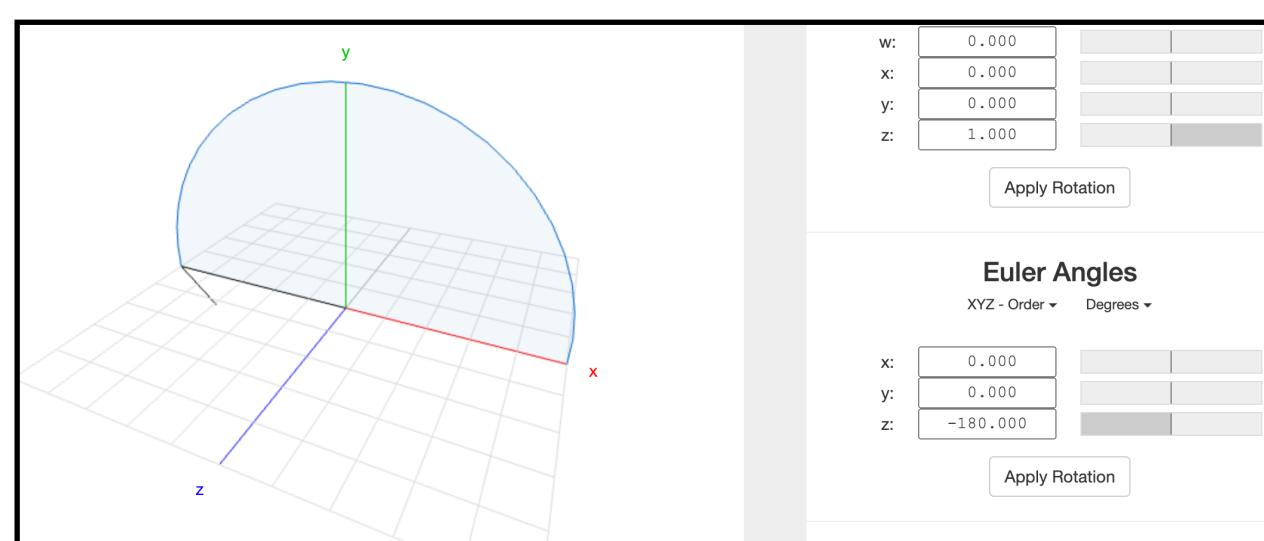
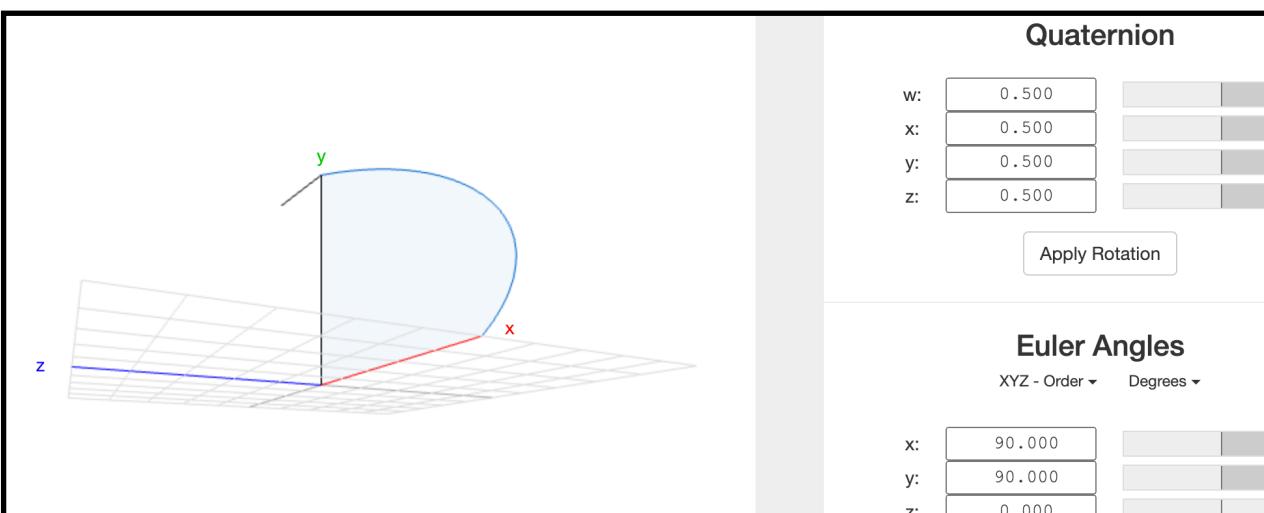


What is Interpolation

Pose = local_joint_position + local_joint_rotation

We can apply the linear on the joint position, but how about the rotation?

