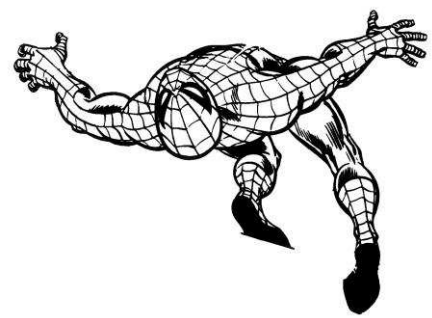


# The Line of Action: an Intuitive Interface for Expressive Character Posing

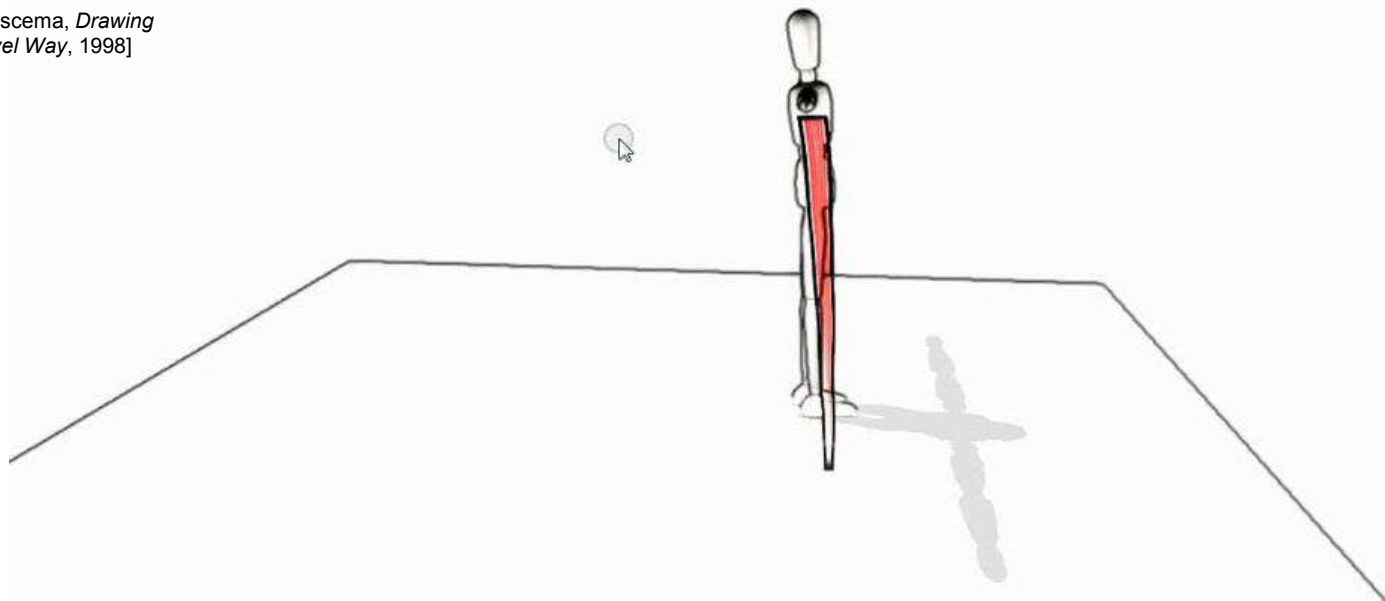
Martin Guay, Marie-Paule Cani, Rémi Ronfard

LJK, INRIA, Université de Grenoble





[S.Lee and J. Buscema, *Drawing Comics the Marvel Way*, 1998]



# Introduction

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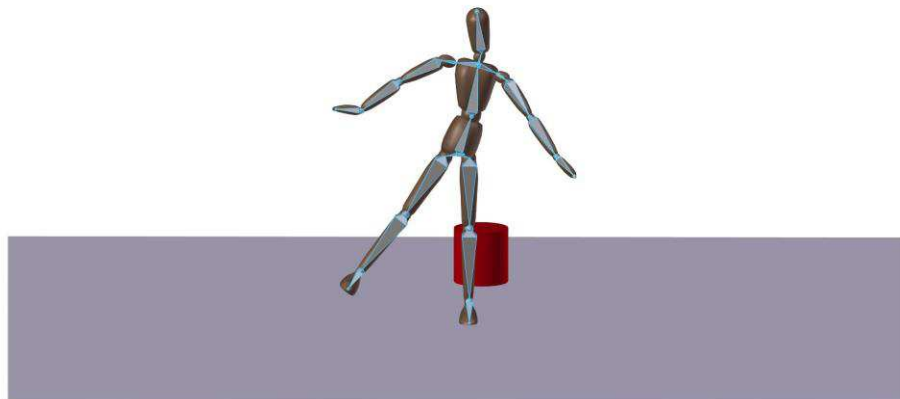
# 3D Character Posing

- ▶ Placing a 3D character in a 3D world.



# 3D Character Posing

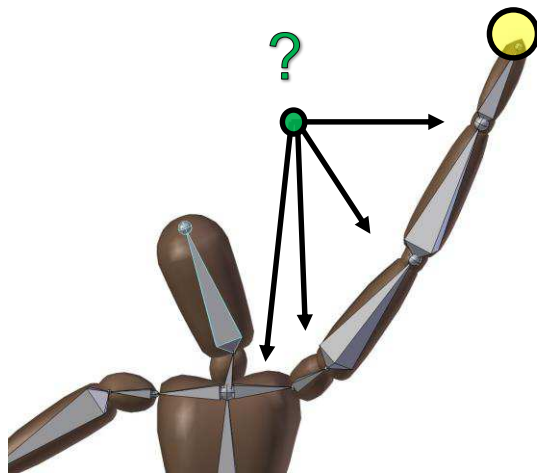
- ▶ Intuitive: **Skeleton** parametrization



[Burtnyk, N., et al, Interactive skeleton techniques for enhancing motion dynamics in key frame animation, 1976.]

# 3D Character Posing

- ▶ More Intuitive: **Inverse Kinematics** (IK)



[Girard, M., et al., *Computational modeling for the computer animation of legged figures*, 1985.]

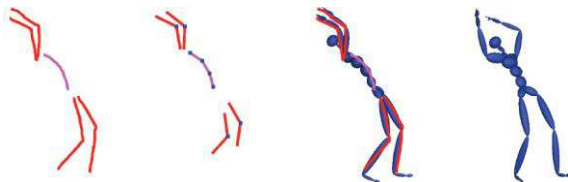
[Zhao, J., et al., *Inverse kinematics positioning using nonlinear programming for highly articulated figures*, 1994]

# 3D Character Posing

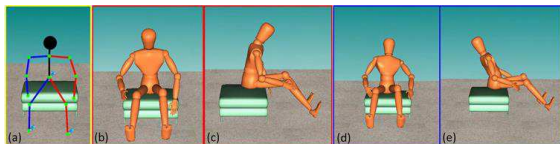
## ► More Intuitive: 2D Stickfigures



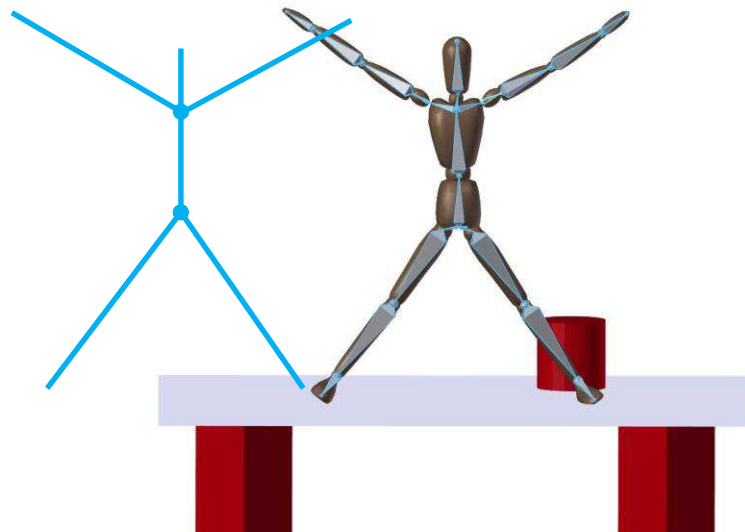
- [Davis, J. et al., A sketching interface for articulated figure animation, 2003.]



- [Wei, X.K., et al., Intuitive interactive human character posing with millions of example poses, 2011]

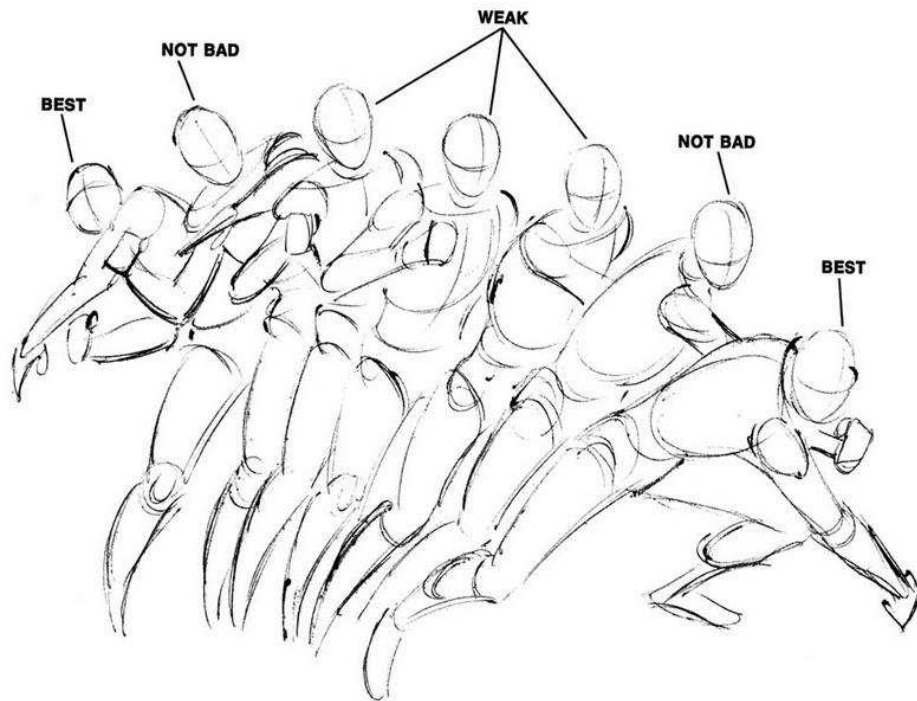


- [Lin, J., et al., A sketching interface for sitting-pose design. 2010]

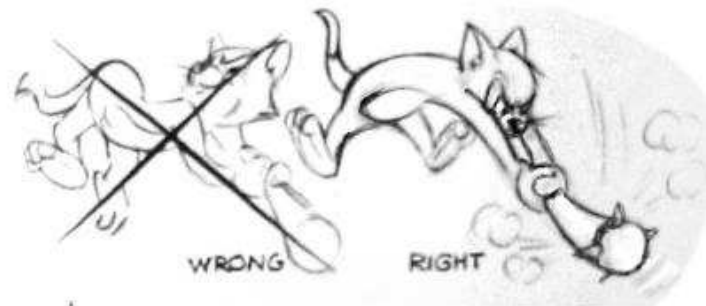
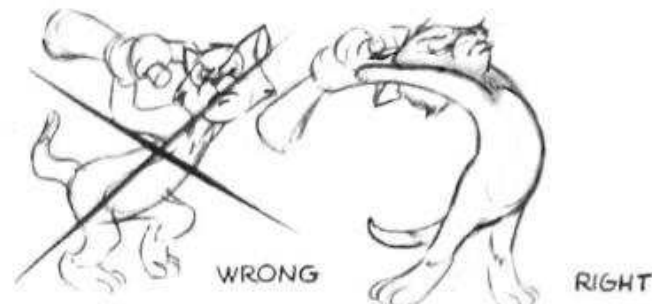


# Expressive Poses

- ▶ Emotion expressed, body language is as *clear*---and *readable*---as possible.



