

# Data Driven Computer Animation

HKU COMP 7580

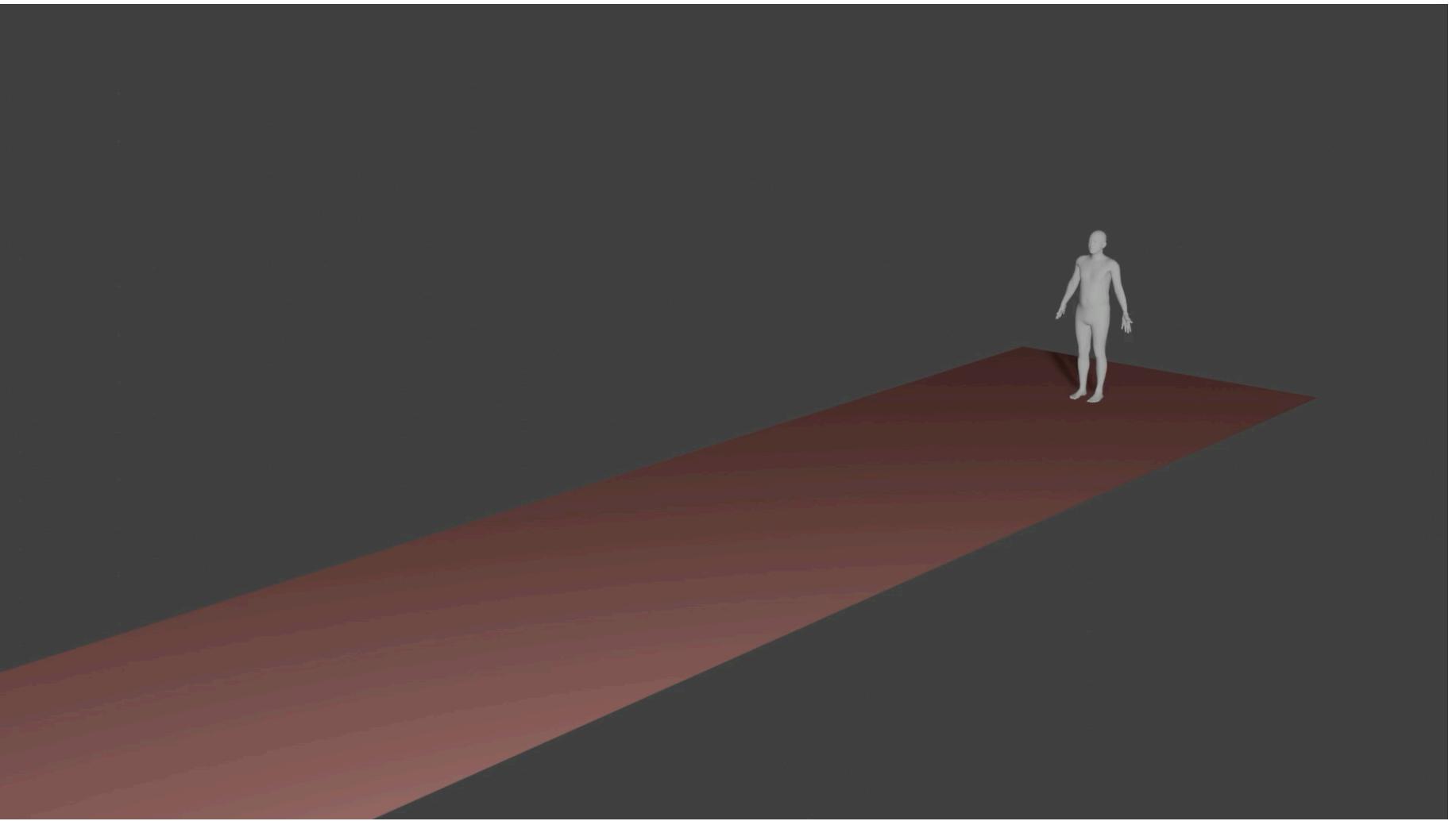
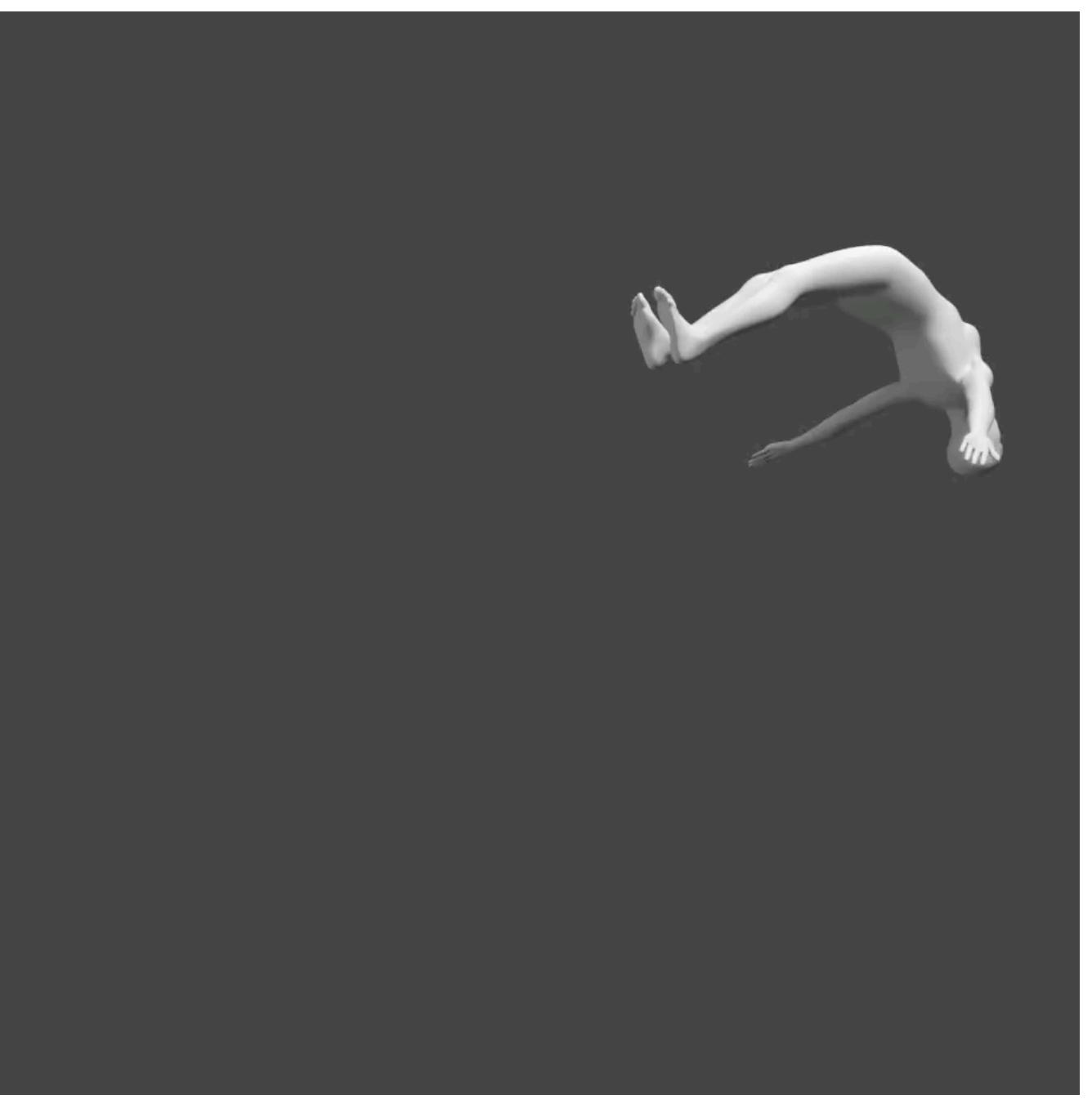
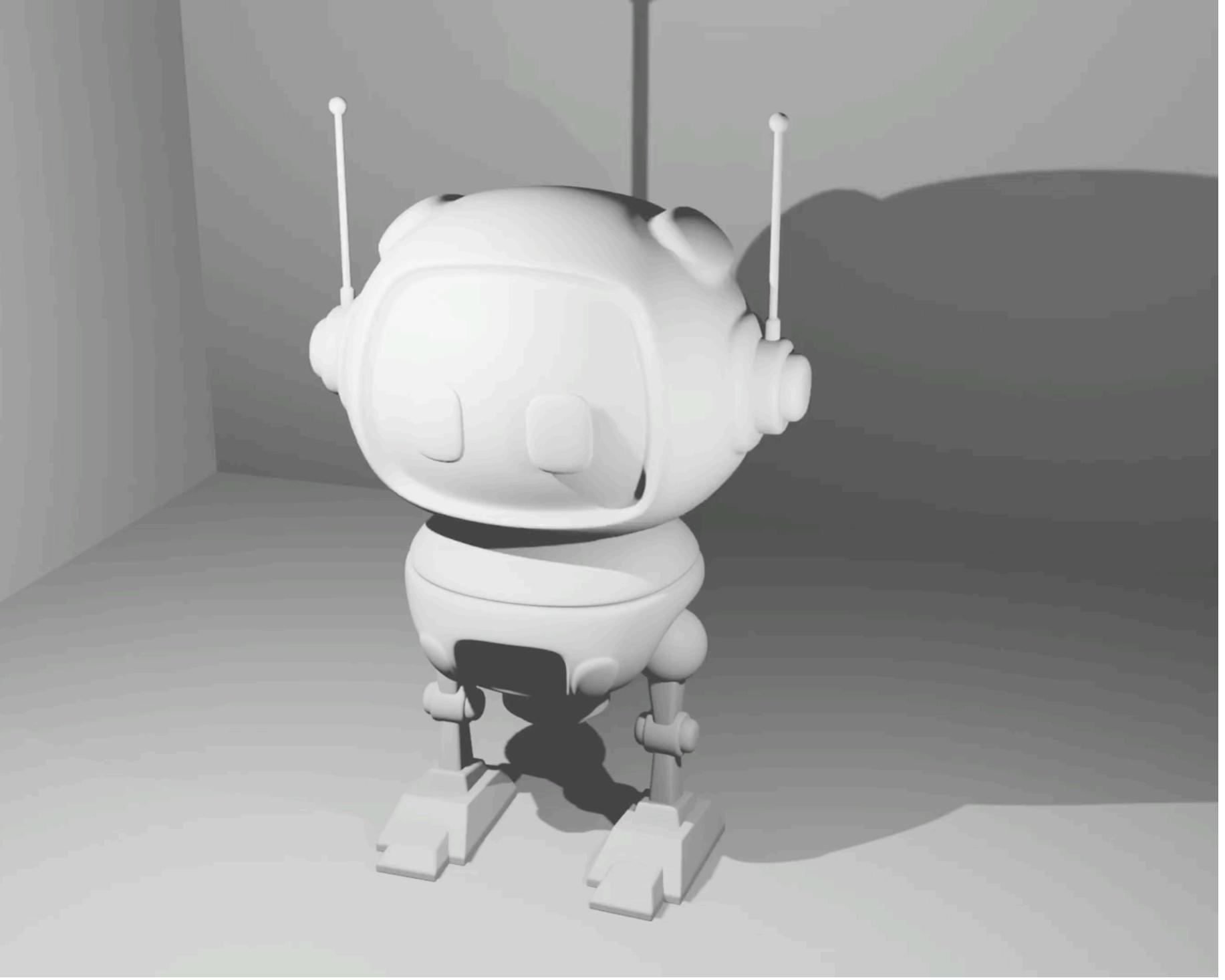
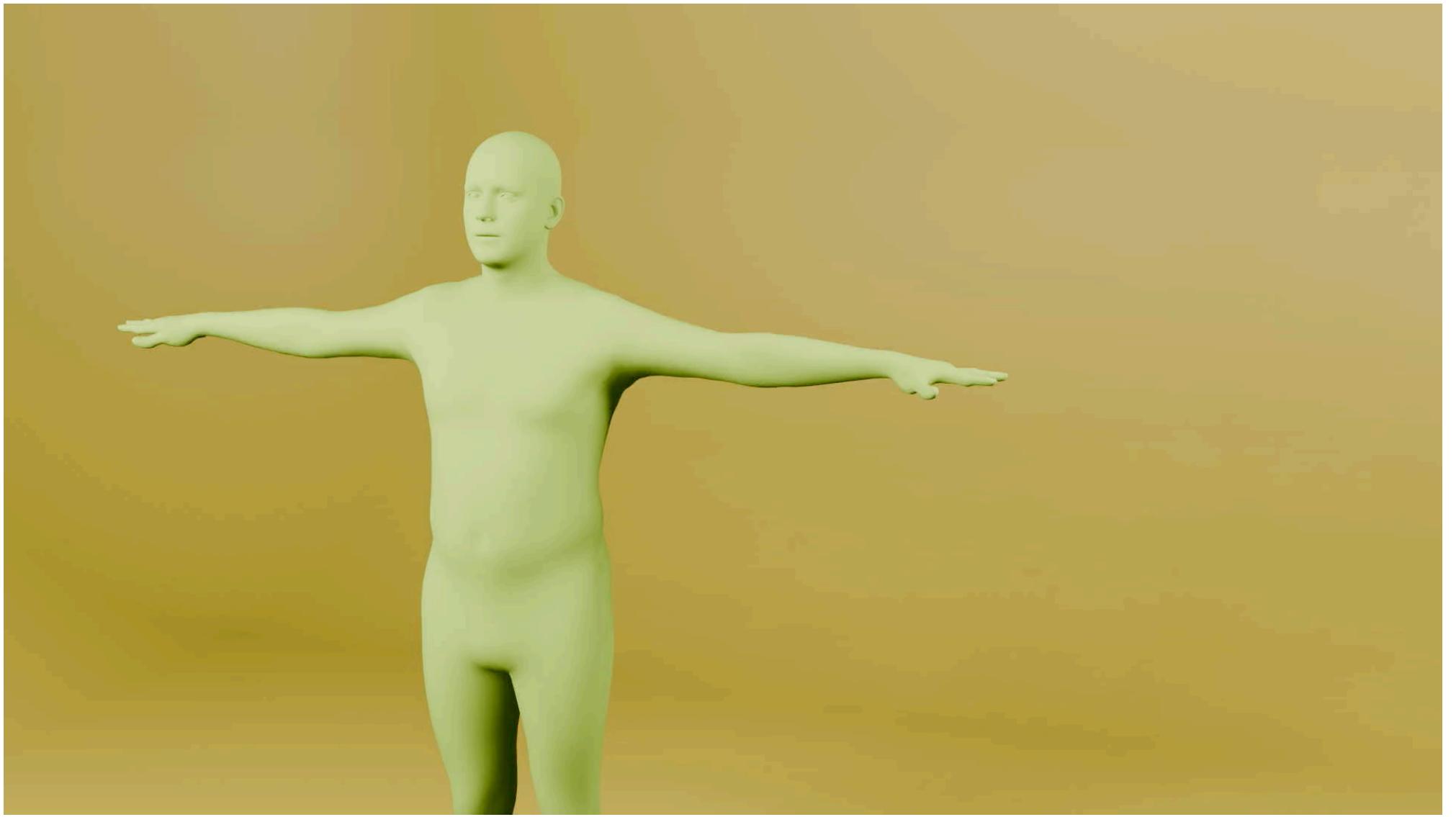
Tutorial 3 - Animation Processing and Scripting