For example, we have [0.5, 0.5, 0.5, 0.5] and [0, 0, 0, 1]

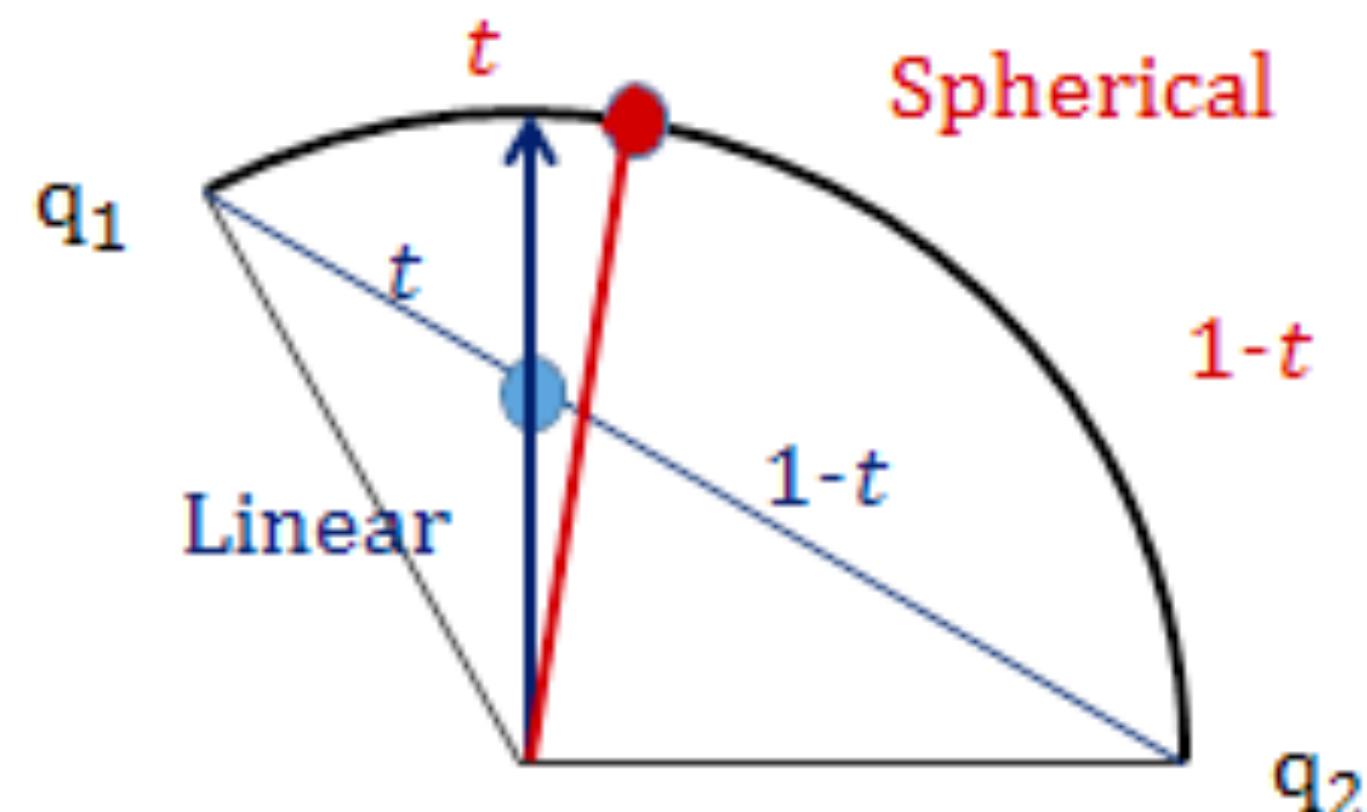


A weird result by linear interpolation

Slerp of Rotation

Name: spherical linear interpolation

We use Scipy to implement it; there are q_1 , q_2 :



More refer to [wiki](#)

```
from scipy.spatial.transform import Slerp
```

```
key_quaternions = R.from_quat(q1), ... (q2)
```

```
keys = [0 , 1]
```

```
slerp_function = Slerp(keys, key_quaternions)
```

```
new_keys = np.linspace(0, 1, 10)      ->      0, 0.1, 0.2 ... 1
```

```
interp_quaternions = slerp_function(new_keys)
```