- ▶ [S.Lee and J. Buscema, *Drawing Comics the Marvel Way*, 1998]

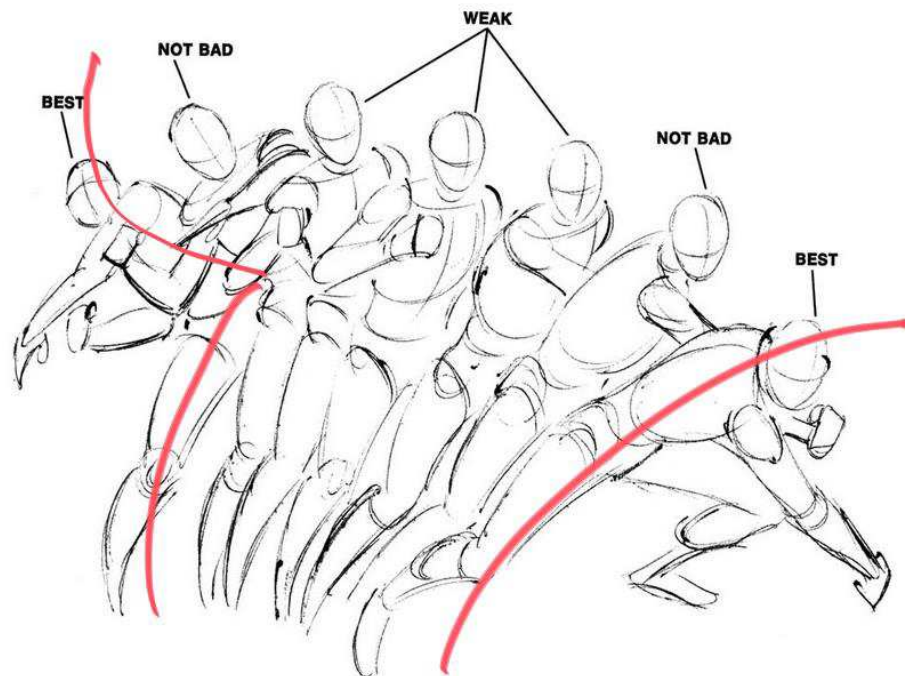


- ▶ [Blair, P., *Cartoon Animation*, 1994]

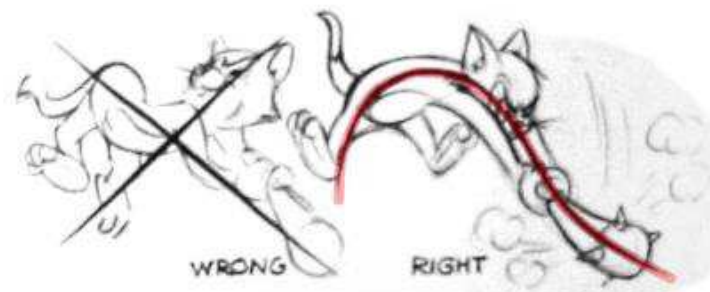
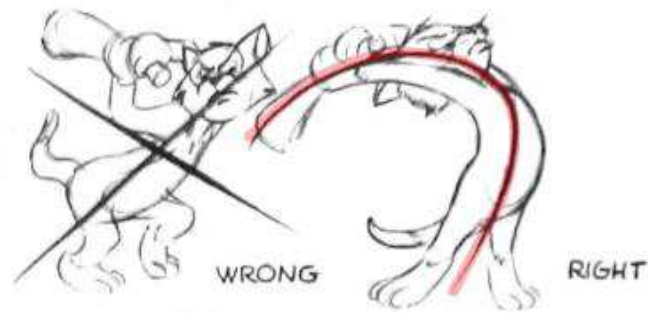


# Expressive Poses

## ► Lines of Action



- [S.Lee and J. Buscema, *Drawing Coming the Marvel Way*, 1998]



- [Blair, P., *Cartoon Animation*, 1994]

# Posing with lines of action

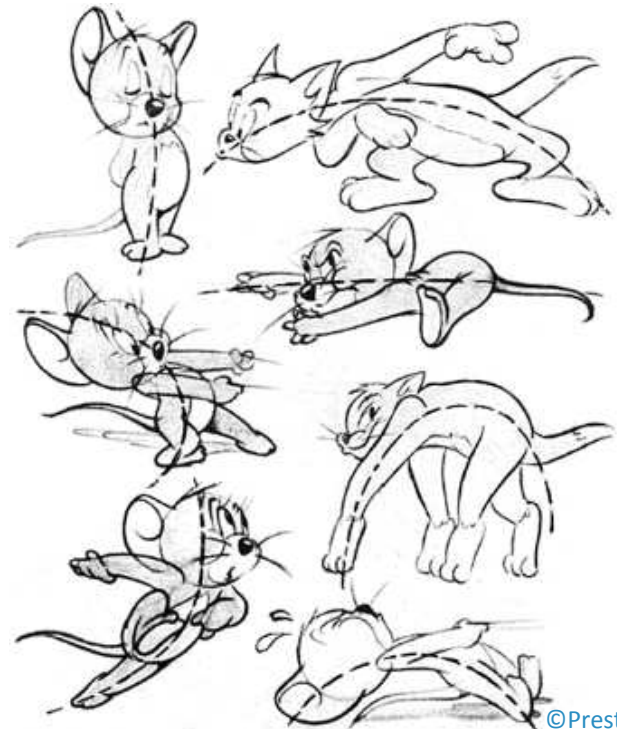
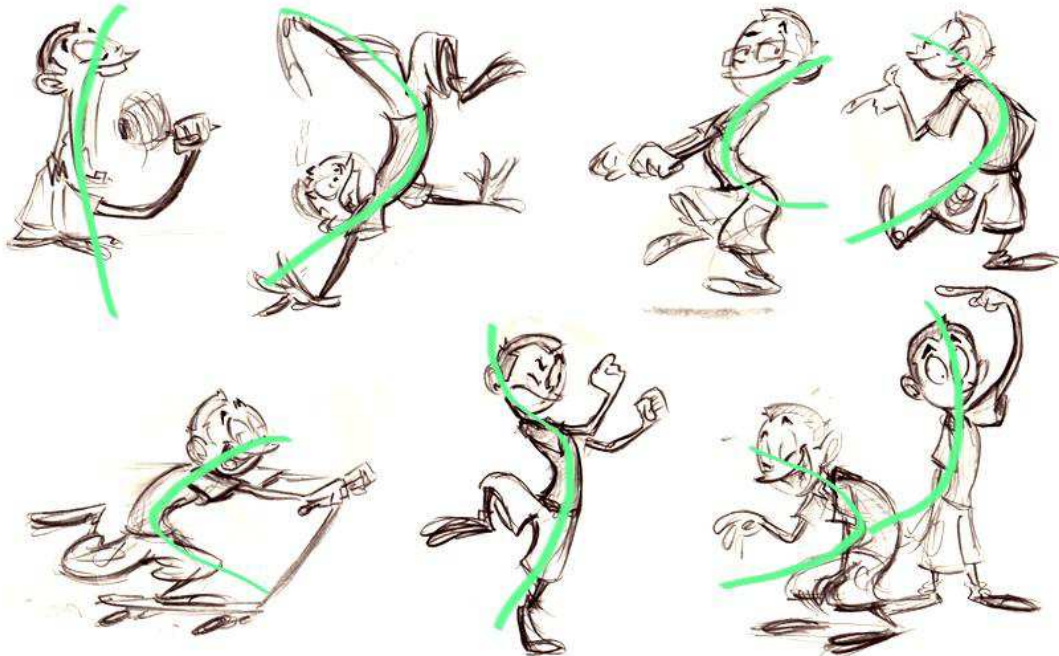
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# Posing with lines of action



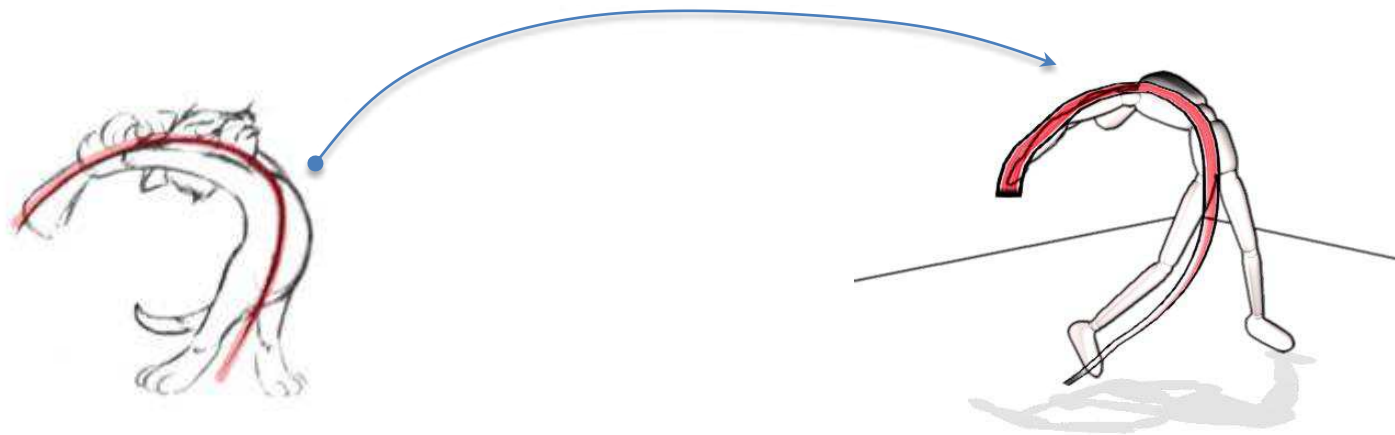
SIGGRAPH ASIA 2013

- ▶ *“It is the imaginary line that passes through the main action of the character”*
- ▶ *“It is the imaginary line that dictates how the body will move”*
- ▶ *“It is the back bone of your character”*