Prof. Taku Komura

TA: Shi Mingyi ([myshi@cs.hku.hk](mailto:myshi@cs.hku.hk)), Zhouyingcheng Liao ([zliao@cs.hku.hk](mailto:zliao@cs.hku.hk))

SECTION 2A, 2023





# Review on Assignment 1

T-Pose

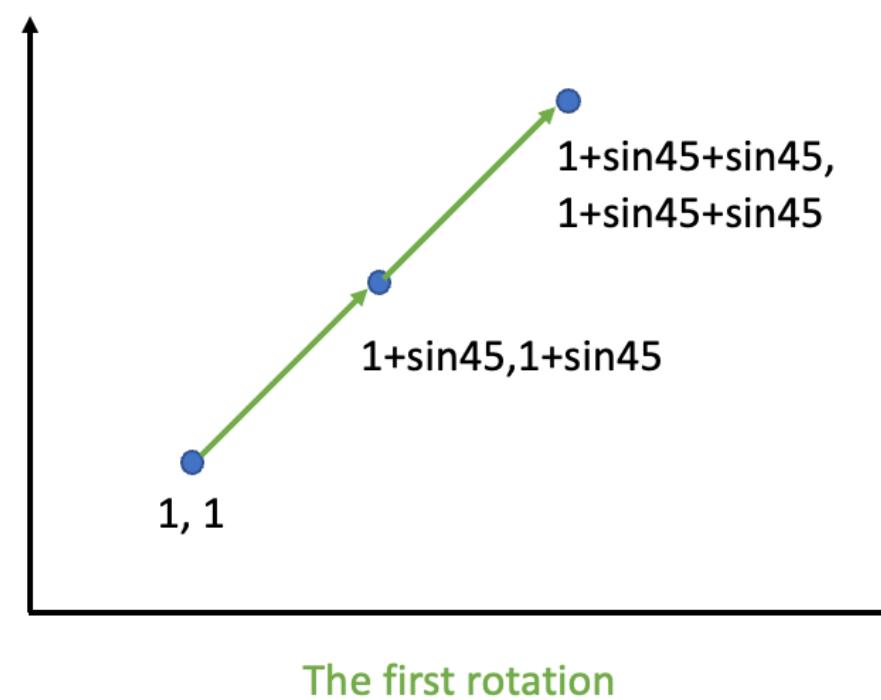
```
if parent_idx == -1:  
    global_joint_position[joint_idx] = joint_offsets[joint_idx]  
else:  
    global_joint_position[joint_idx] = global_joint_position[parent_idx] + joint_offsets[joint_idx]
```



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

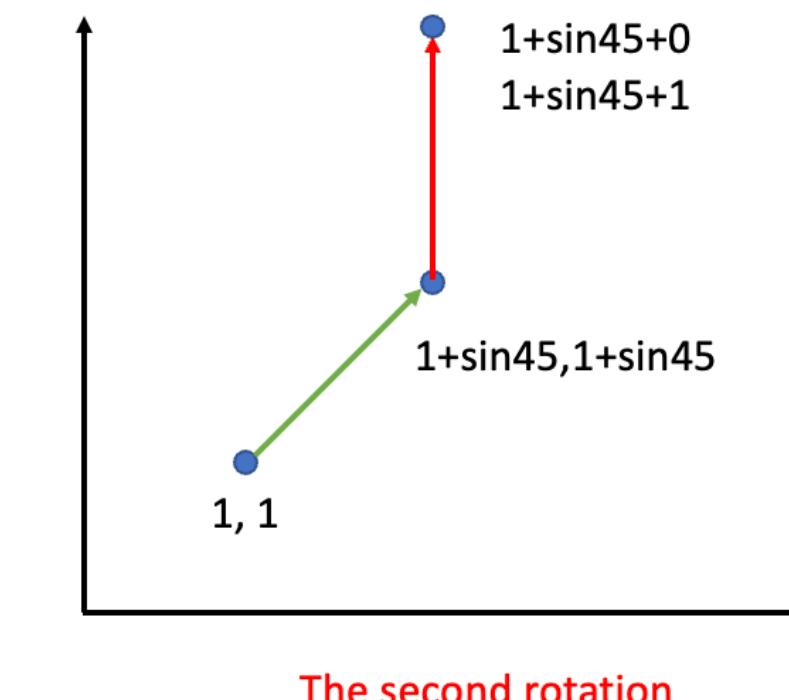
# Review on Assignment 1

Method 1: Consider each rotation



The first rotation  
 $\text{new\_bone0} = \text{bone0} @ 45 \text{ degree} = (\sin 45, \sin 45)$   
 $\text{new\_bone1} = \text{bone1} @ 45 \text{ degree} = (\sin 45, \sin 45)$

Joint 1:  $\text{joint0.position} + \text{new\_bone0}$   
 Joint 2:  $\text{joint1.position(new)} + \text{new\_bone1}$