Assignment 2 - Part 1

```
def part1_key_framing(viewer, time_step, target_step):
    motion = BVHMotion('data/motion_walking.bvh')

    motio_length = motion.local_joint_positions.shape[0]
    keyframes = np.arange(0, motio_length, time_step)

    new_motion_local_positions, new_motion_local_rotations = [], []

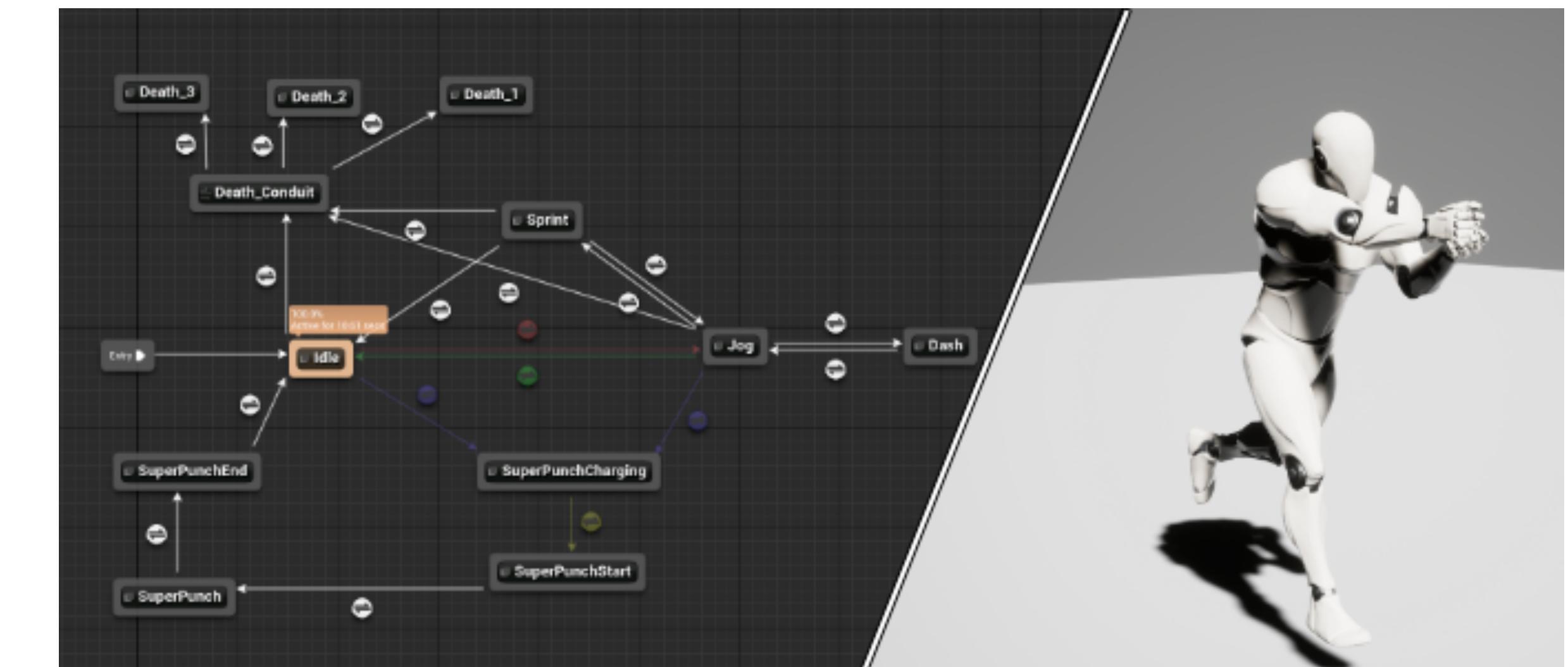
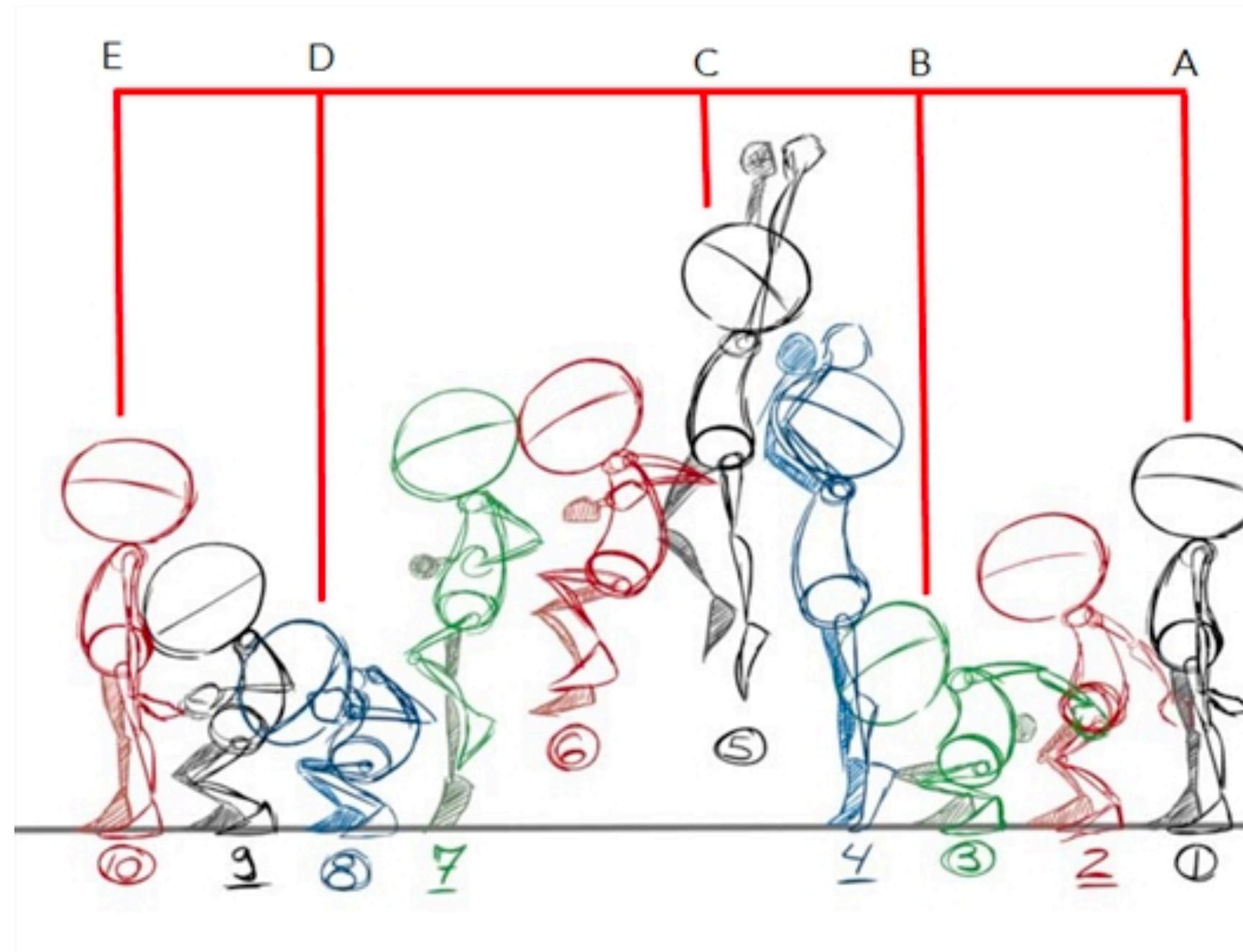
    previous_frame_idx = 0
    for current_frame_idx in keyframes[1:]:
        between_local_pos = interpolation(motion.local_joint_positions[previous_frame_idx],
                                            motion.local_joint_positions[current_frame_idx],
                                            target_step - 1, 'linear')
        between_local_rot = interpolation(motion.local_joint_rotations[previous_frame_idx],
                                            motion.local_joint_rotations[current_frame_idx],
                                            target_step - 1, 'slerp')
        new_motion_local_positions.append(between_local_pos)
        new_motion_local_rotations.append(between_local_rot)
        previous_frame_idx = current_frame_idx
```

```
##### Code Start #####
if method == 'linear':
    return res
elif method == 'slerp':
    return res
##### Code End #####
```