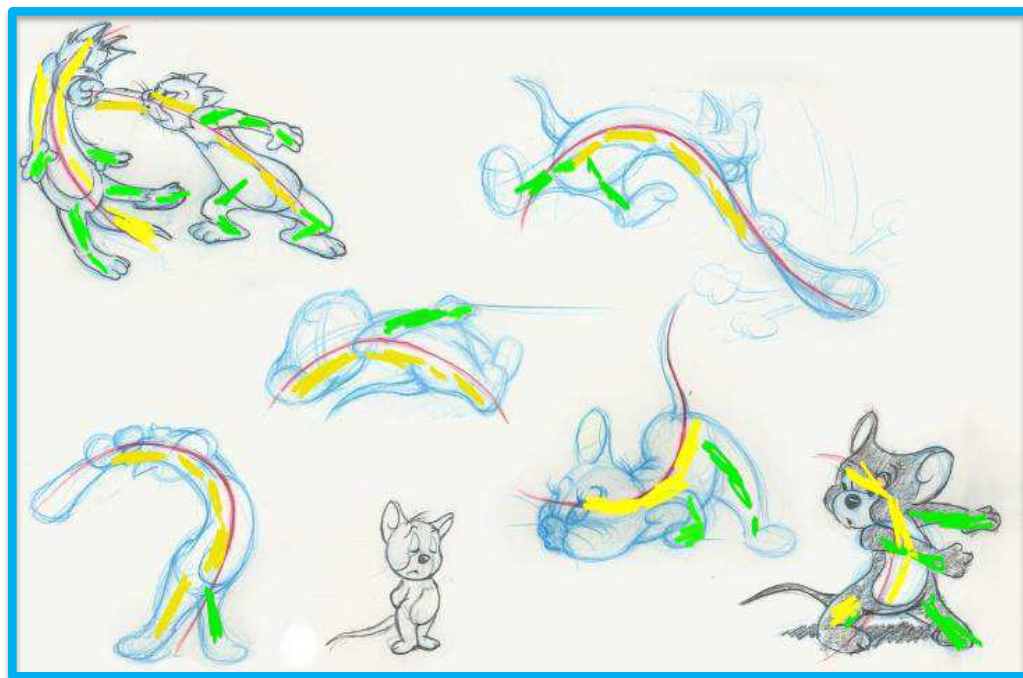
# Posing with lines of action: Overview

- ▶ A formal **definition** of the line of action.
- ▶ **Posing** as an **optimization** problem.



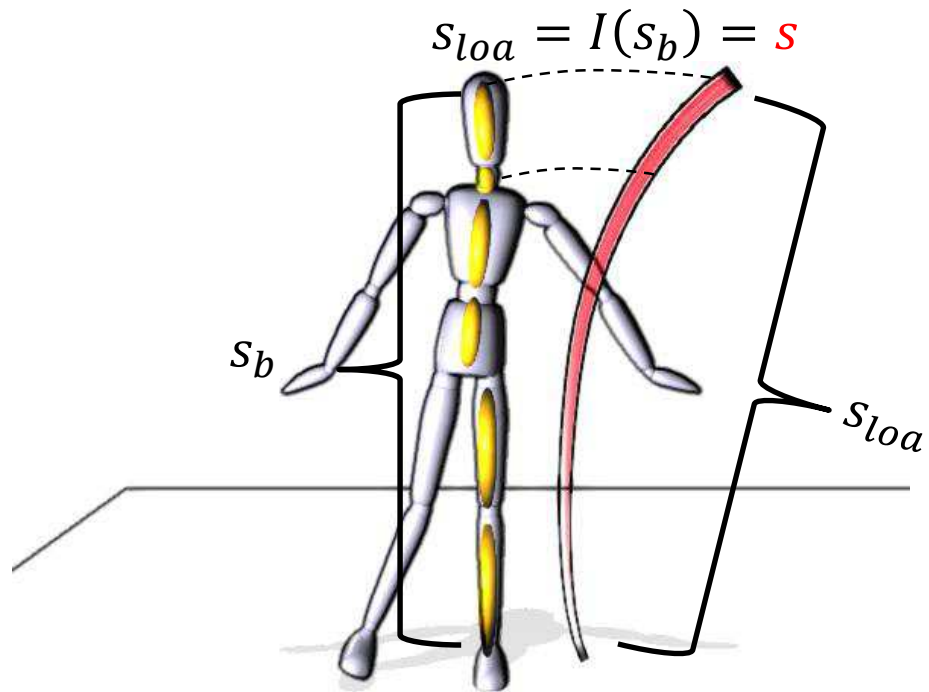
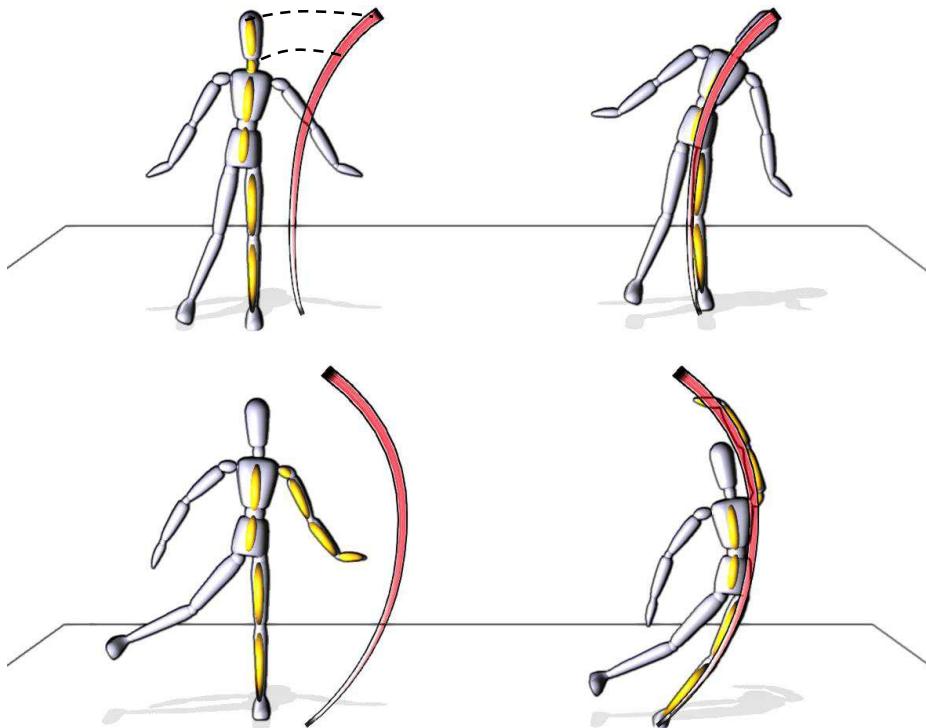
# Line of Action: Definition

- ▶ **Definition:** A line of action dictates the *shape*, in image space, of a linear sub-chain in the kinematic tree.



# Line of Action: Definition

- ▶ Dictates shape of a body line:



# Line of Action: Problem

$$\min_{\mathbf{x}_b(s)} \int_s E_x(s) + E_{\partial x}(s) ds$$

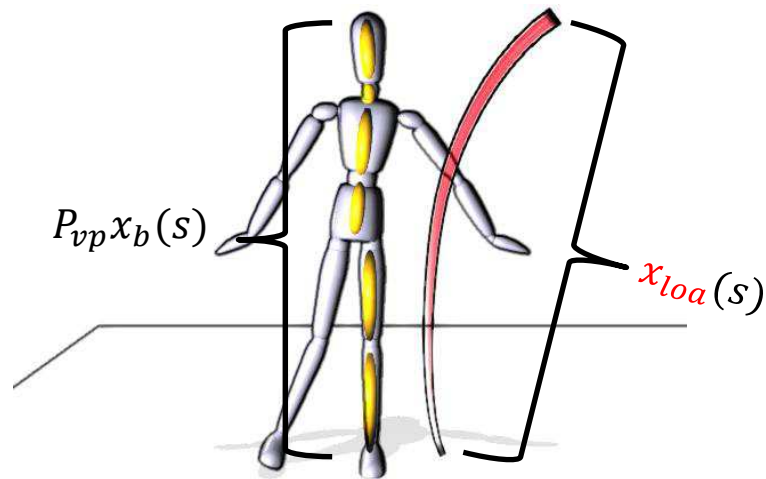
$$E_x(s) = \mu_x(s) \left\| \mathbf{P}_{vp} \mathbf{x}_b(s) - \mathbf{x}_{loa}(s) \right\|^2$$

$$E_{\partial x}(s) = \mu_{\partial x}(s) \left\| \frac{\partial \mathbf{P}_{vp} \mathbf{x}_b}{\partial s}(s) - \frac{\partial \mathbf{x}_{loa}}{\partial s}(s) \right\|^2$$

$\mathbf{x}_b(s)$ : Bone Position (world space)

$\mathbf{x}_{loa}(s)$ : Line of Action Position (screen space)

$\mathbf{P}_{vp}$ : View Projection Transformation



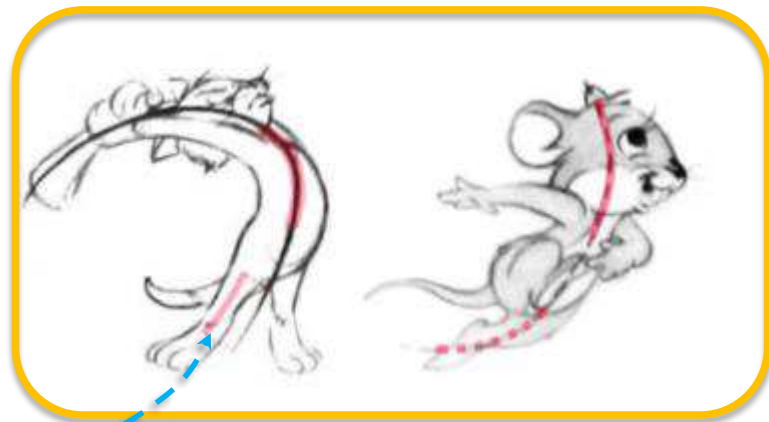


# Line of Action: Problem

$$\min_{\mathbf{x}_b(s)} \int_s E_x(s) + E_{\partial x}(s) ds$$

$$E_x(s) = \mu_x(s) \left\| \mathbf{P}_{vp} \mathbf{x}_b(s) - \mathbf{x}_{loa}(s) \right\|^2$$

$$E_{\partial x}(s) = \mu_{\partial x}(s) \left\| \frac{\partial \mathbf{P}_{vp} \mathbf{x}_b}{\partial s}(s) - \frac{\partial \mathbf{x}_{loa}}{\partial s}(s) \right\|^2$$