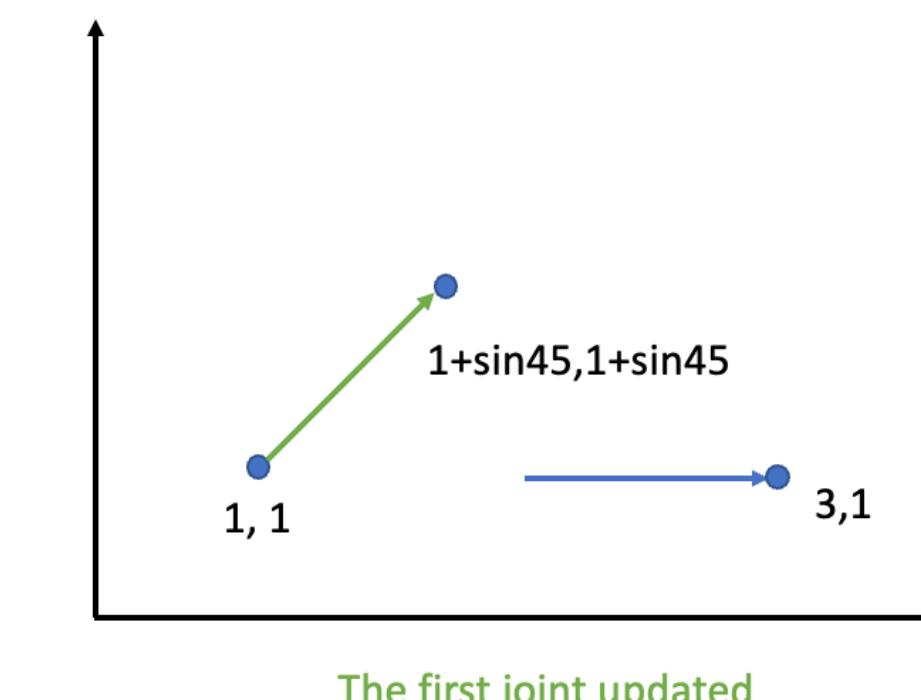


The second rotation  
 $\text{new\_new\_bone1} = \text{new\_bone1} @ 45 \text{ degree} = (0, 1)$

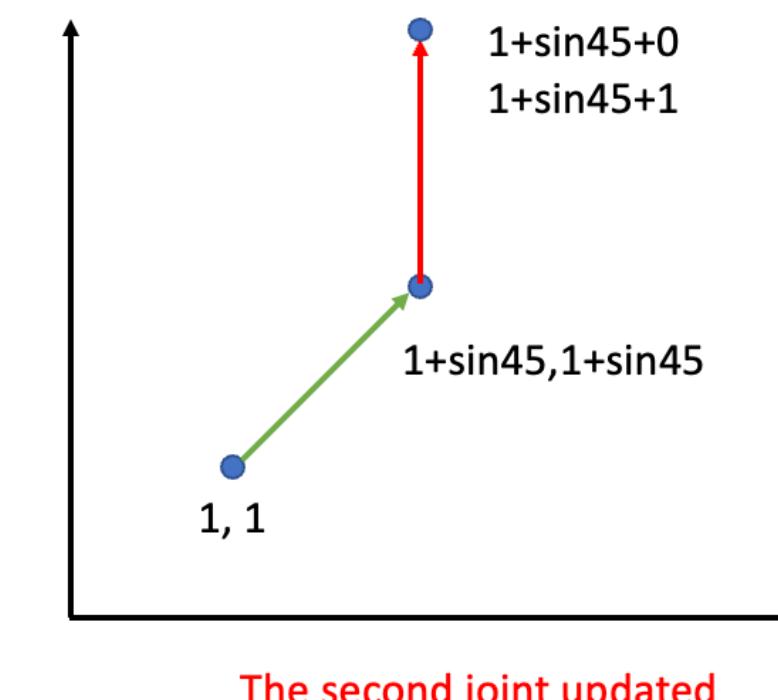
Joint 2:  $\text{joint1.position(new)} + \text{new\_new\_bone1}$

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

Method 2: Consider each bone



The first joint updated  
 $\text{new\_bone0} = \text{bone0} @ 45 \text{ degree} = (\sin 45, \sin 45)$   
 Joint 1:  $\text{joint0.position} + \text{new\_bone0} = 1 + \sin 45, 1 + \sin 45$



The second joint updated  
 $\text{new\_joint1\_rotation} = 45 + 45 = 90$   
 $\text{new\_bone1} = \text{bone1} @ 90 \text{ degree} = (0, 1)$   
 Joint 2:  $\text{joint1.position(new)} + \text{new\_bone1}$

