SCA '13

View-Dependent Control of Elastic Rod Simulation for 3D Character Animation

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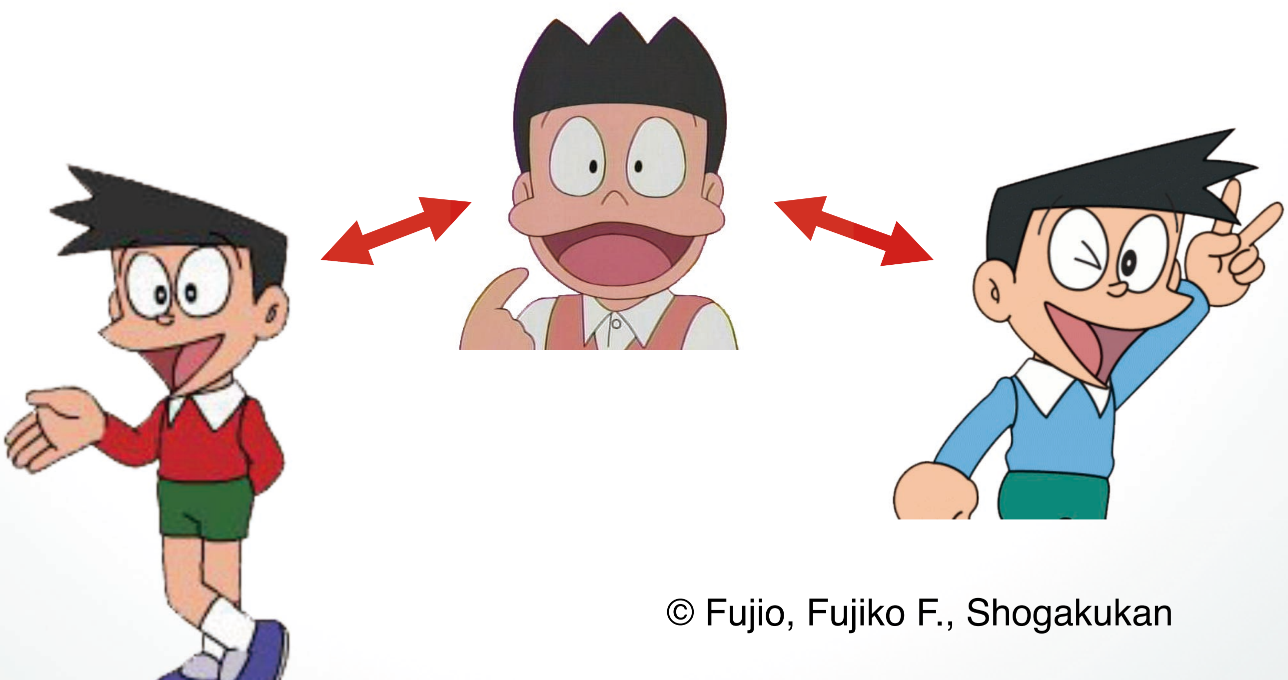
Motivation