$\mathbf{x}_b(s)$ : Bone Position (world space)

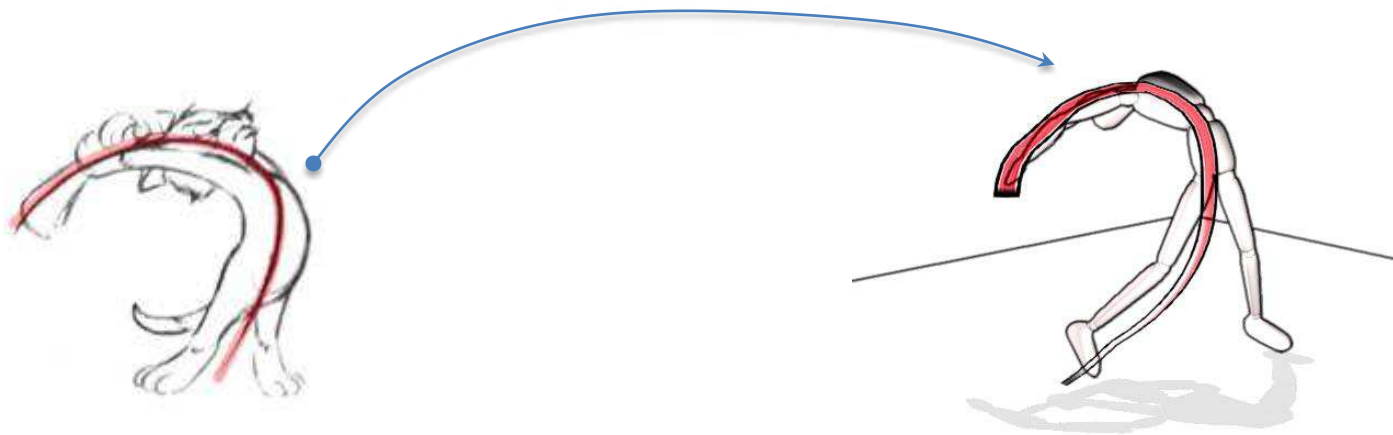
$\mathbf{x}_{loa}(s)$ : Line of Action Position (screen space)

$\mathbf{P}_{vp}$ : View Projection Transformation



# Posing with lines of action: Overview

- ▶ A formal **definition** of the line of action.
- ▶ **Posing** as an **optimization** problem.
  - ▶ Select the body line
  - ▶ Resolve Depth Ambiguities
  - ▶ Determine Correspondence (spatial warping)

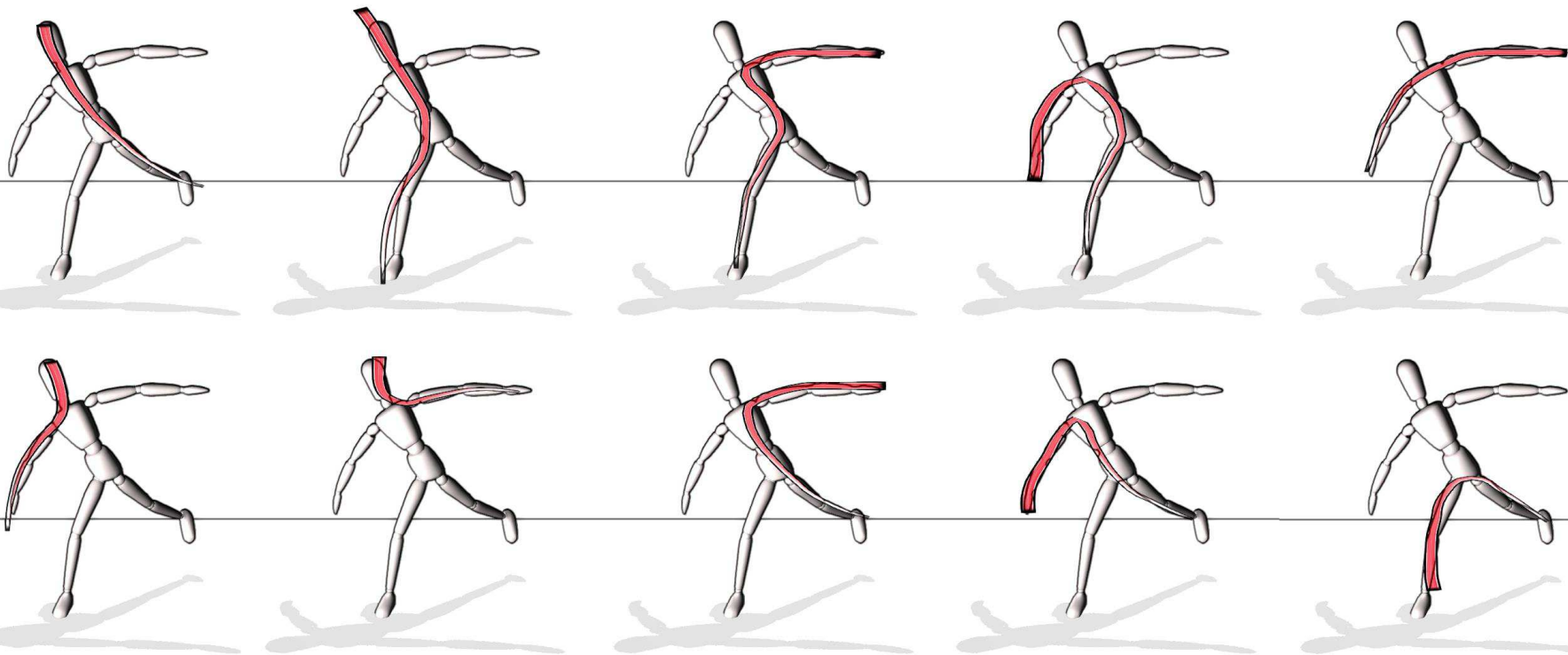


# Line Selection

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# Body Line Selection

- ▶ 10 Maximal chains for a humanoid:



# Depth Ambiguities

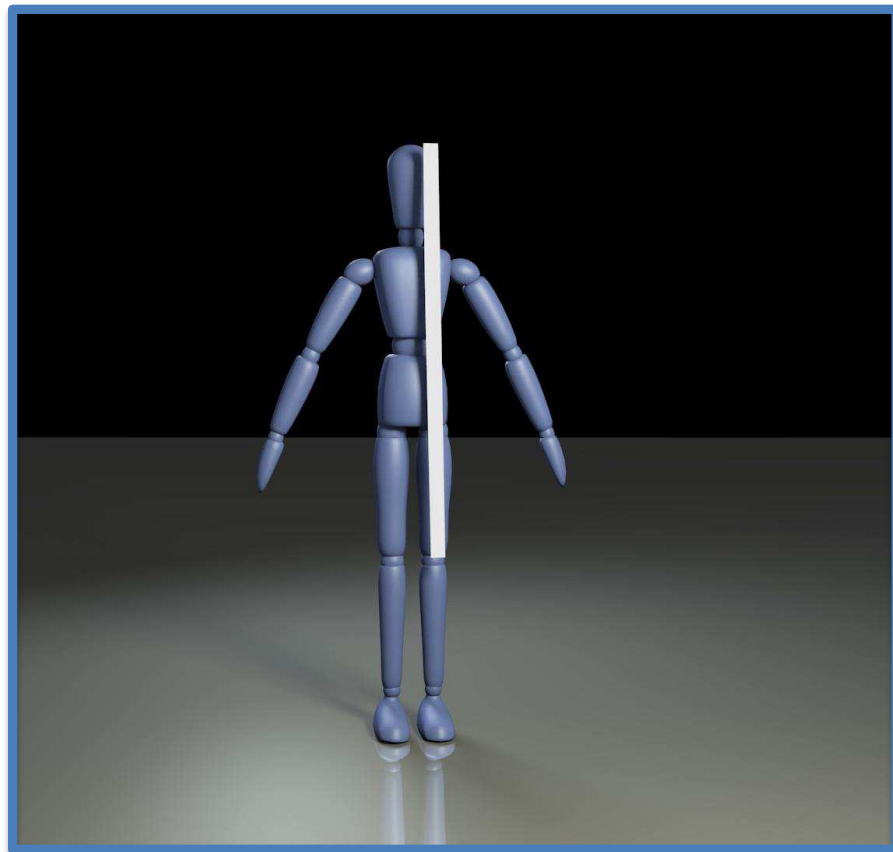
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# Resolving Depth Ambiguities



SIGGRAPHASIA2013

- ▶ 2D to 3D reconstruction is **under-constrained**
- ▶ Many **solutions** (poses) for the same initial conditions



# Resolving Depth Ambiguities



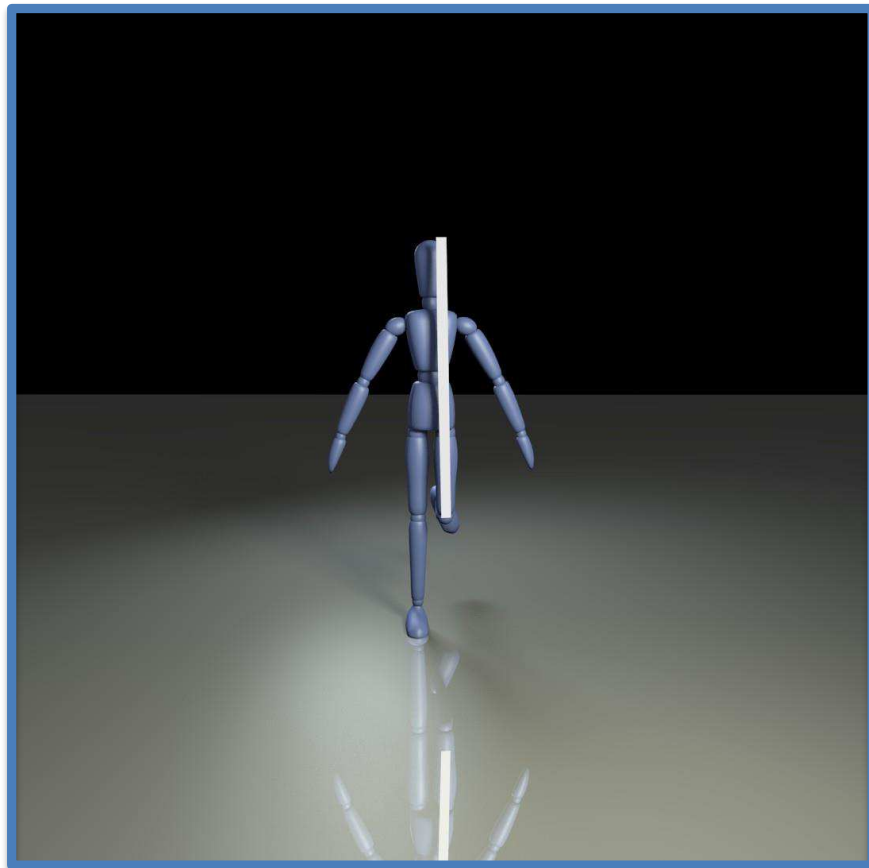
SIGGRAPHASIA2013

- ▶ 2D to 3D reconstruction is **under-constrained**
- ▶ Many **solutions** (poses) for the same initial conditions