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

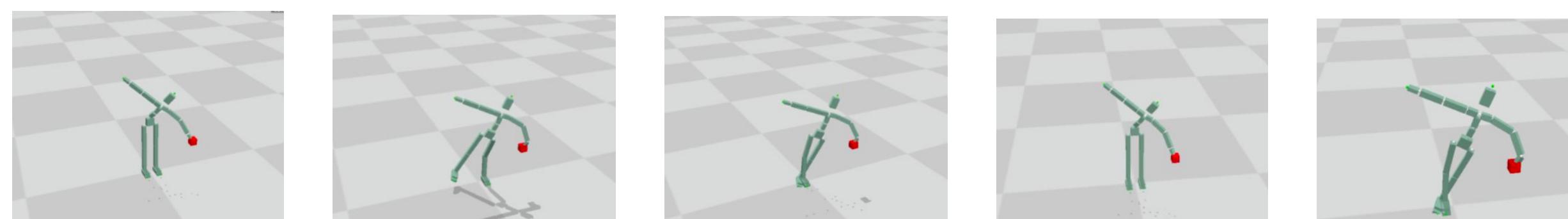
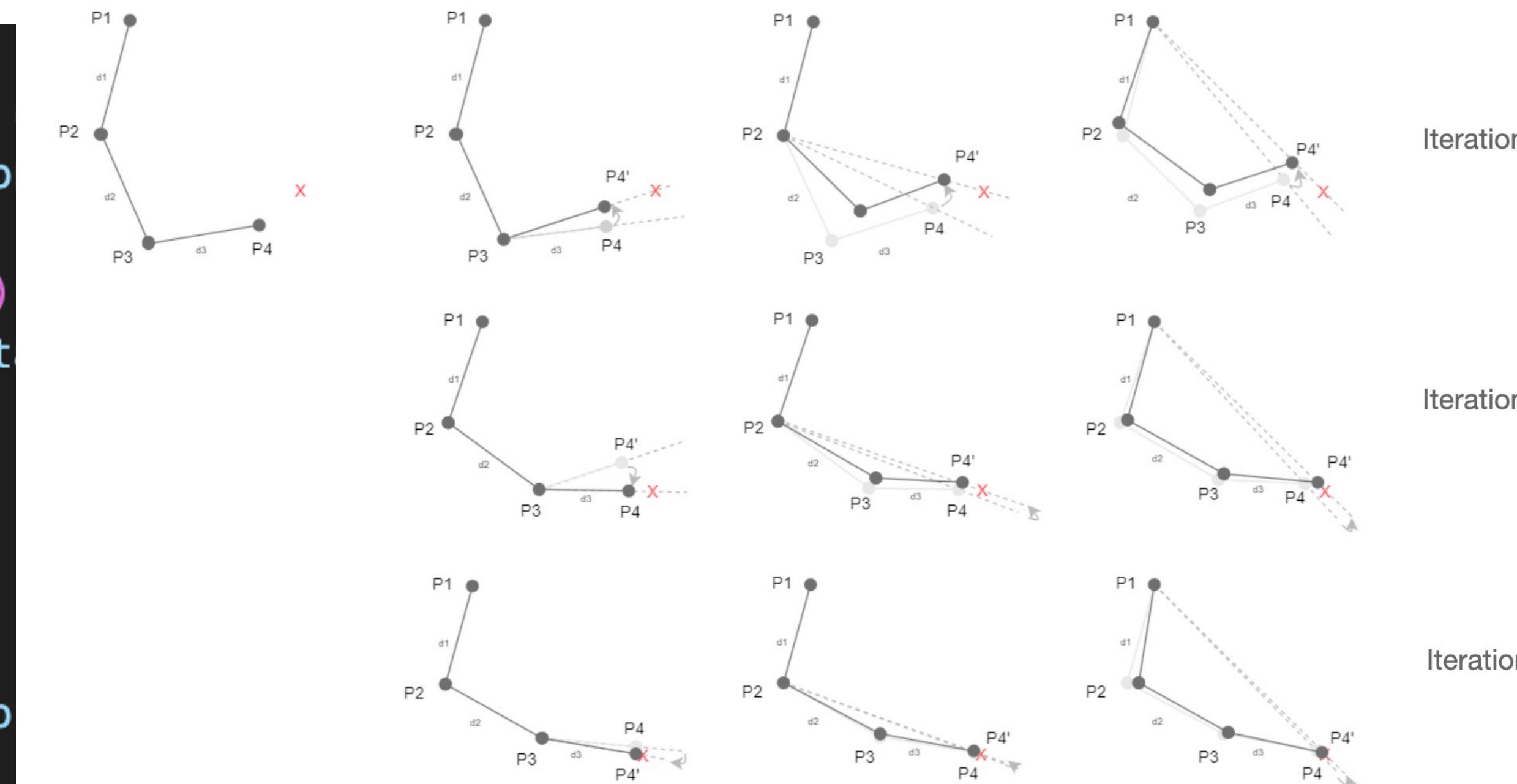
```
##### Code Start #####
vec_cur2end = norm(chain_positions[end_idx] -
vec_cur2tar = norm(target_pose - chain_positio

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)

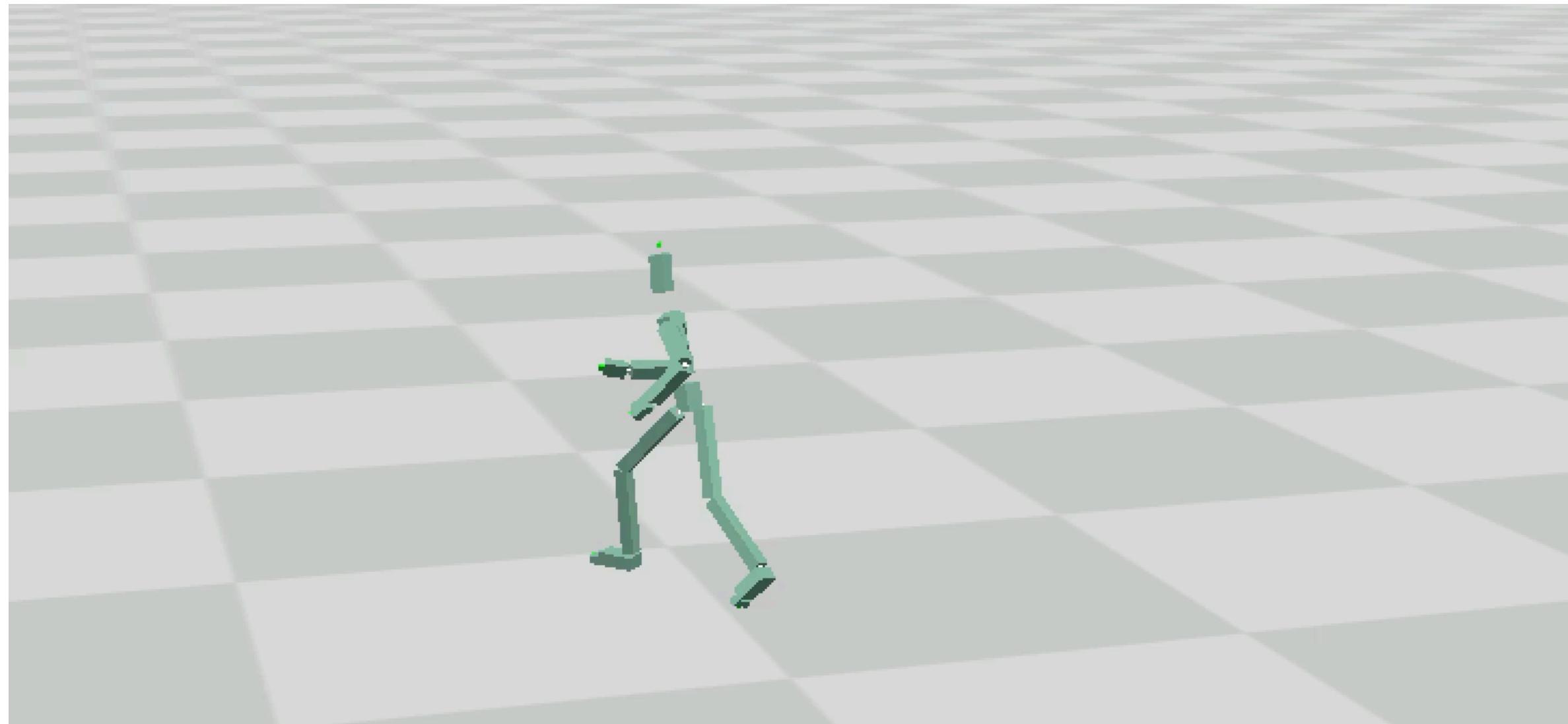
**We are trying to improve it**

**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

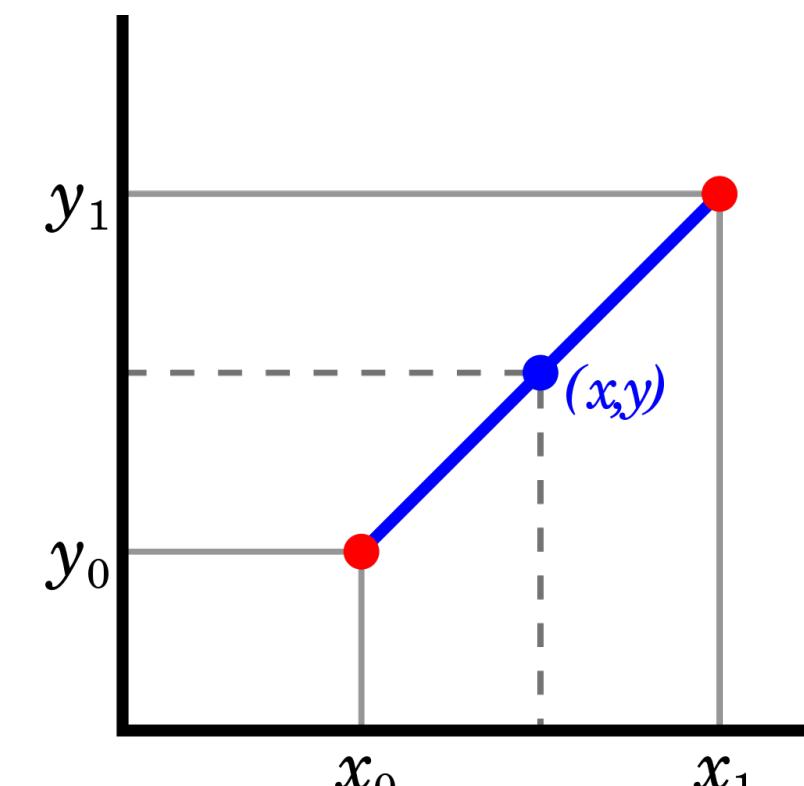
- 1, 2, 3, 4, 5, 6, ?, ?, ?, 10, 11      can we fill it?