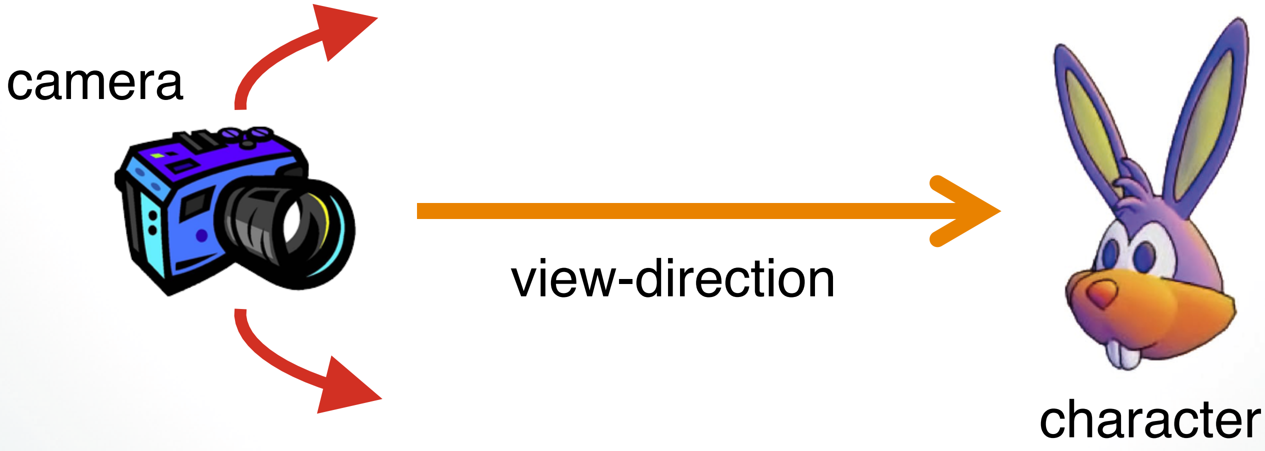
- **2D-like stylizations in 3DCG**
  - View-dependent, inconsistent shapes

Example of inconsistency:



Existing method

- **View-dependent geometry (VDG)**
  - [Rademacher, 1999]
  - Changing the geometry according to the view direction



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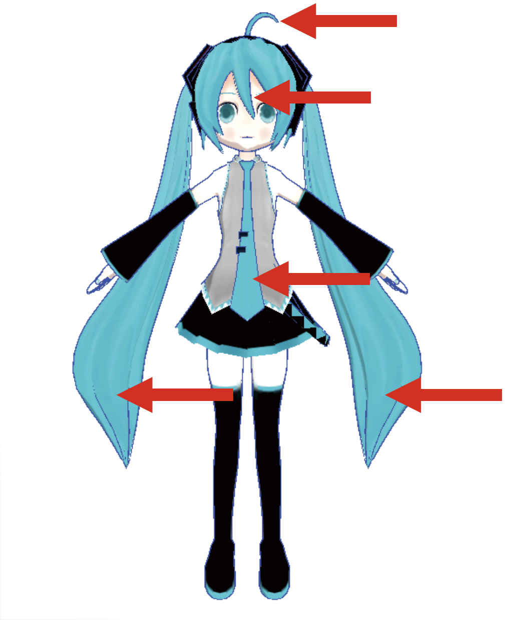
Existing method

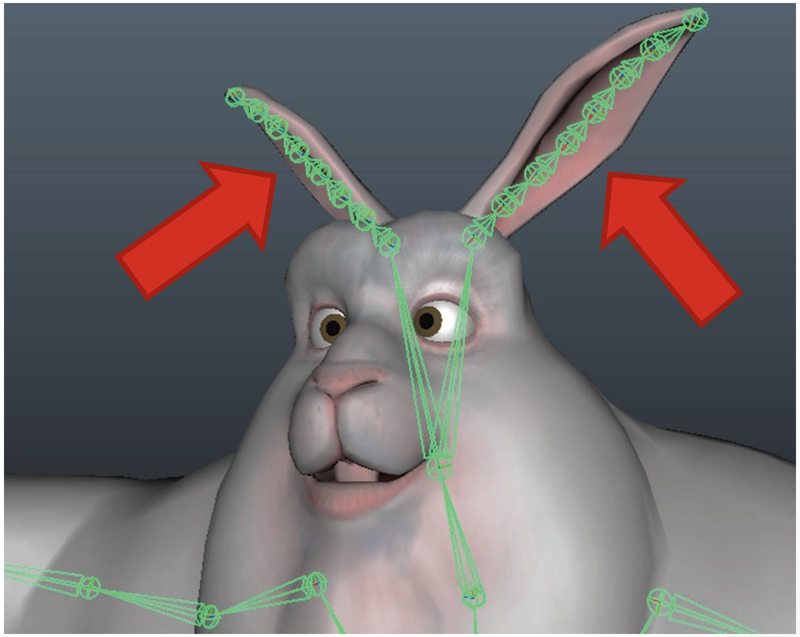
- **View-dependent geometry (VDG)**
  - [Rademacher, 1999]
  - Changing the geometry according to the view direction