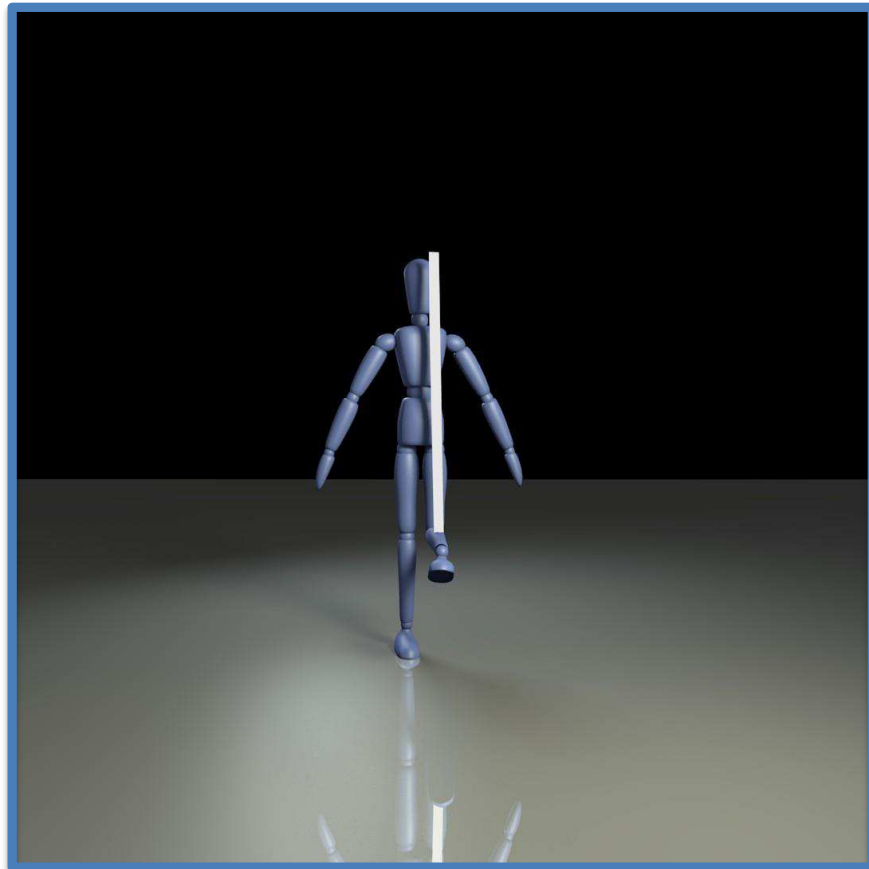
# Resolving Depth Ambiguities

- ▶ 2D to 3D reconstruction is **under-constrained**
- ▶ Many **solutions** (poses) for the same initial conditions



# Resolving Depth Ambiguities

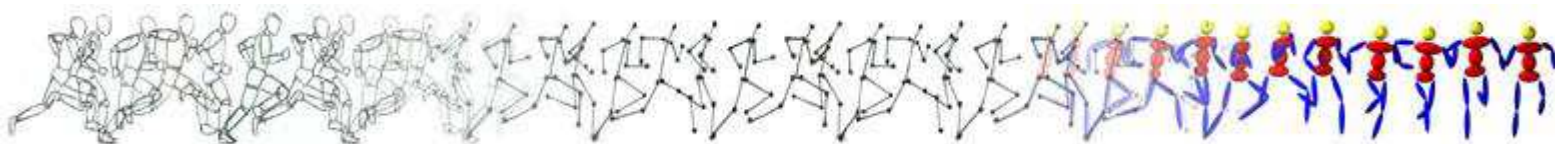
- ▶ 2D to 3D reconstruction is **under-constrained**
- ▶ Many **solutions** (poses) for the same initial conditions



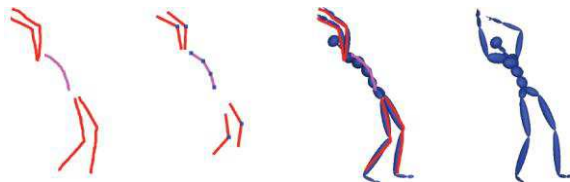


# Resolving Depth Ambiguities

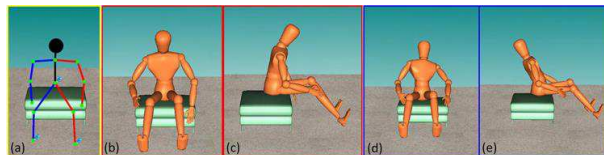
## ▶ Previous Work: Stick figures



- ▶ [Davis, J. et al., A sketching interface for articulated figure animation, 2003.]



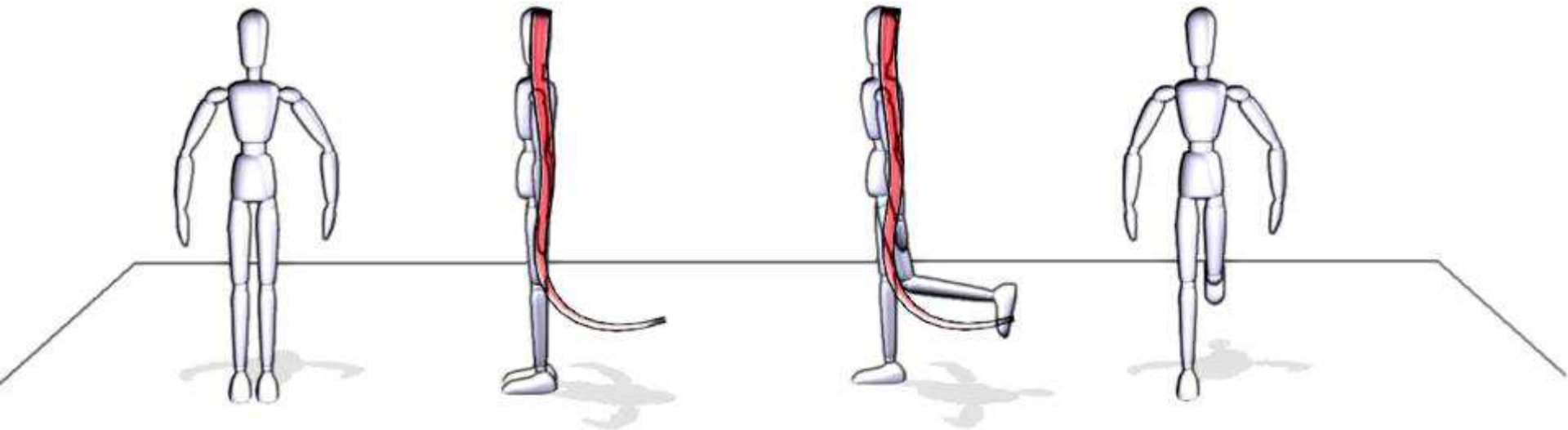
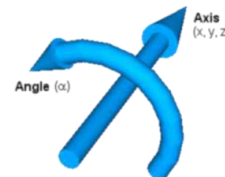
- ▶ [Wei, X.K., et al., Intuitive interactive human character posing with millions of example poses, 2011]