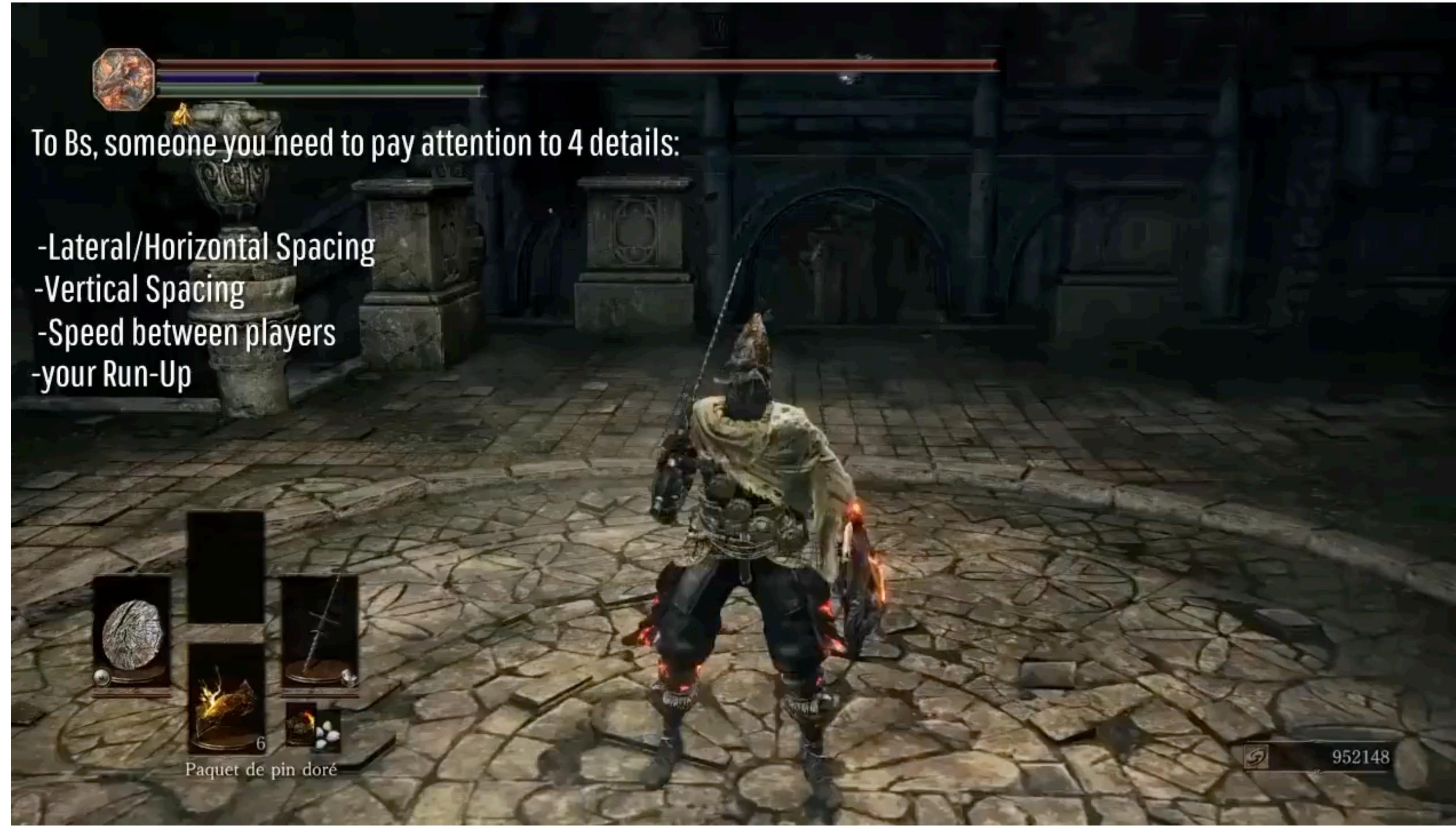
- Linear interpolation (10%)
- Slerp Interpolation (15%)
- Report the different performance by giving different numbers (5%)

```
# part1_key_framing(viewer, 10, 10)
# part1_key_framing(viewer, 10, 5)
# part1_key_framing(viewer, 10, 20)
# part1_key_framing(viewer, 10, 30)
```