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

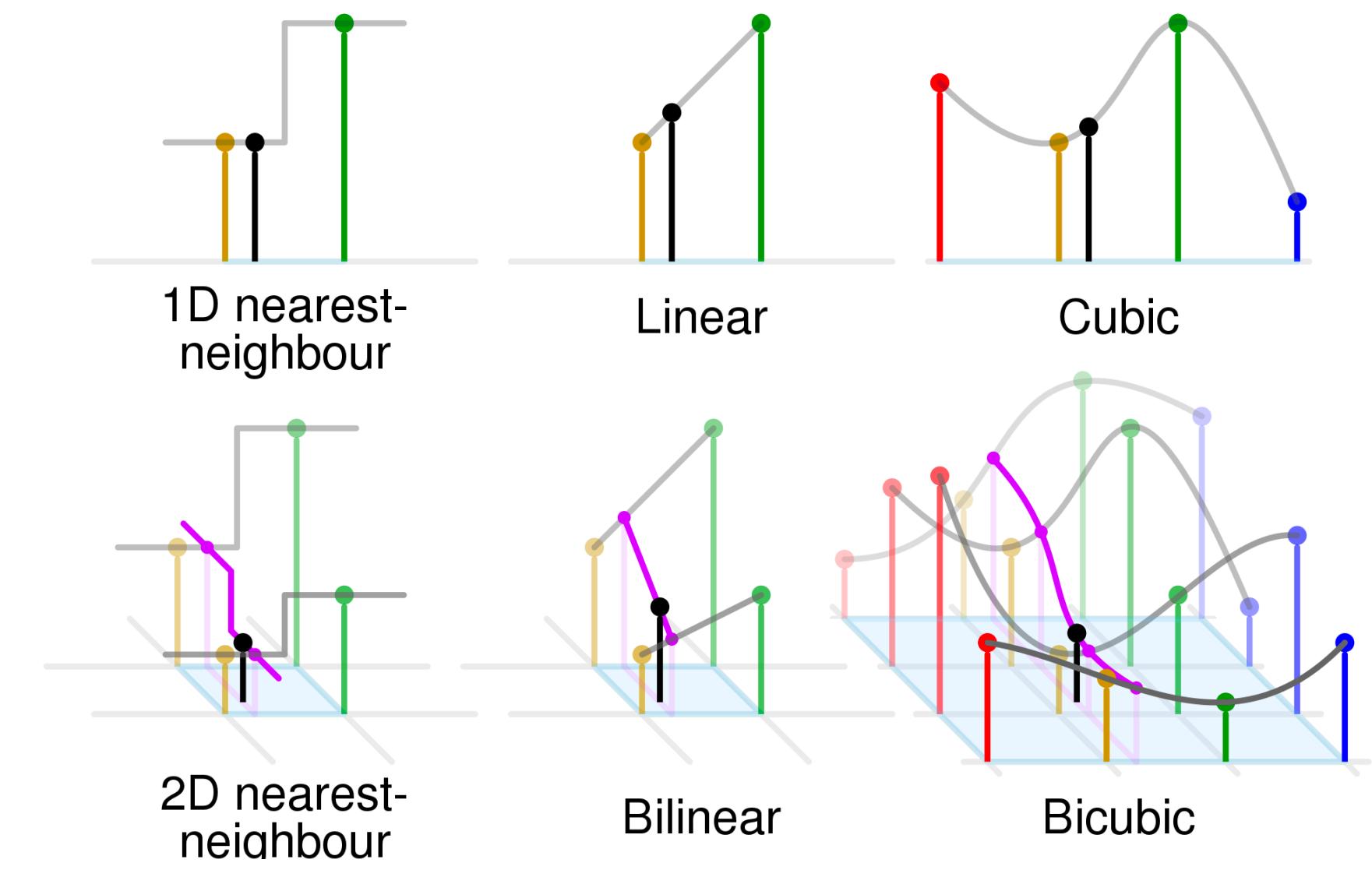
$$\text{offset} = 11 - 1 = 10$$

$$\text{per\_item\_offset} = 10 / 10 = 1$$

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

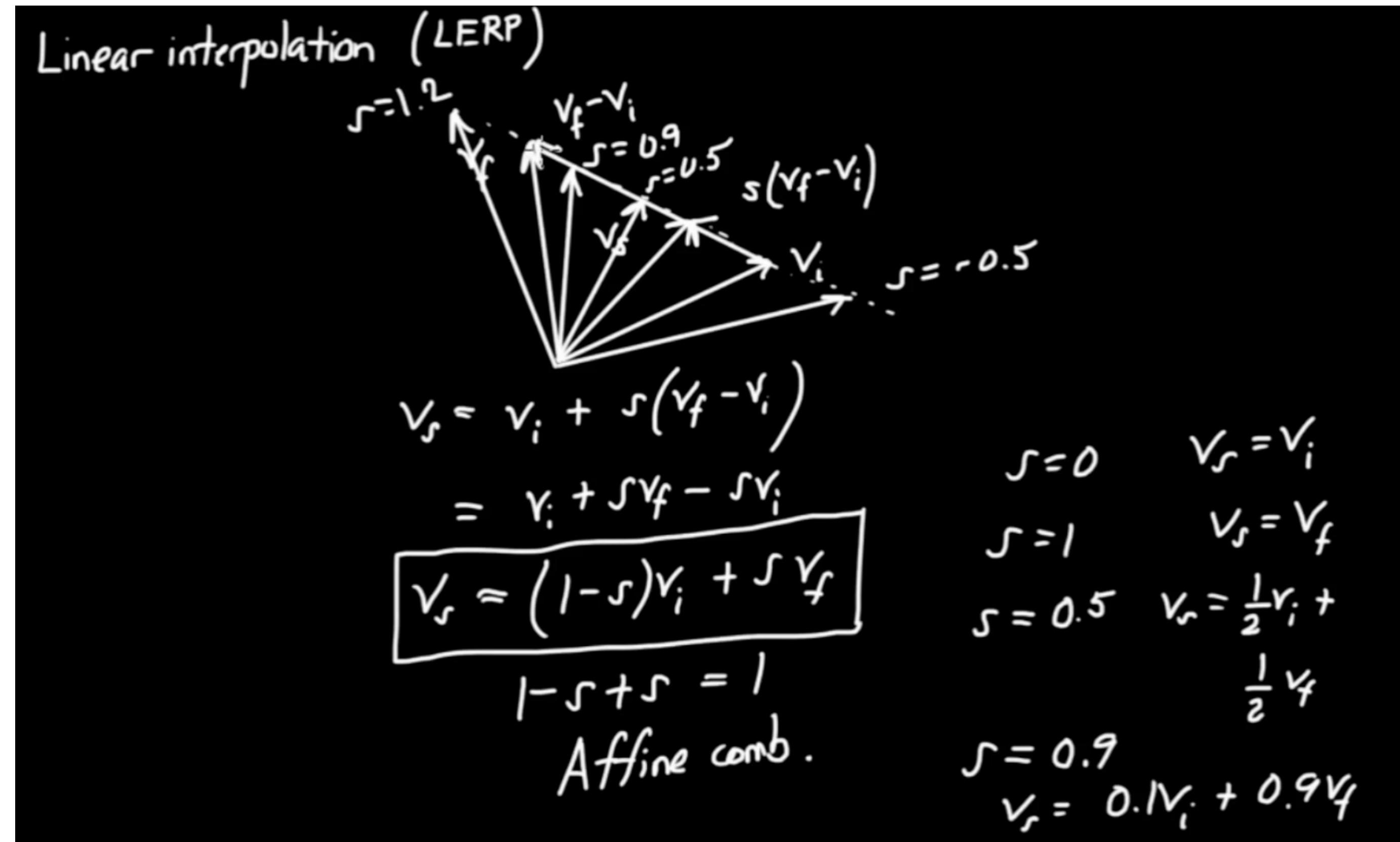


Linear interpolation, refer to [wiki](#)



The zoo of interpolation method

# Linear Interpolation for vector

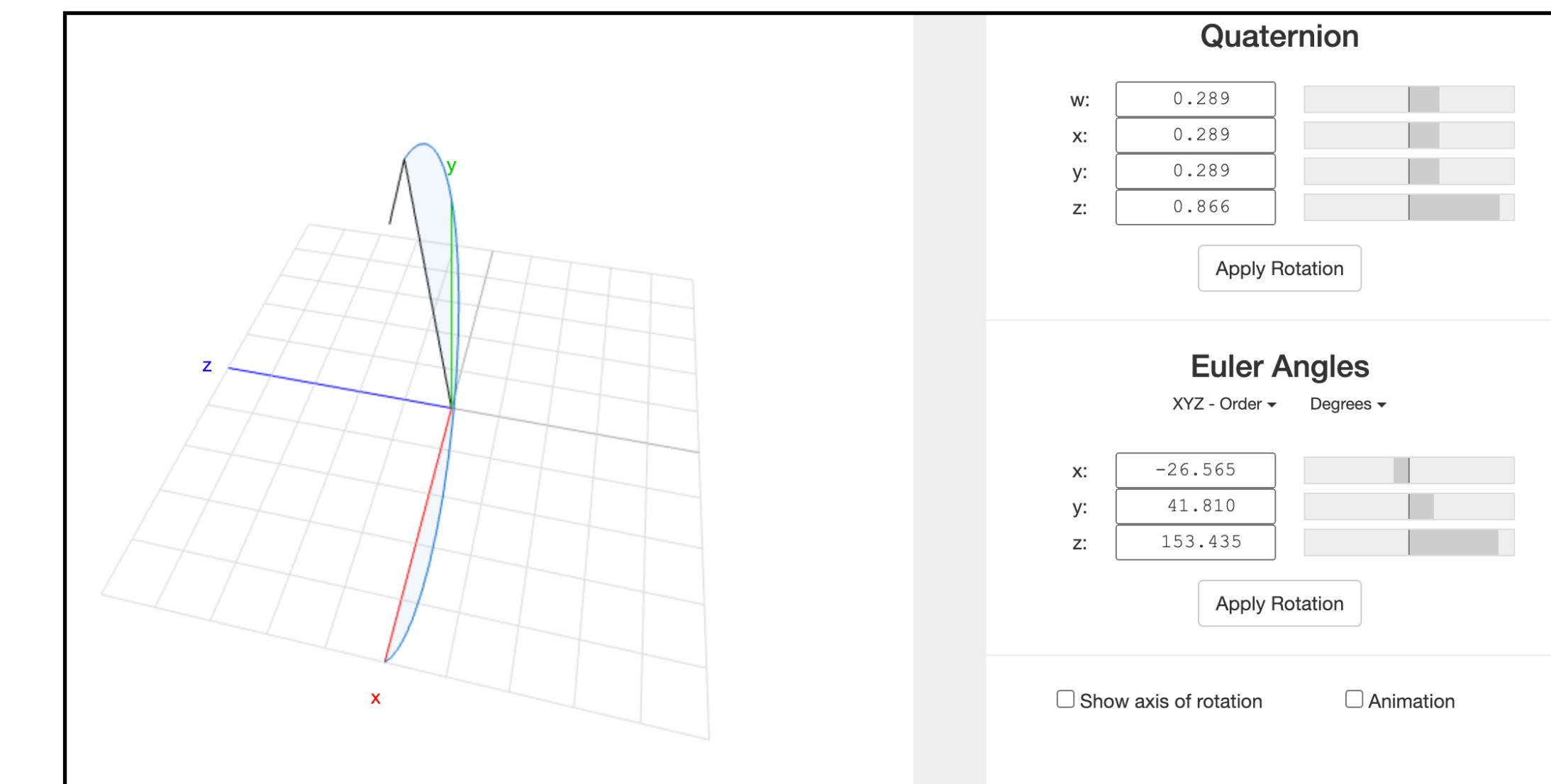
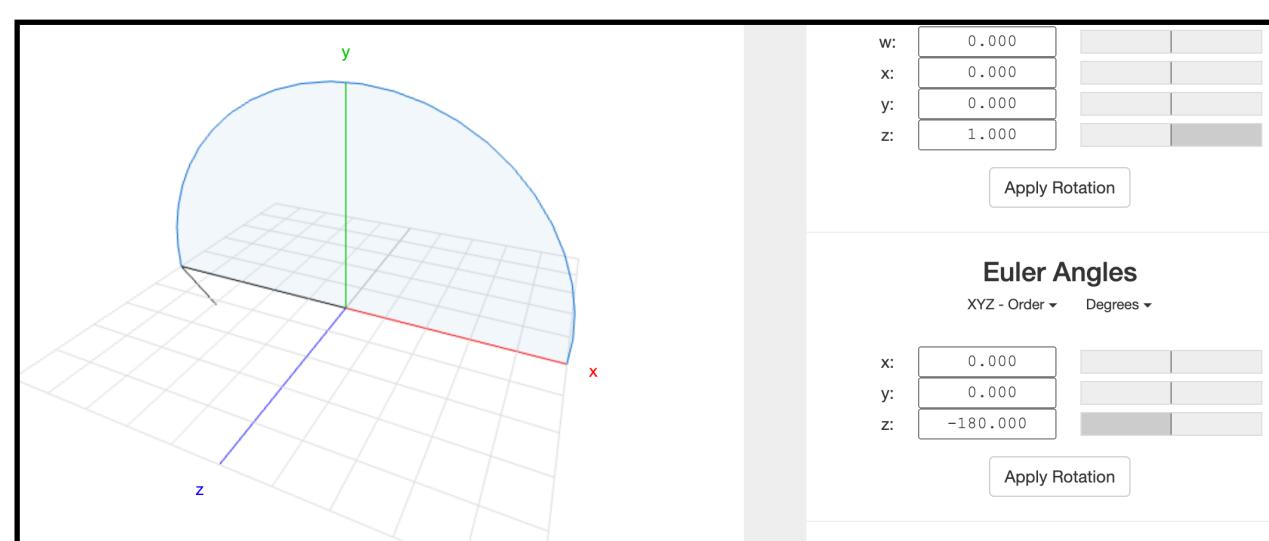
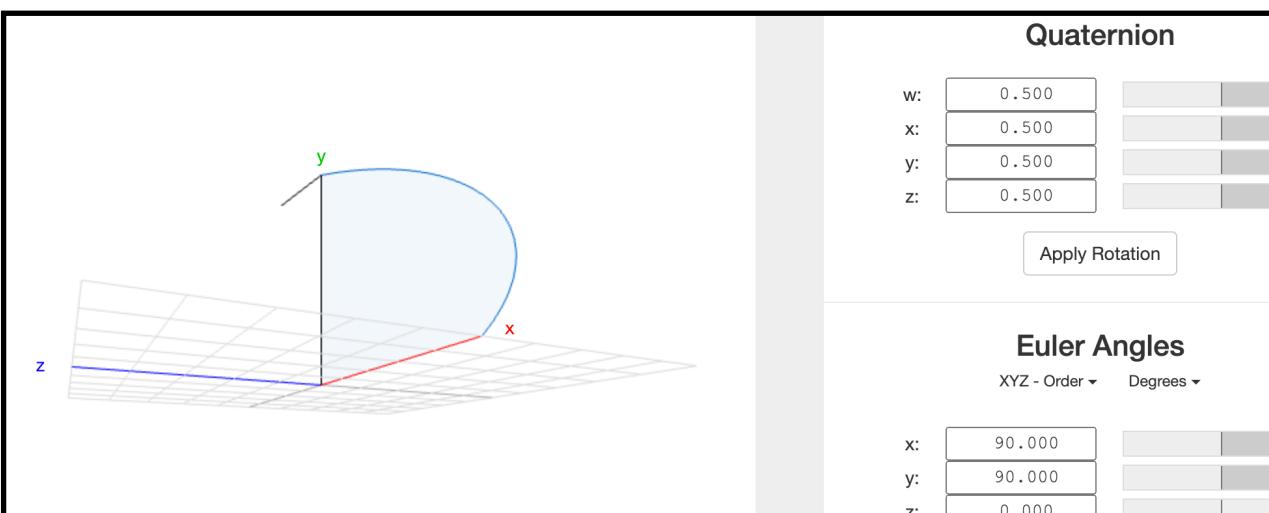


# What is Interpolation

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]