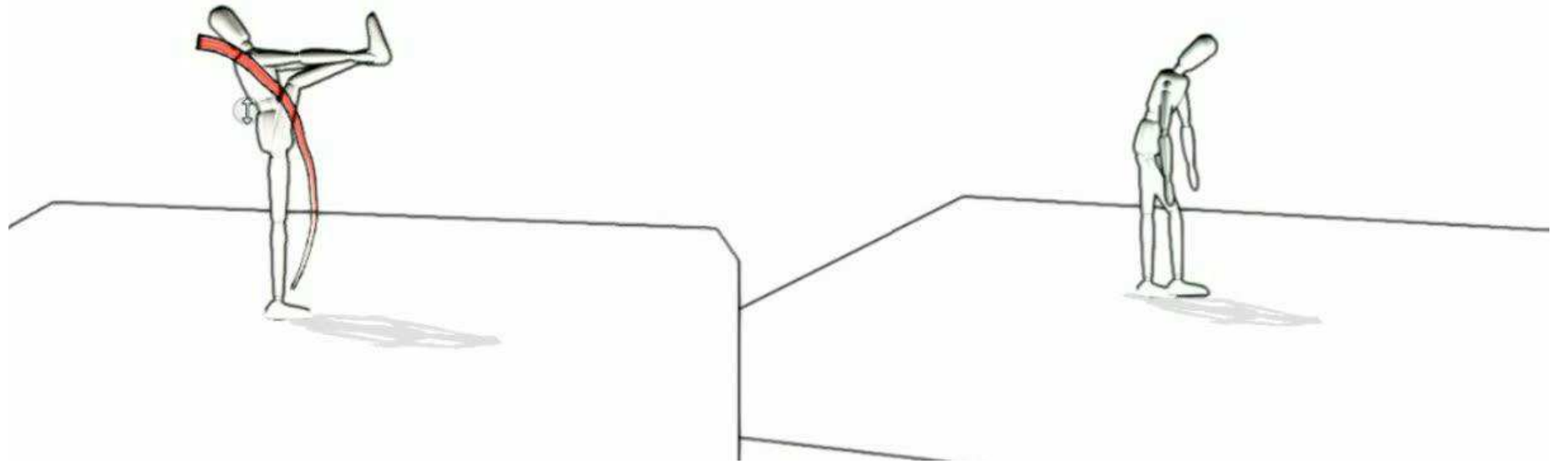


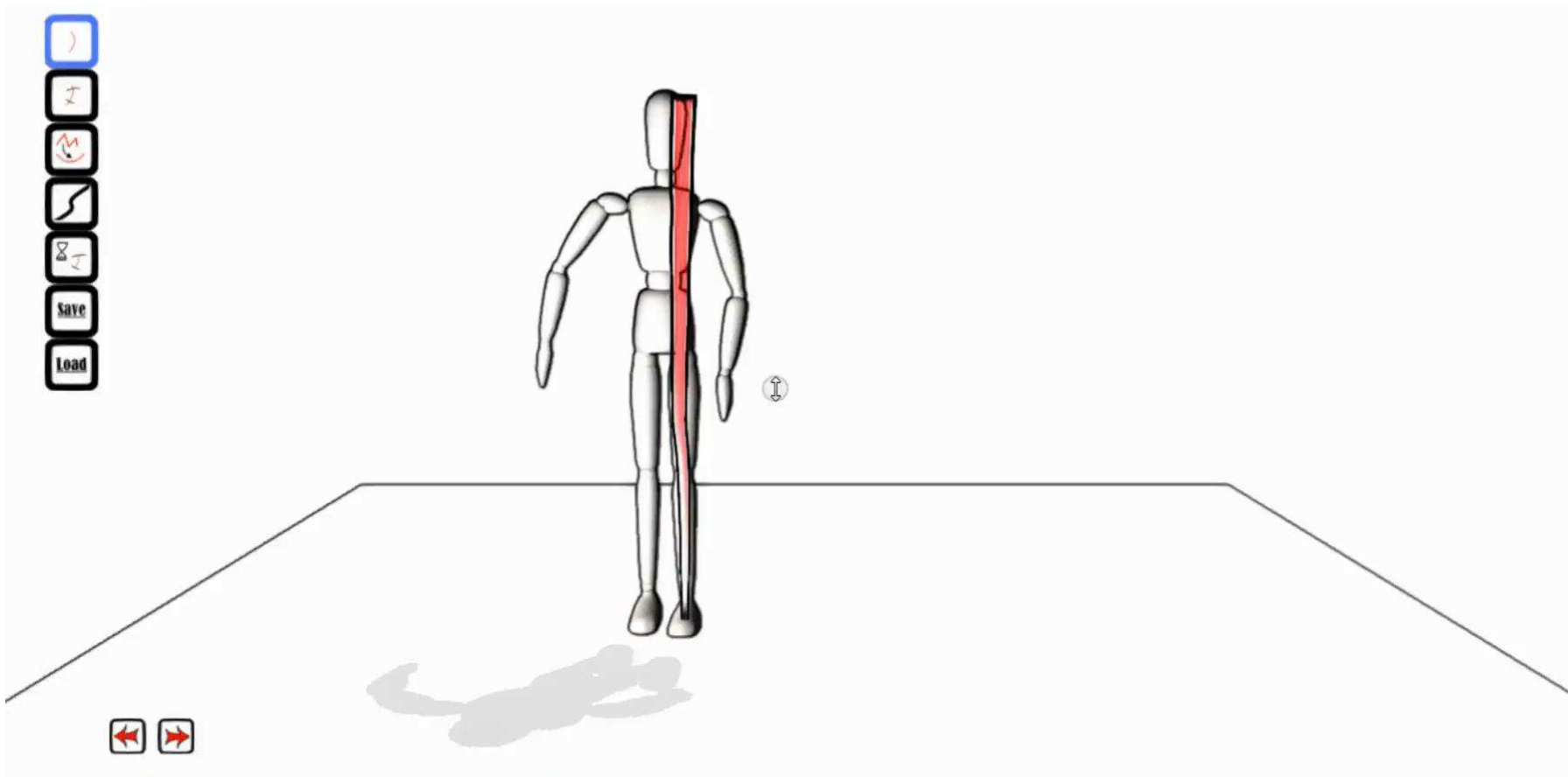
- ▶ [Lin, J., et al., A sketching interface for sitting-pose design. 2010]

# Resolving Depth Ambiguities

- ▶ Solution: constrain transformations to **viewing plane**
- ▶ Single **axis-angle parametrization** of bone rotations
- ▶ Along the view direction.





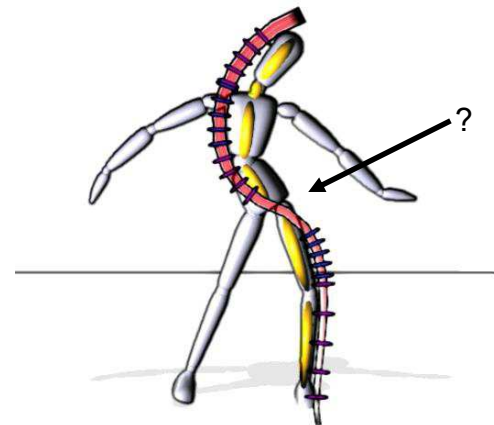
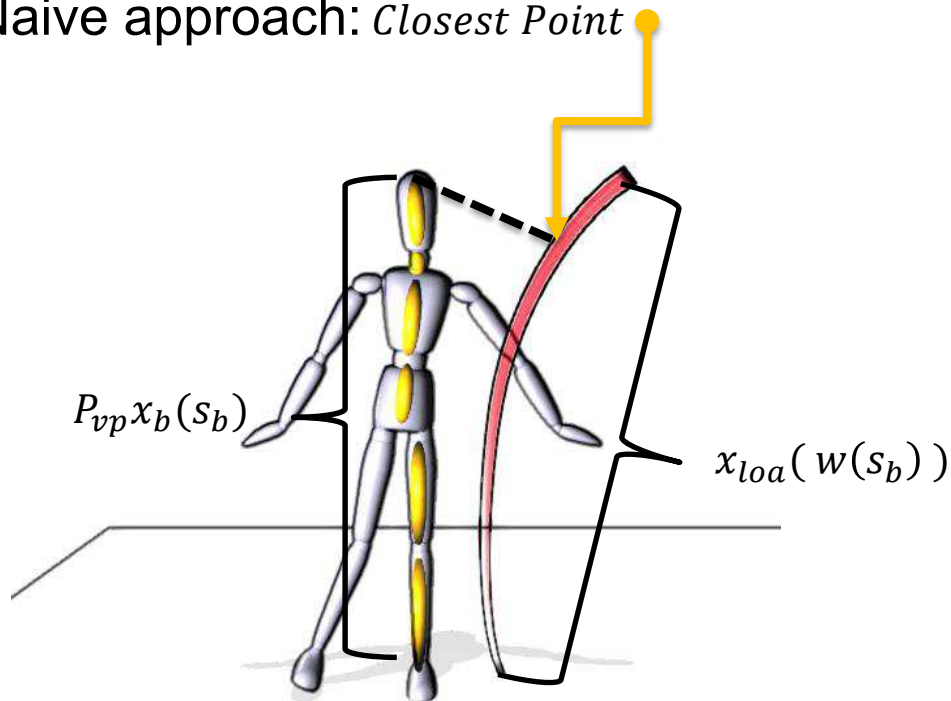


# Mapping Both Lines

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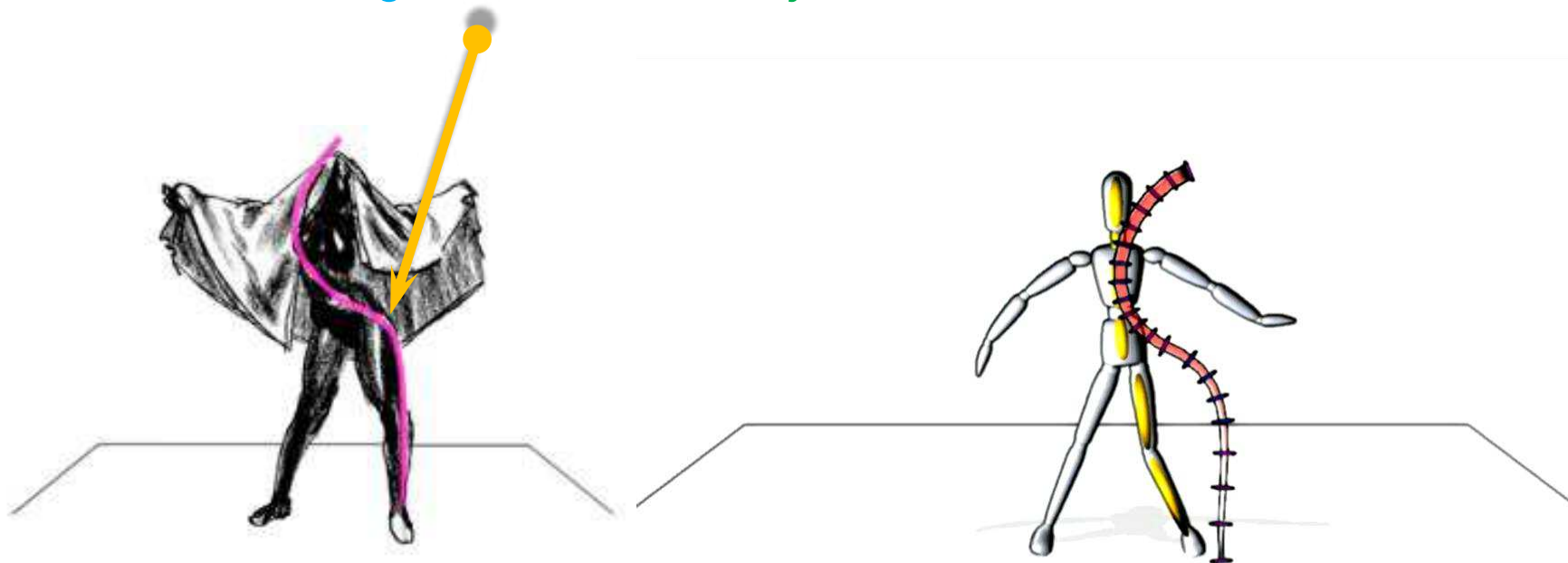
# Mapping Both Lines

- ▶ Spatial Warping  $w : s_b \rightarrow s_{loa}$
- ▶ Naive approach: *Closest Point*

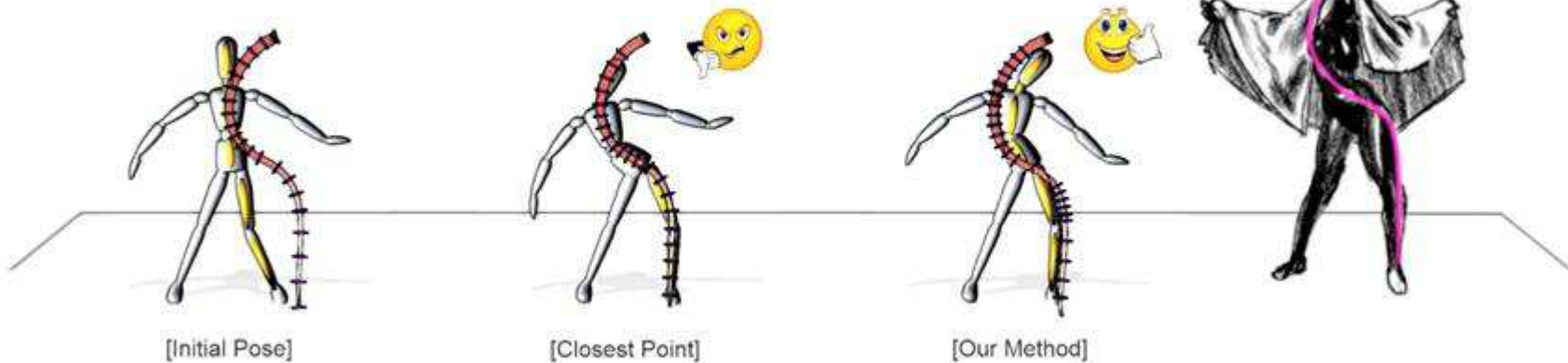


# Mapping Both Lines

- ▶ Solution: High curvature  joint.