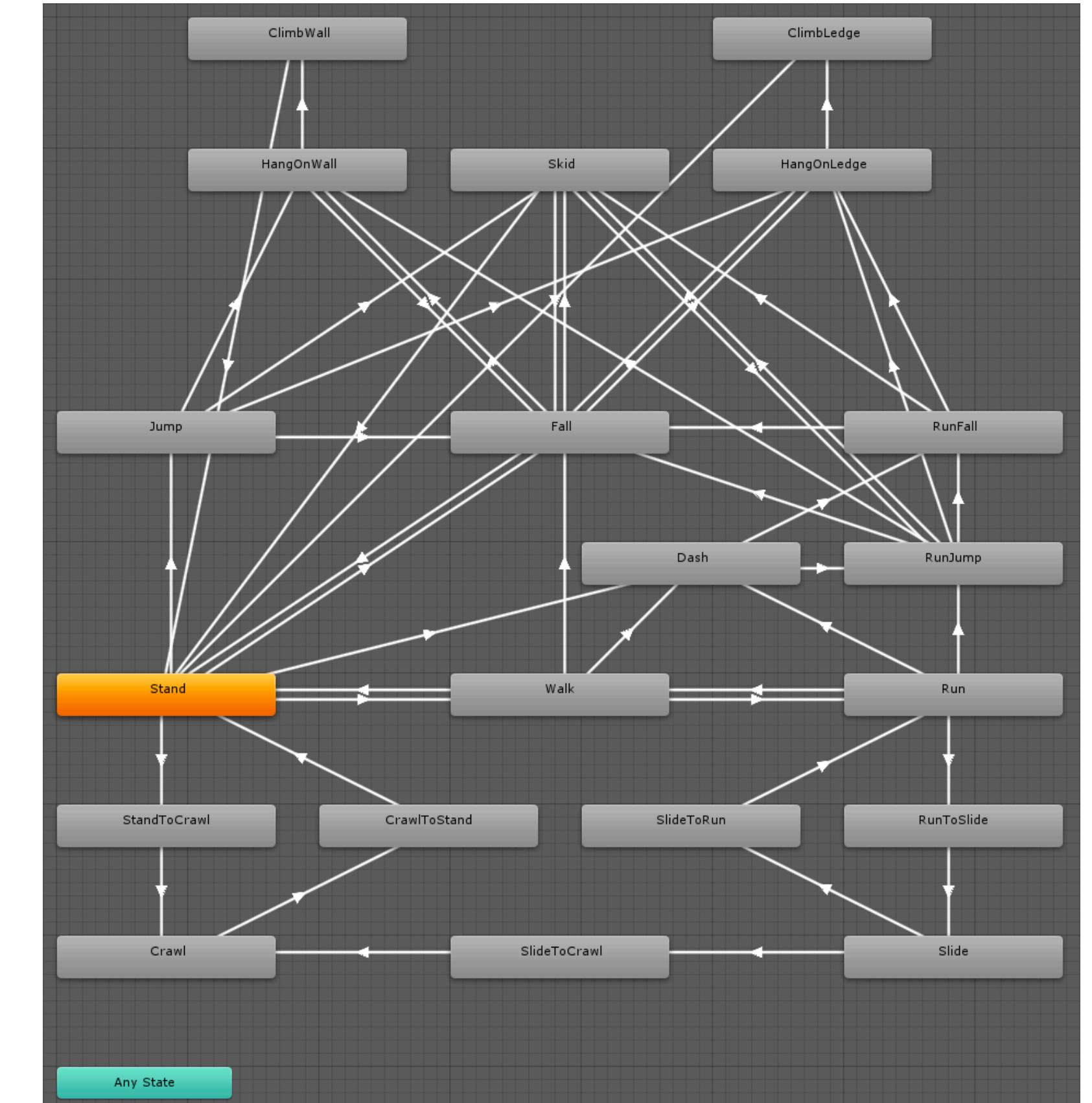
When will we use the interpolation?