Only for static geometry ☹

Our goal

- **Extending VDG for physical simulation**
  - Passively deformable **rod** structures





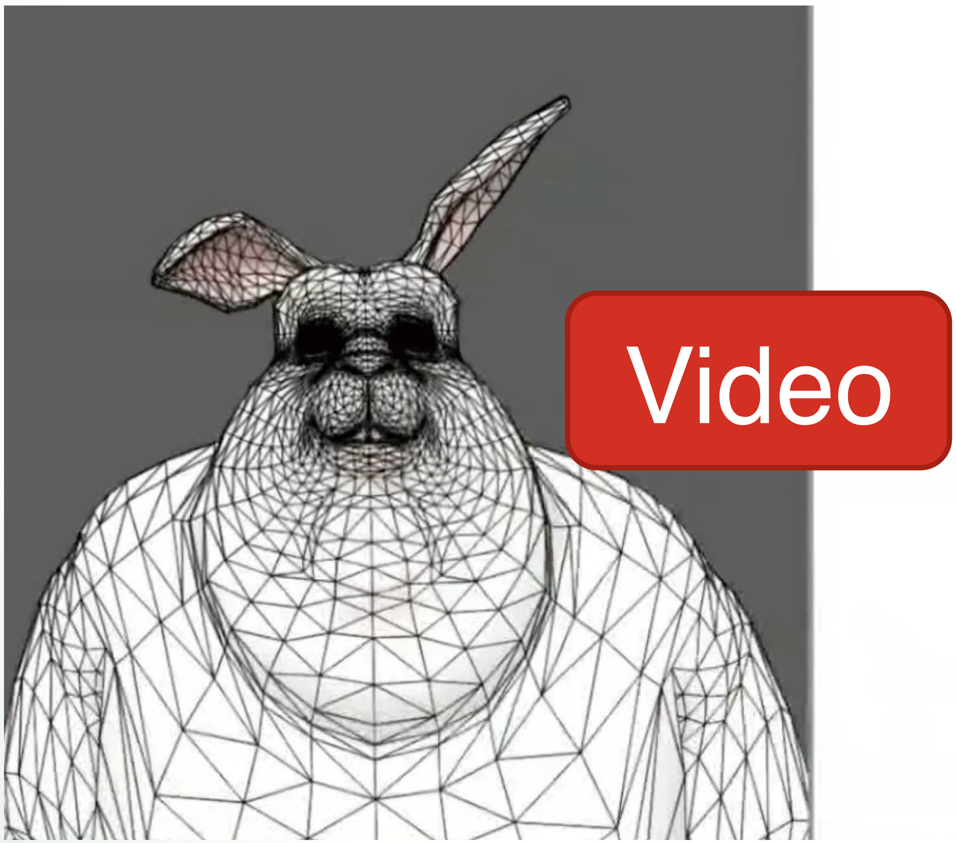
Target: hairs, ties, long ears, …

Big Buck Bunny

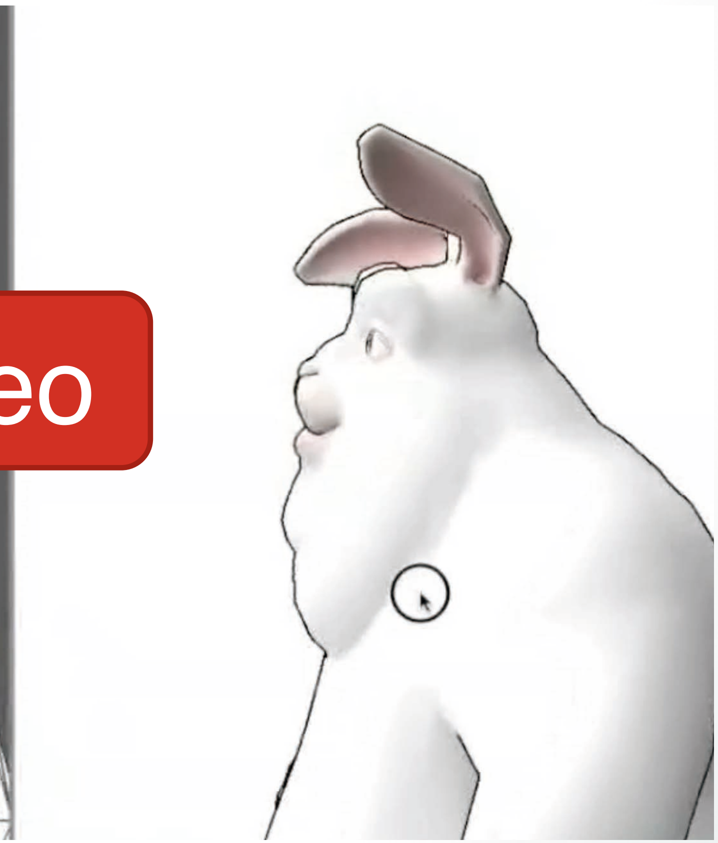
DEMO

Demo