# Mapping Both Lines

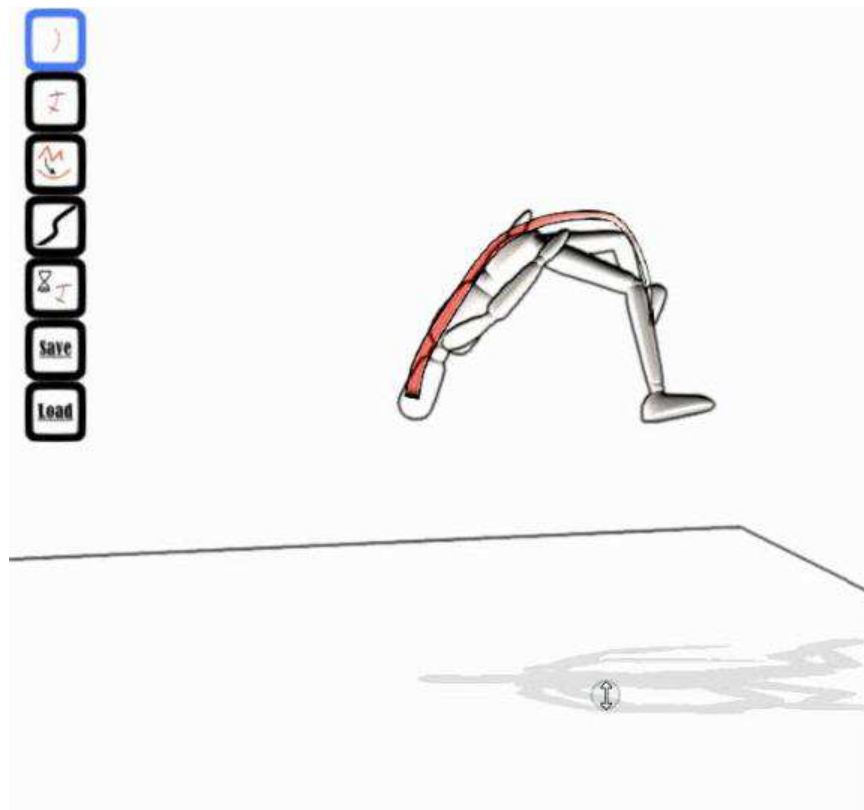




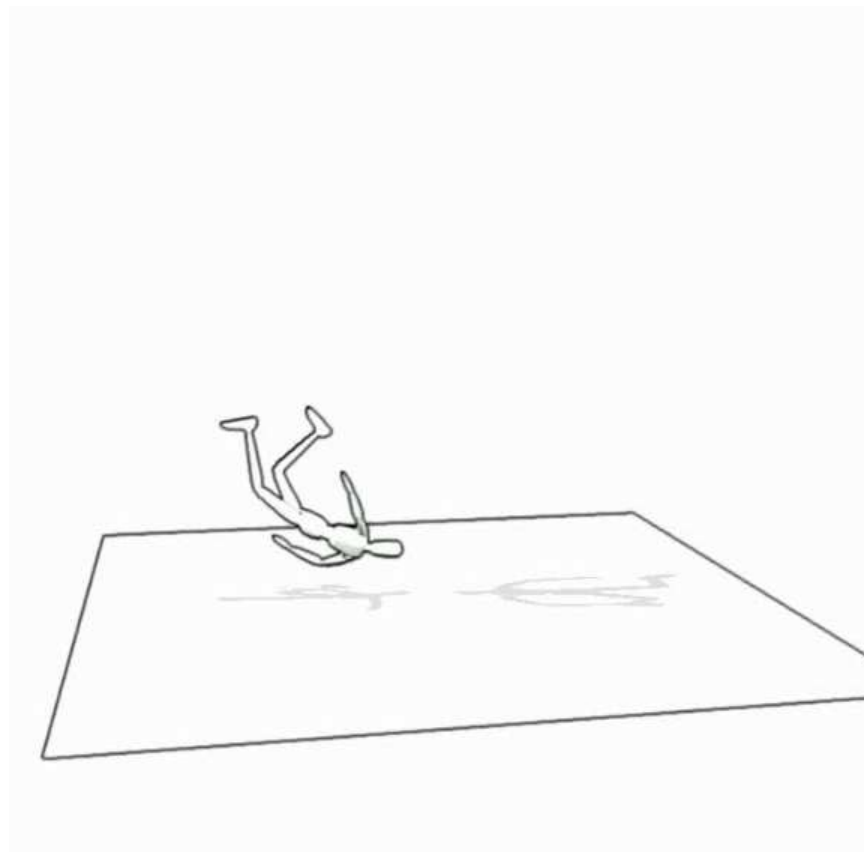
# Results

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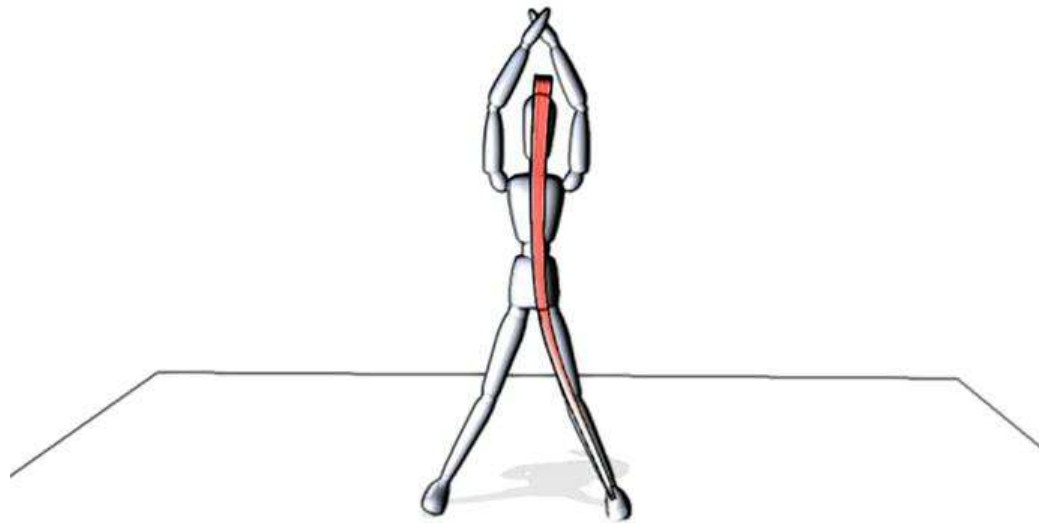
# Results