Have you played any digital Games?



Controlling system is a combination for lots of motion clips



Character State Machine

Motion Concatenation / Transition

Given two different motions, how can we concatenate them into one?



An idea: The **interpolation** between two frame in these two motion clips

(a simple solution, there are more advanced way in industry)

The basic Idea

- Find a frame_i in motion 1
- Find a frame_j in motion 2
- Generate the between frames for pose_i and pose_j
- Make a new motion by motion1[:frame_i] + between + motion2[frame_j:]

Idea

Source



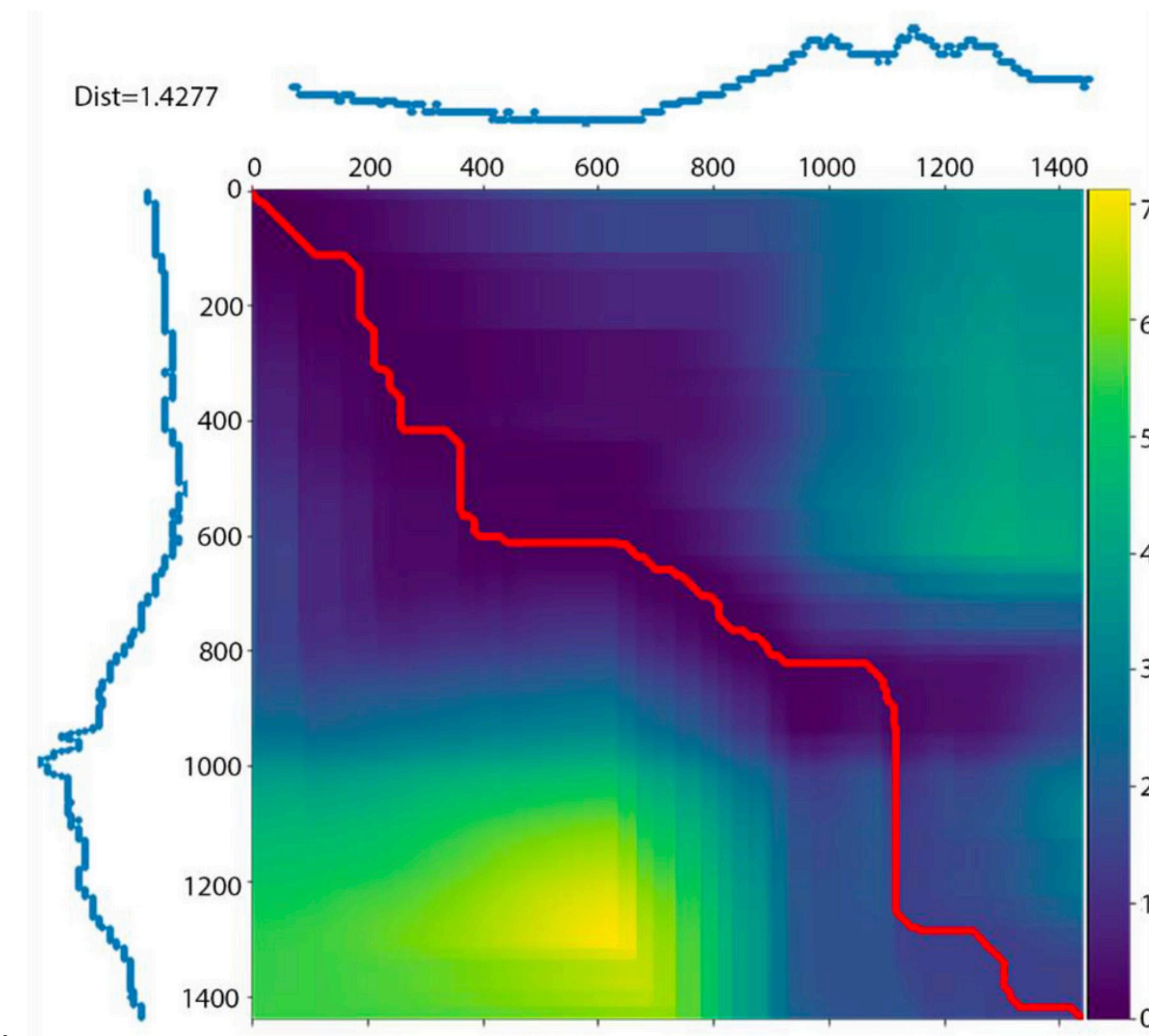
The closest frames



Target

1. Find the closest frames between two motions
2. Get the interpolation by these two frames as betweening poses
3. Concatenate the motion 1, betokening and motion 2 to produce a new one

How to find the closest frames?



Motion 1: 40 frames

Motion 2: 40 frames

We can calculate a similarity matrix with shape (40*40)

i -> the frame index of motion 1

j -> the frame index of motion 2

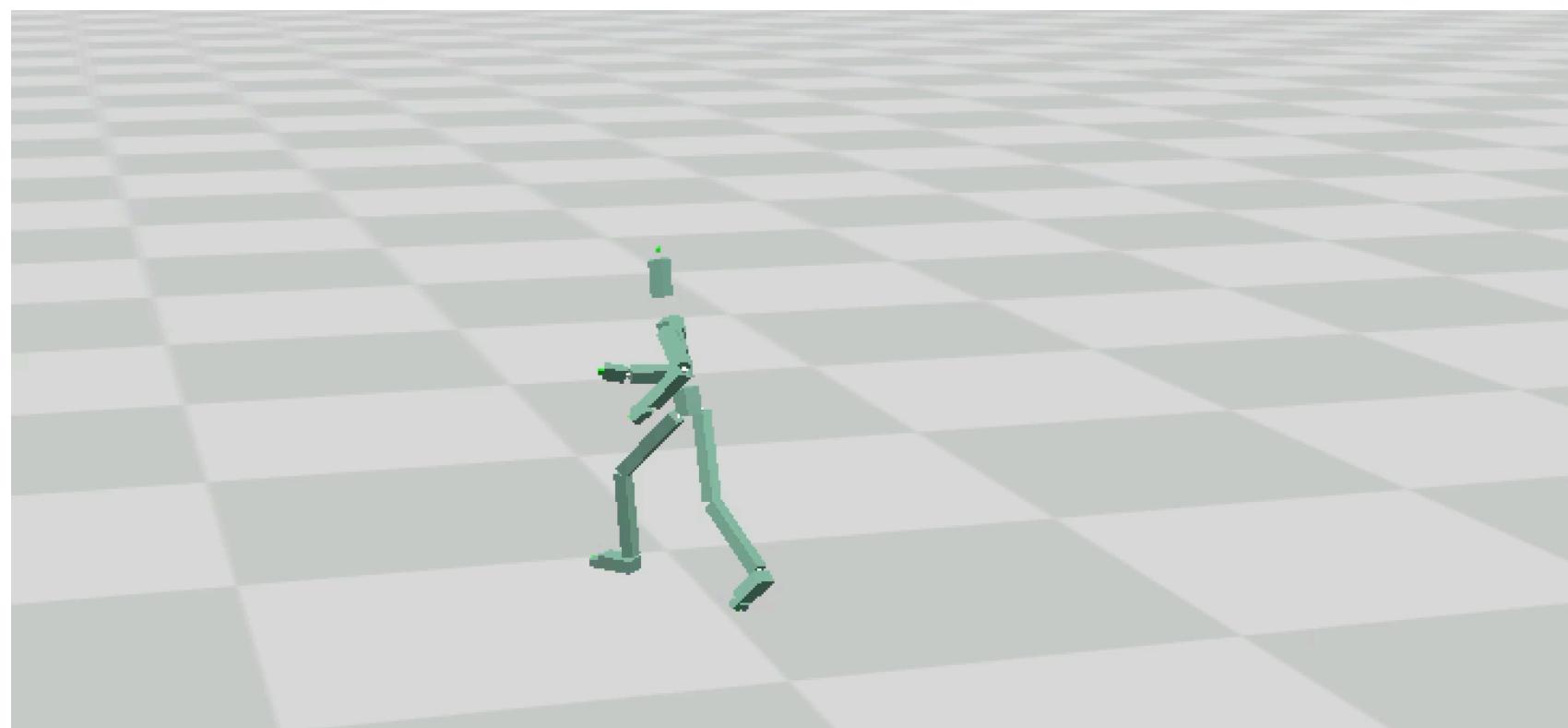
sim_m[i, j] -> the difference between frame i in motion_1 and frame j in motion_2