- **Side-by-side comparison**



Fixed view



Camera view

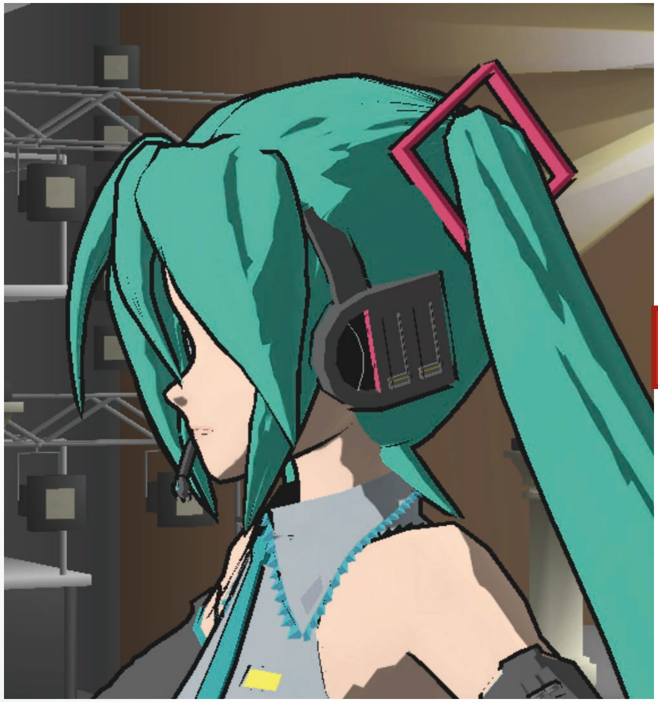
OTHER RESULTS

Other results

- **Front hair avoiding the eyes**

Other results

- **Front hair avoiding the eyes**

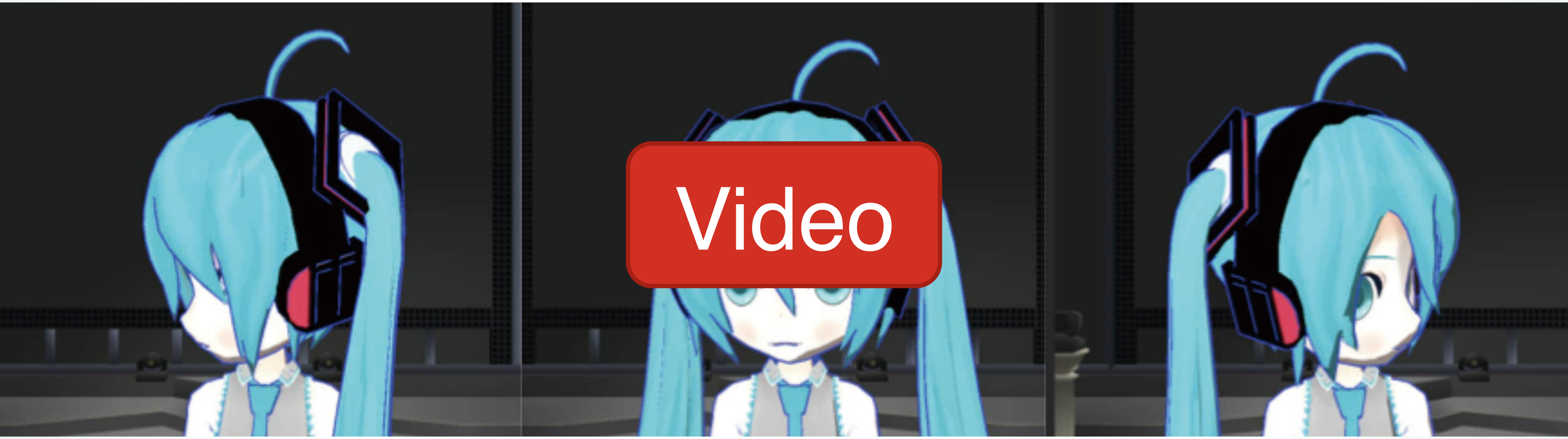


Without our method