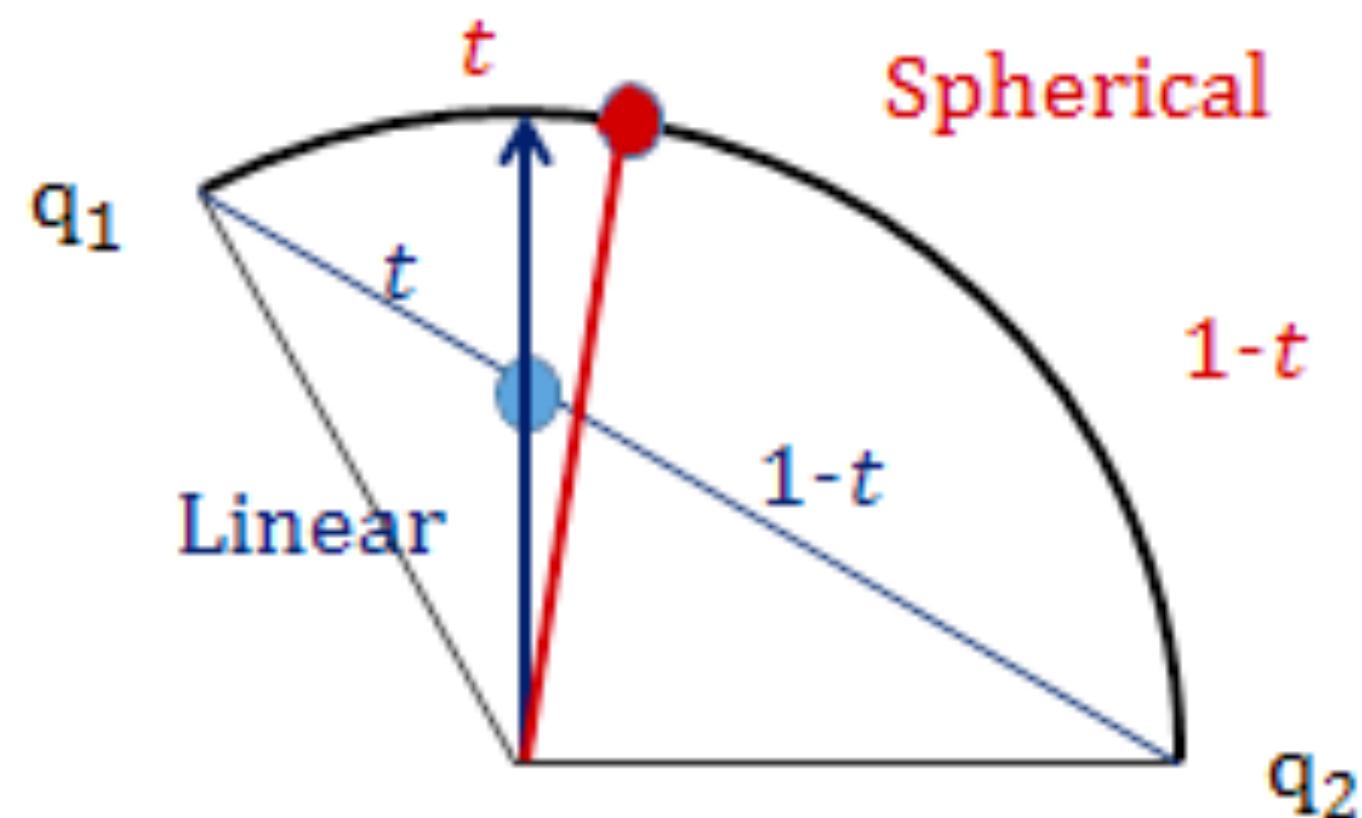


A weird result by linear interpolation

# 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 = [], []

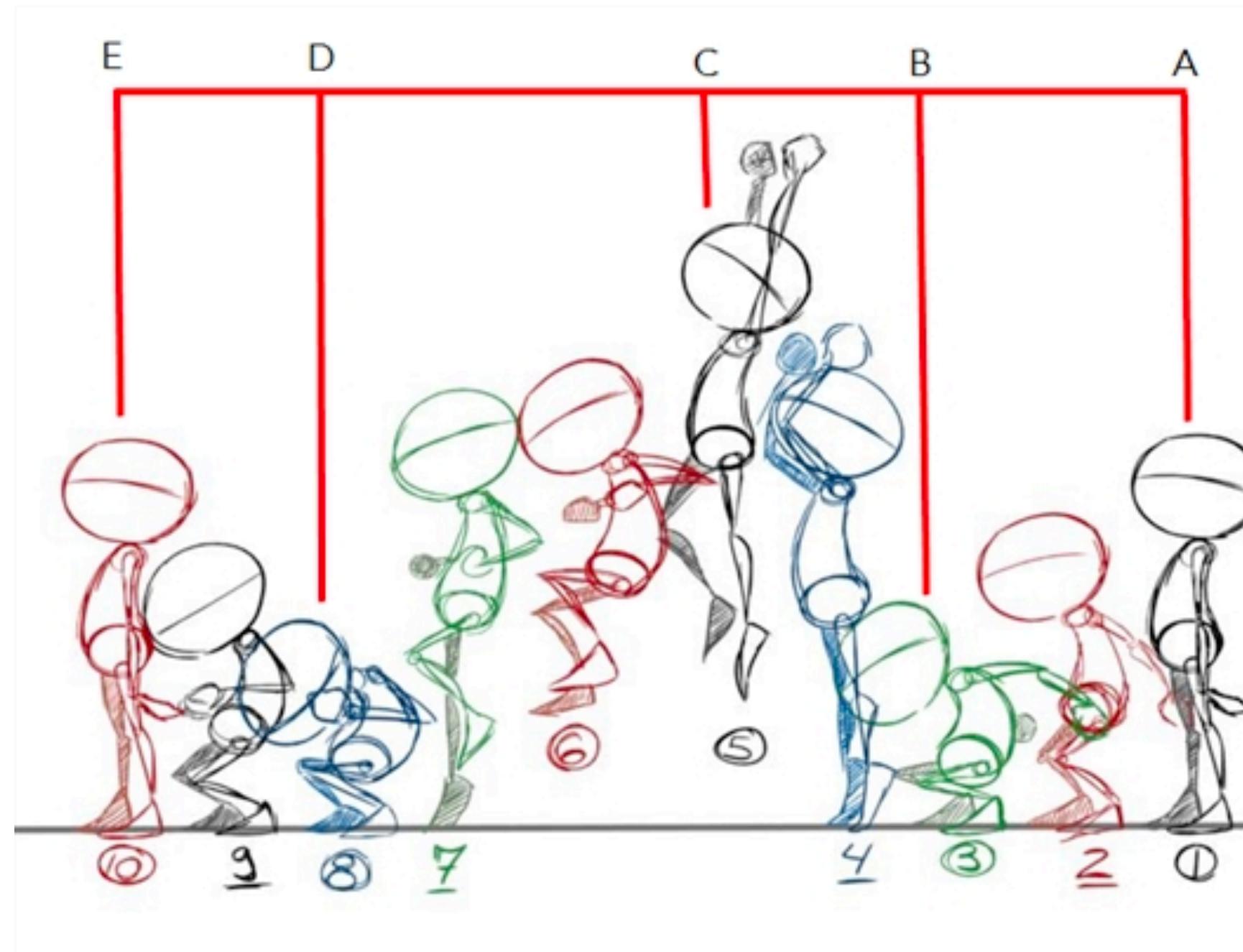
    previous_frame_idx = 0
    for current_frame_idx in keyframes[1:]:
        between_local_pos = interpolation(motion.local_joint_positions[previous_frame_idx],
                                            motion.local_joint_positions[current_frame_idx],
                                            target_step - 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 #####
```