Then find the index of min value by np.argmin

(The similarity matrix can do lots of things, but we only choose the min value here)

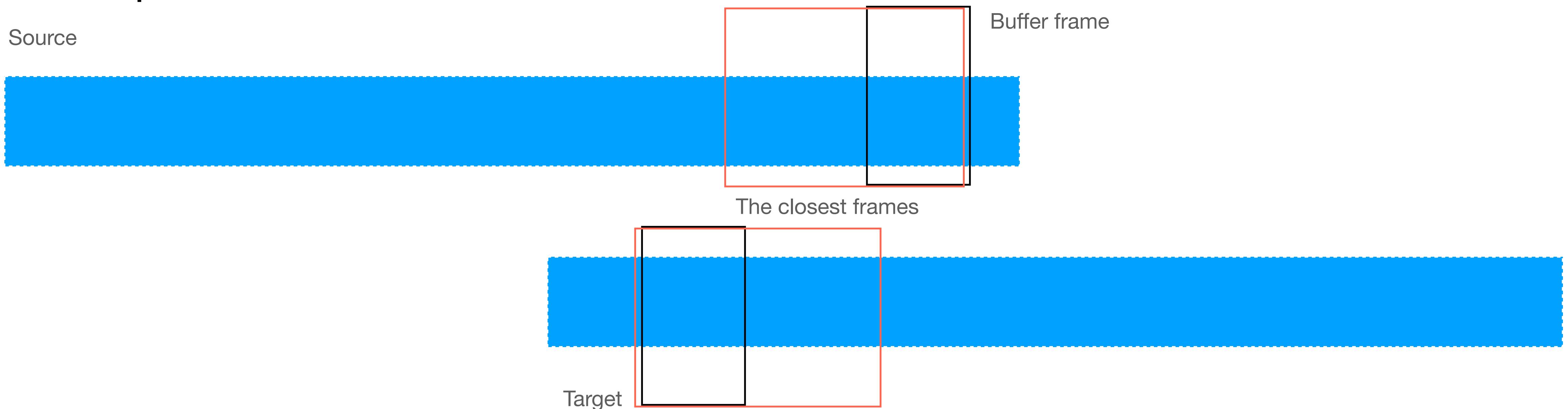
More details

- For the rotations data
 - Find the closest frame, and do the interpolation will be enough
- For the root position data
 - Shift the motion 2 to the motion 1
 - Then do the interpolation between two frames



More details (bonus)

- The velocities of motion1 and motion2 are different If we concatenate them together, it's fine - but not the perfect because of the sharp change of velocity
- Can we use some buffer frame to shift the velocity difference?
- For example, find an average velocity of source_v and target_v, then do the interpolation



Bonus - part 2 is an open problem

- There are N between_frames, but the root position in these frames are not considered
- The velocity of two motions are not the same, it can give different weight to the two motions interpolation
- The inertialization method provides the best results
 - ref:<https://theorangeduck.com/page/spring-roll-call#inertialization>
- Any way to produce more smooth and natural transitions
- Thinking about the above questions will help you in part 3 of assignment 2.

Assignment 2 - Part 2

```
walk_forward = BVHMotion('data/motion_walking.bvh')
run_forward = BVHMotion('data/motion_running.bvh')
run_forward.adjust_joint_name(walk_forward.joint_name)

last_frame_index = 40
start_frame_idx = 0

if not example:
    motion = concatenate_two_motions(walk_forward, run_forward, last_frame_index, start_frame_idx, between_frames, method='interpolation')
```

```
##### Code Start #####
# search_win1 =
# search_win2 =
# sim_matrix =
# min_idx =
# i, j = min_idx // sim_matrix.shape[1], min_idx % sim_matrix.shape[1]
# real_i, real_j =
# between_local_pos =
# between_local_rot =
#
##### Code End #####
```

- Define the search window (10%)
- Calculate the sim_matrix (10%)
- Find the real_i and real_j (10%)
- The shifting on the root joint position (5)

Overview

- part1_key_framing (30%)
 - - Linear interpolation (10%); Slerp Interpolation (15%)
 - - Report the different performance by giving different numbers (5%)
- part2_concatenate (35%)
 - - Define the search window (10%); Calculate the sim_matrix (10%); Find the real_i and real_j (10%); The shifting on the root joint position (5)
 - - Any improvements will get bonus