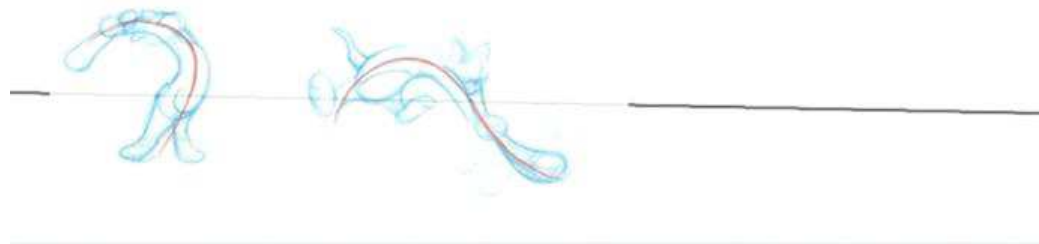
# Results



# Results



Inspiration



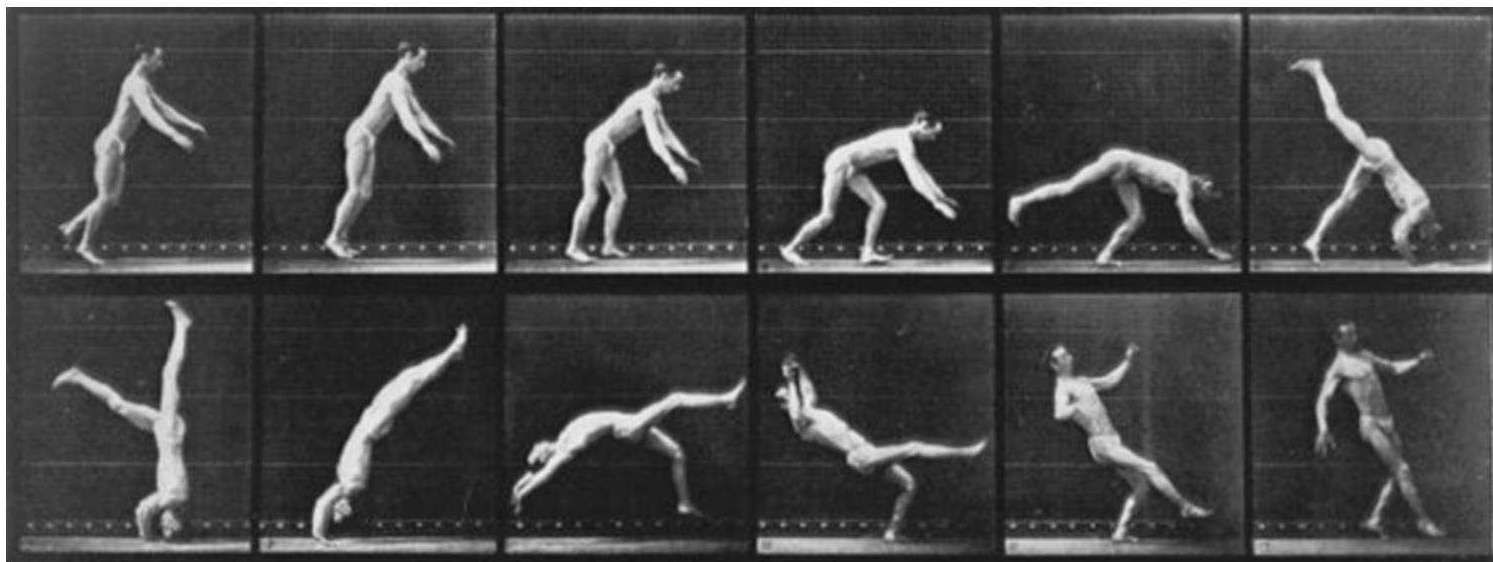
# Result

## Dance

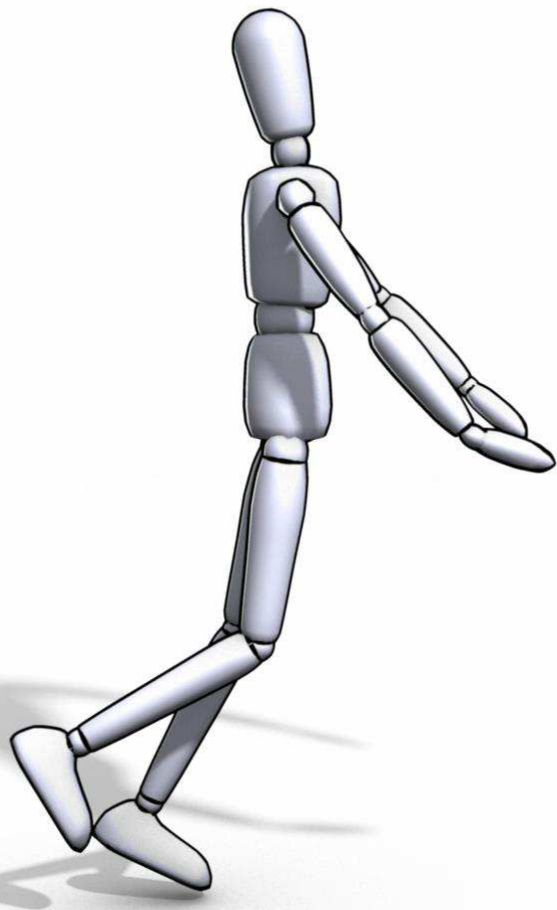


# Result

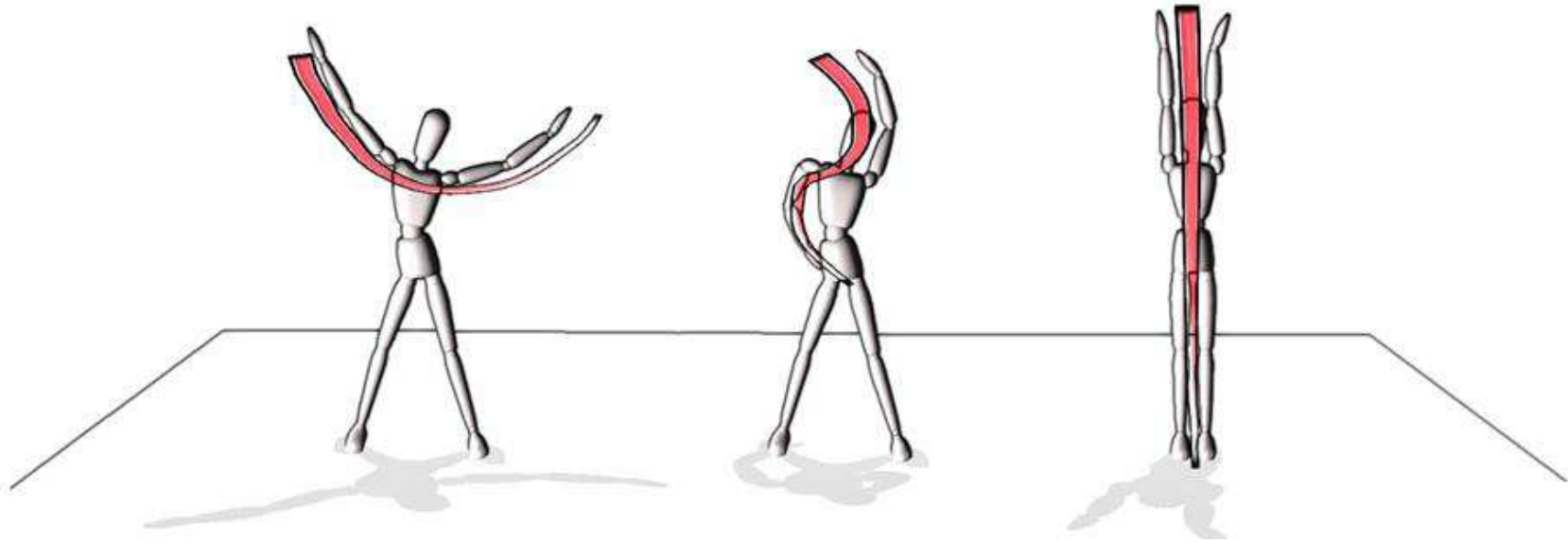
# Muybridge







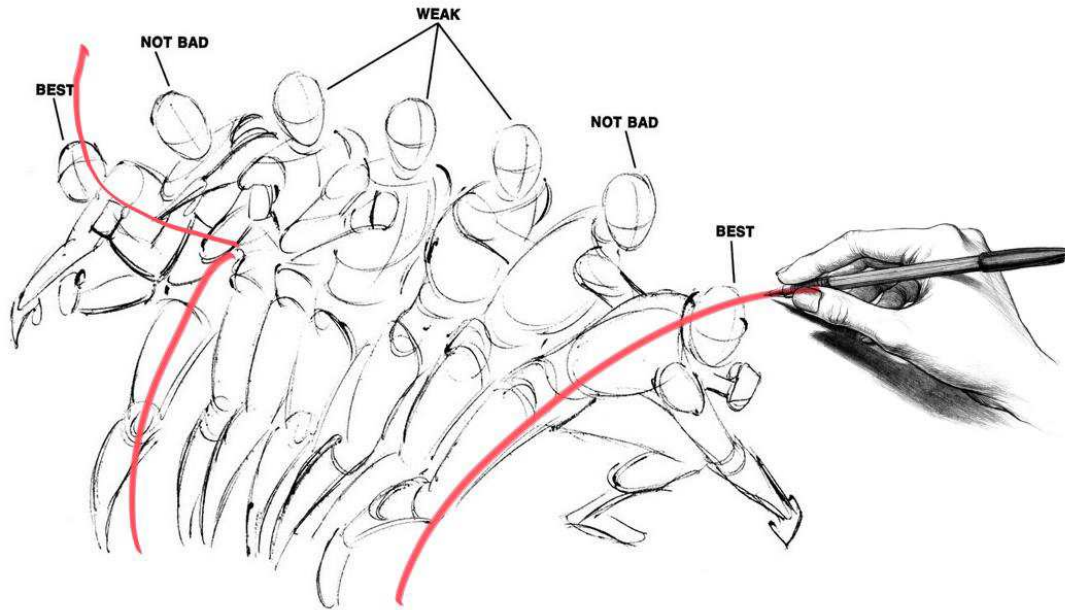
# Expressive: CSI-shaped curves



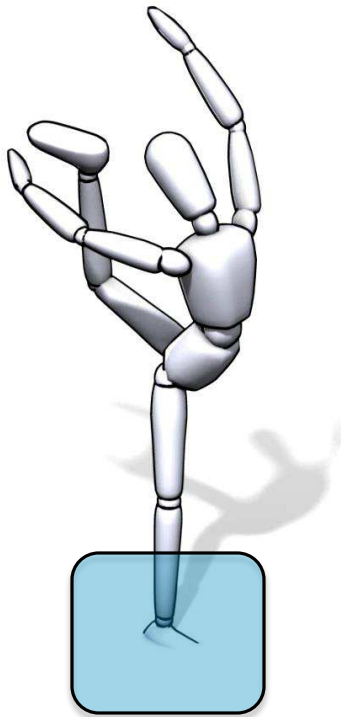
- ▶ Simple curves make the pose as *readable* as possible.
- ▶ Freeform curves allow more poses, and nuances.

# Expressive

- ▶ **Single stroke**, in a single hand **gesture**---with direct *visual* feedback.
- ▶ (Gesture comes from the heart)

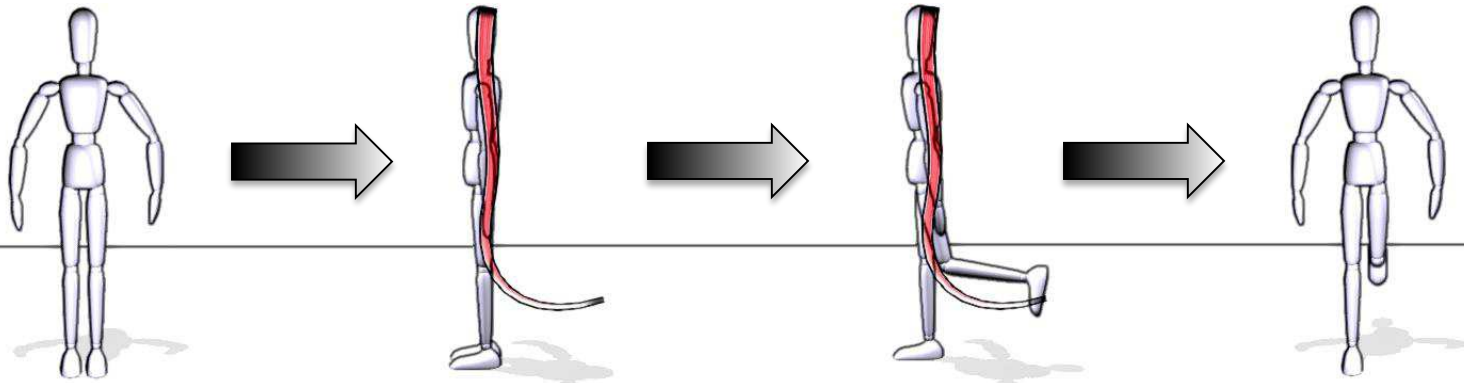


## ► Foot contacts



# Limitations

## ► Sketch-Rotate-Sketch



# Limitations

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- ▶ Assumed rigid transformations
  - ▶ No stretch,
  - ▶ But **bending is possible!**

# Thank You !

- ▶ Also, thank:
- ▶ **Laura Paiardini** for support with Maya,
- ▶ **Anonymous reviewers** for useful comments and suggestions,
- ▶ **ERC *Expressive*** grant for funding.