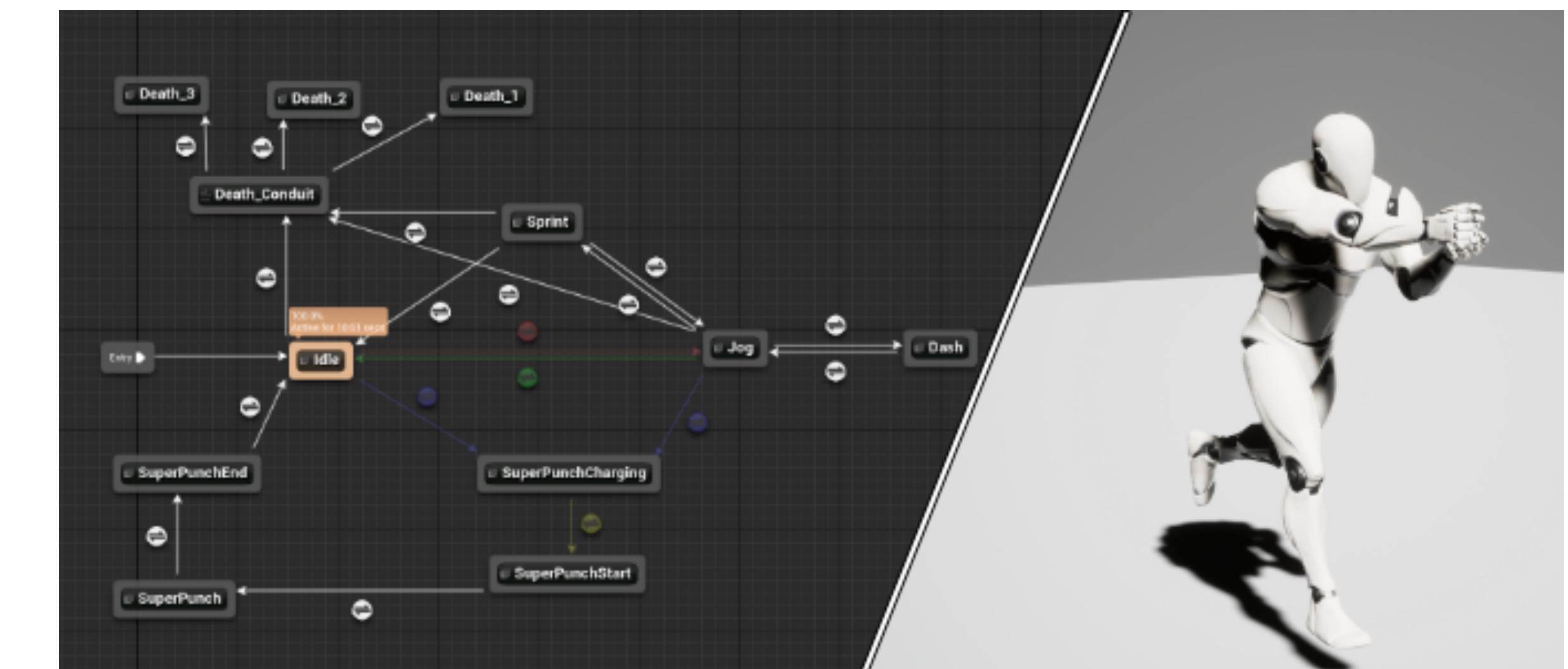
- Linear interpolation (10%)
- Slerp Interpolation (15%)
- Report the different performance by giving different numbers (5%)

```
# 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?

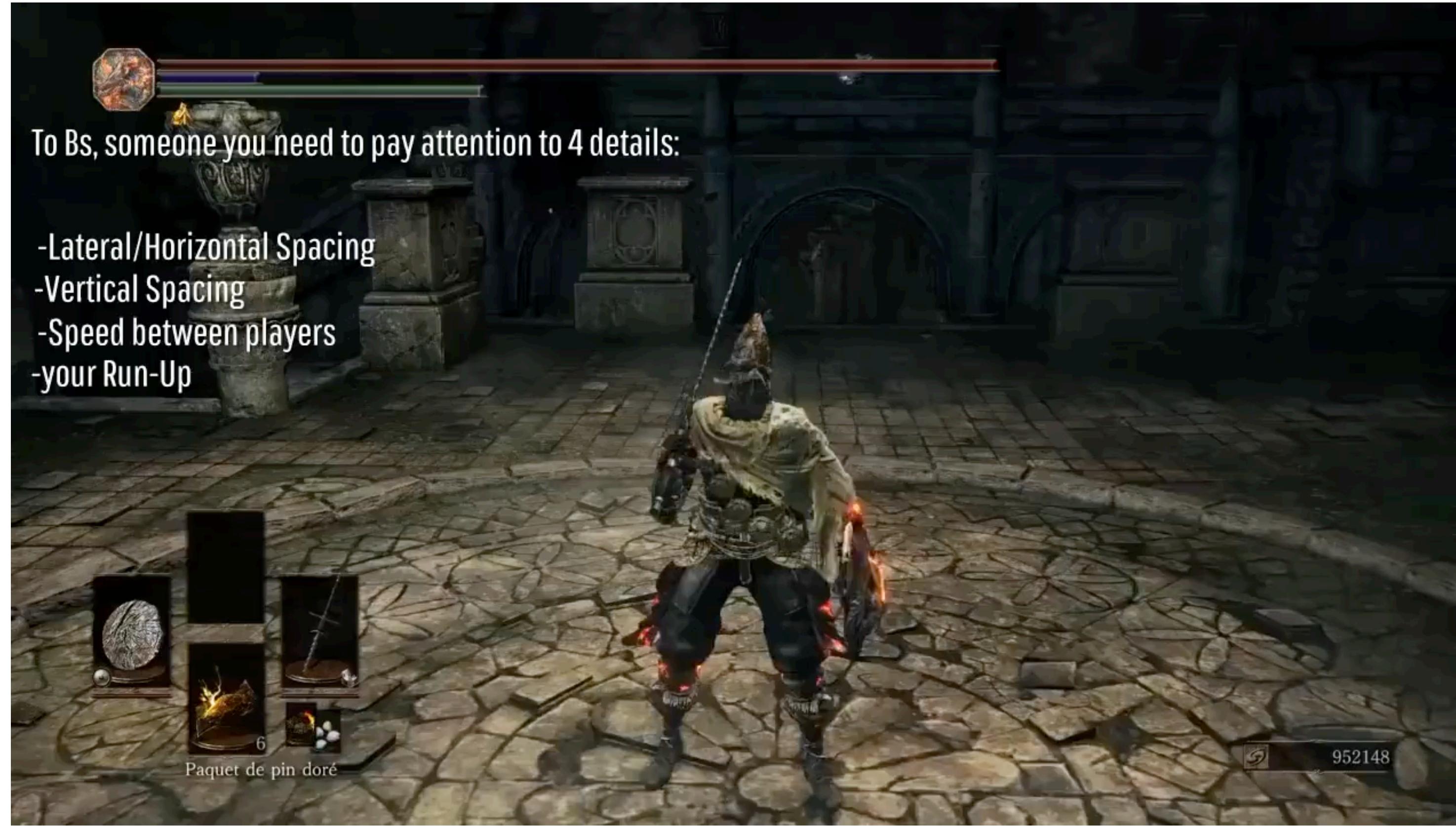


Offline production

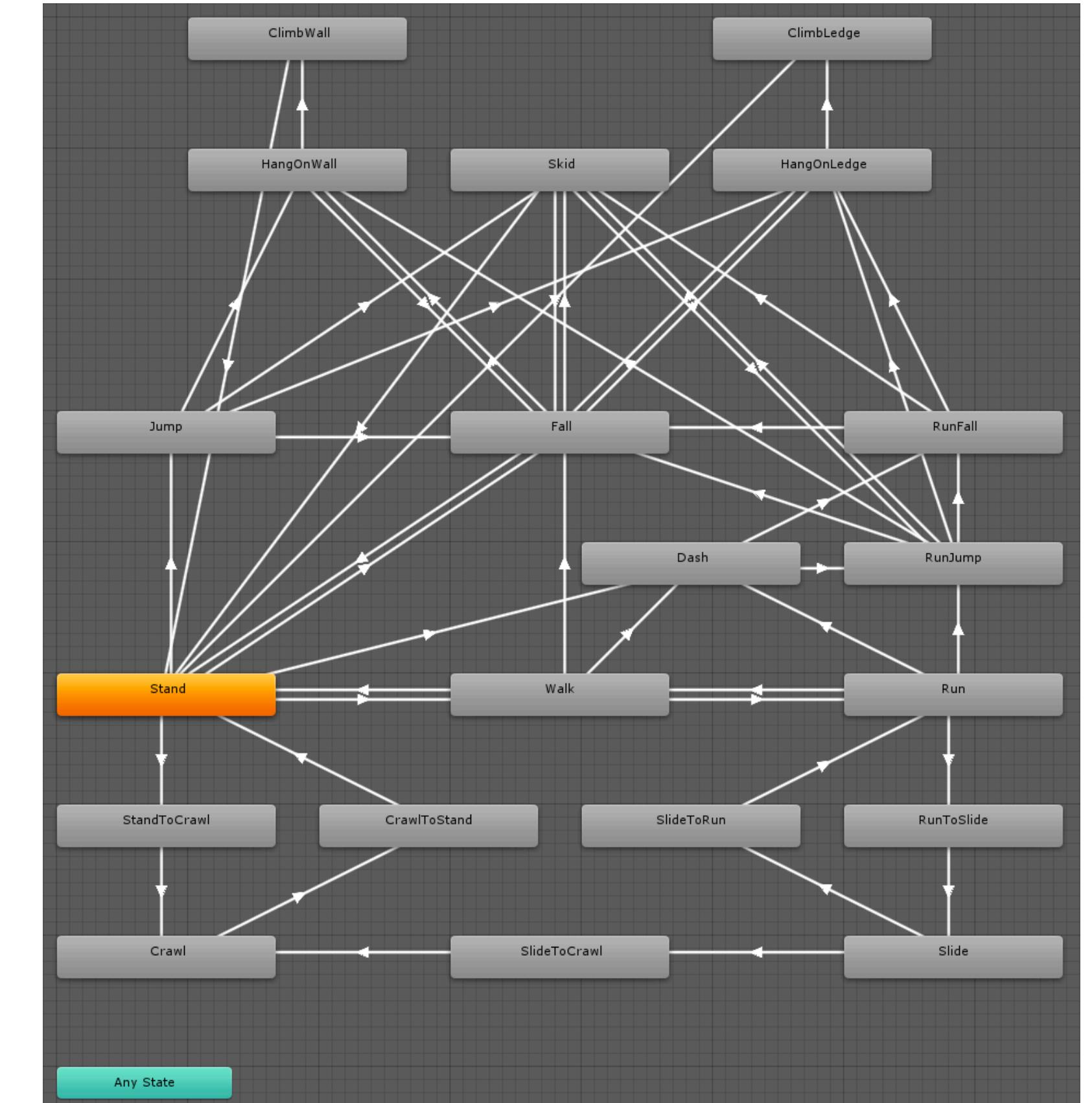


Real-time Animation

# Have you played any digital Games?



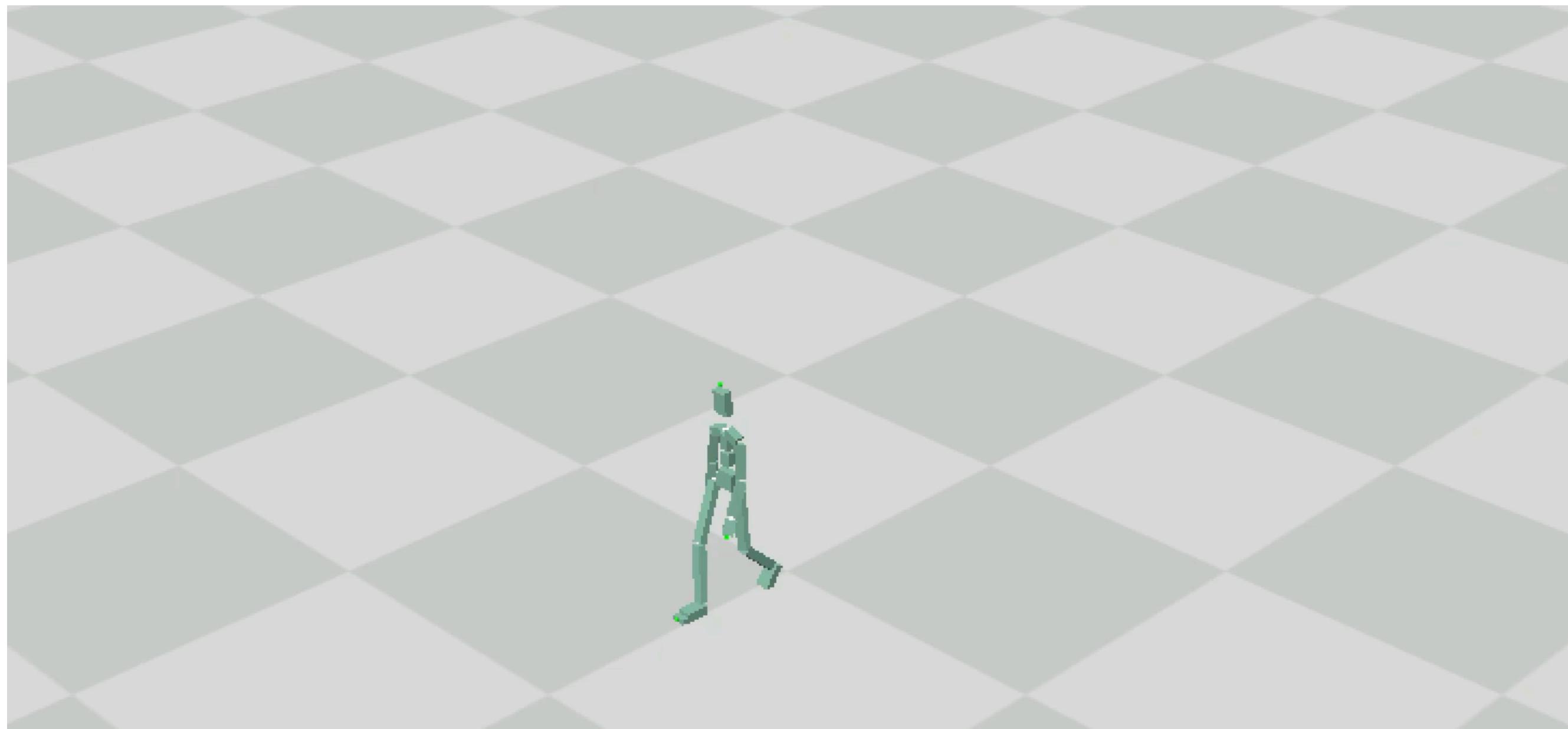
Controlling system is a combination for lots of motion clips



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<sub>i</sub> in motion 1
- Find a frame<sub>j</sub> in motion 2
