# Introduction & Motivation

In this homework, I construct a motion graph from several motions.

- Transform motions for motion blending.
- Draw edges between close motion segments.
- Blend motion segments when traversing for smooth transition between motion segments.

# Fundamentals

- Motion matching : Calculate the distance between two motion segments by summing the difference between the angles of joints of each frame. If the distance is small enough, we say “The two motion segments match.”

# Implementation

## Motion Transformation

- Motion transformation : Rotate and translate the latter motion segment to make the facing angle and the root position be continuous after concatenating two motion segments.
- Implemented by following formula
    1. $R \triangleq {}_0R_{amc}$
    2. $\theta_o \triangleq \tan^{-1}(\frac{R_{02}}{R_{22}})$
    3. $R_d[n] = R_y(\theta_d - \theta_o)_0R_{amc}$
    4. $T_d[n] = R_y(\theta_d - \theta_o)({}_0T[n] - {}_0T[0]) + T_{d0}$

## Motion Blending

- Motion blending : Merge the overlapped frames of two motion segments by interpolation.
    - Root position : linear interpolation

- Facing angle : spherical linear interpolation

- Implemented by following formula

| Notation | Description or Definition |
|---|---|
| $T_i$ | The global coordinate of the root bone in frame $i$ in the blended motion |
| $w_i$ | $i_{\text{th}}$ blending weight |
| ${}_1T_i$ | The global coordinate of the root bone in frame $i$ in the former motion |
| ${}_2T_i$ | The global coordinate of the root bone in frame $i$ in the latter motion |
| $q_i$ | The quaternion corresponding to the facing angle in frame $i$ in the blended motion |
| ${}_1q_i$ | The quaternion corresponding to the facing angle in frame $i$ in the former motion |
| ${}_2q_i$ | The quaternion corresponding to the facing angle in frame $i$ in the latter motion |

1. $w_i = \frac{1}{2}\sin(\frac{i}{N_b - 1}\pi - \frac{\pi}{2}) + \frac{1}{2}$
2. $T_i = (1 - w_i) \cdot {}_1T_i + w_i \cdot {}_2T_i$
3. $q_i = Slerp({}_1q_i, {}_2q_i; w_i)$

## Motion Graph

- Motion graph : simple weighted graph, which could be used to generate infinite motion.
    - Nodes : motion segments
    - Weights : probabilities of transferring along the edges
- Implemented by following formula

| Notation | Description or Definition |
|---|---|
| $d_{i,j}$ | The distance between the corresponding motion segments of node $i$ and node $j$ |
| $t$ | The threshold of motion matching |

| Notation | Description or Definition |
| --- | --- |
| $e_{i,j}$ | The edge between node $i$ and node $j$ |
| $w_{i,j}$ | The weight corresponds to $e_{i,j}$ |
| $E$ | The edge set of the motion graph |
| $E_i$ | $\{e_{i,j} \| (e_{k,j} \in E \vee e_{j,k} \in E) \wedge k = i\}$ |

1. $d_{i,j} < t$ → Add $e_{i,j}$ with $w_{i,j} = \frac{1}{d_{i,j}^2}$
2. $e_{i,i+1}$ hasn't been added → Add $e_{i,i+1}$ with $w_{i,i+1} = 7 \cdot \max(\{w_{i,j} | e_{i,j} \in E_i\})$
3. Normalize the weights of edges : $w_{i,j} \leftarrow \frac{w_{i,j}}{\sum_{w \in E_i} w}$

# Result & Discussion

## Effects of Length of Blending Window

If the length of blending window is too small, the transition between motions can be abrupt if $t$ isn't adjusted correspondingly.

## Effects of Length of Segment

The larger the length of segment, the easier to match two segment, but wasting more sub-segment for blending and fewer nodes. Therefore, the infinite motion generated would be smoother but less diverse.

## Names of the AMC Files I would Like TAs to Use while Testing My Code

- walk_fwd_circle.amc
- walk_fwd_curve1.amc
- walk_fwd_curve2.amc

# Conclusion

By finishing this homework, I have implemented motion transformation, motion blending, and motion graph construction for infinite motion generation.