- Generate the between frames for pose<sub>i</sub> and pose<sub>j</sub>
- Make a new motion by motion1[:frame<sub>i</sub>] + between + motion2[frame<sub>j</sub>:]

# Idea

Source



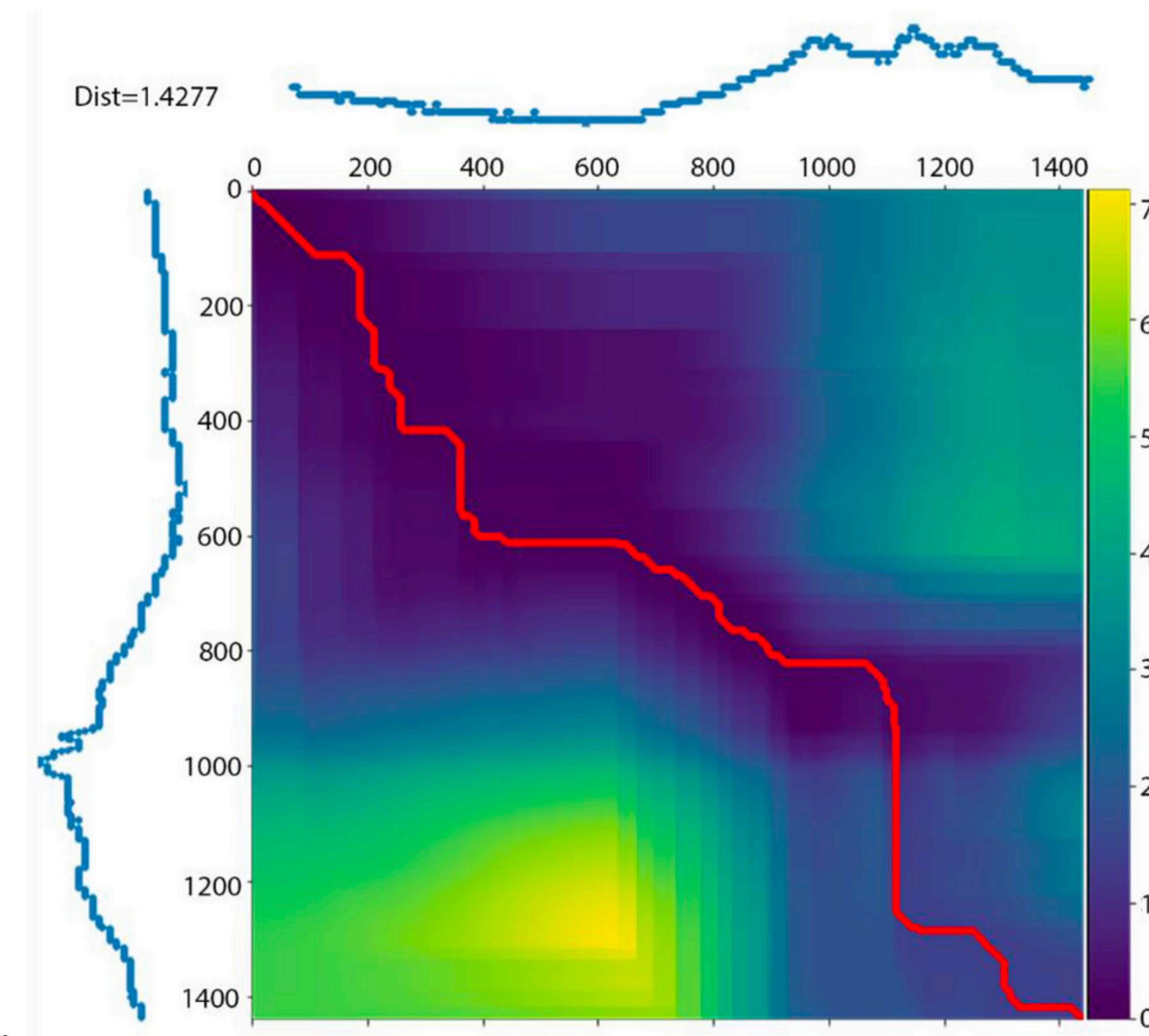
The closest frames



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

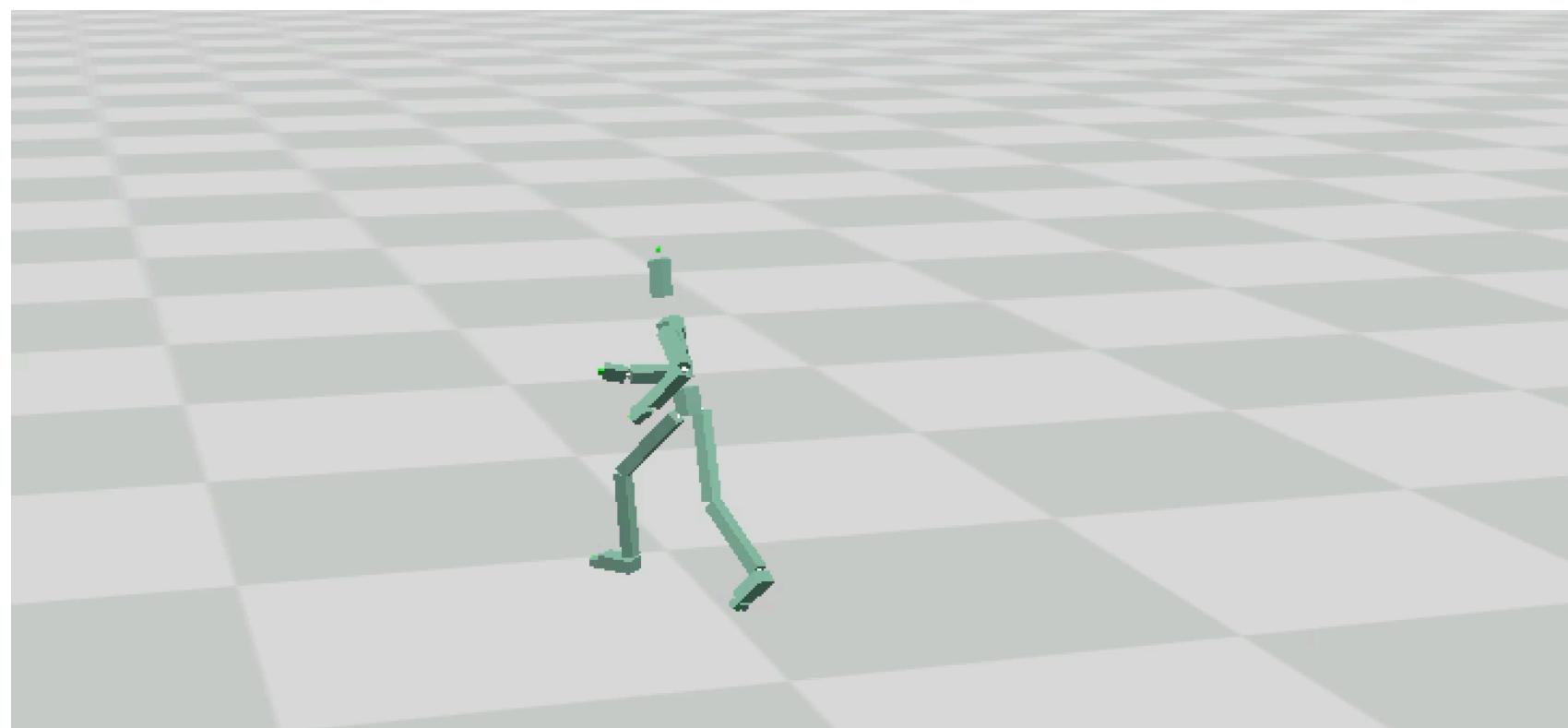
sim\_m[i, j] -> the difference between frame i in motion\_1 and frame j in motion\_2

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)

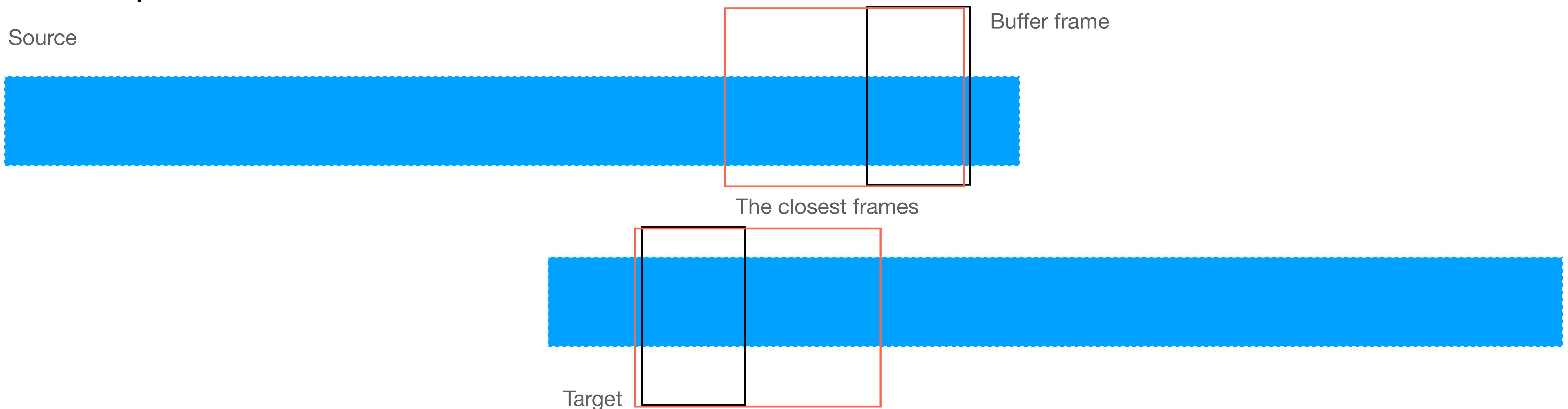
# More details

- 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