With our method

Other results

- **Hair always facing the camera**



Other results

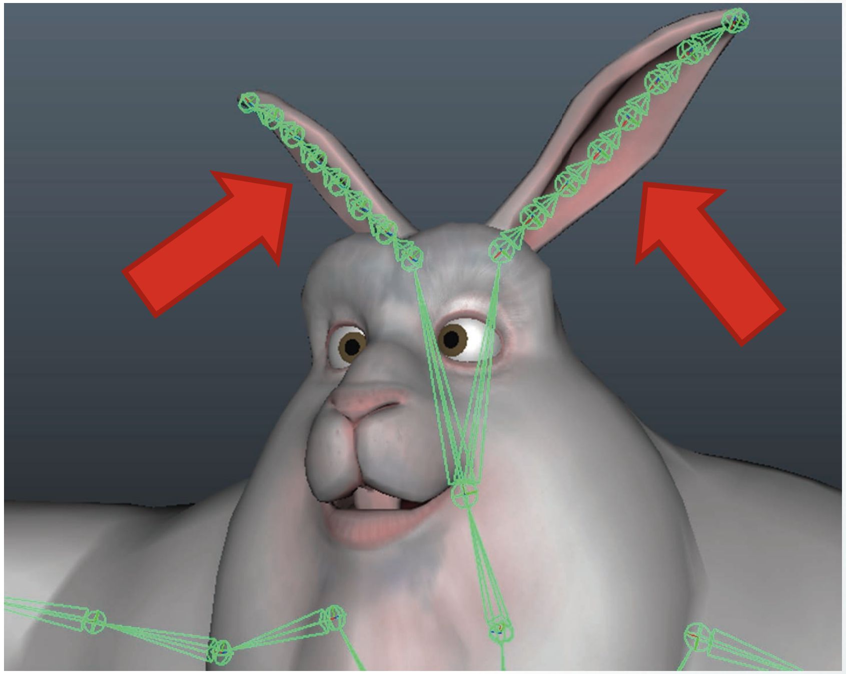
- **Hair always facing the camera**

  – This “cowlick” effect is popular especially in recent Japanese 2D animations

OUR METHOD

User inputs

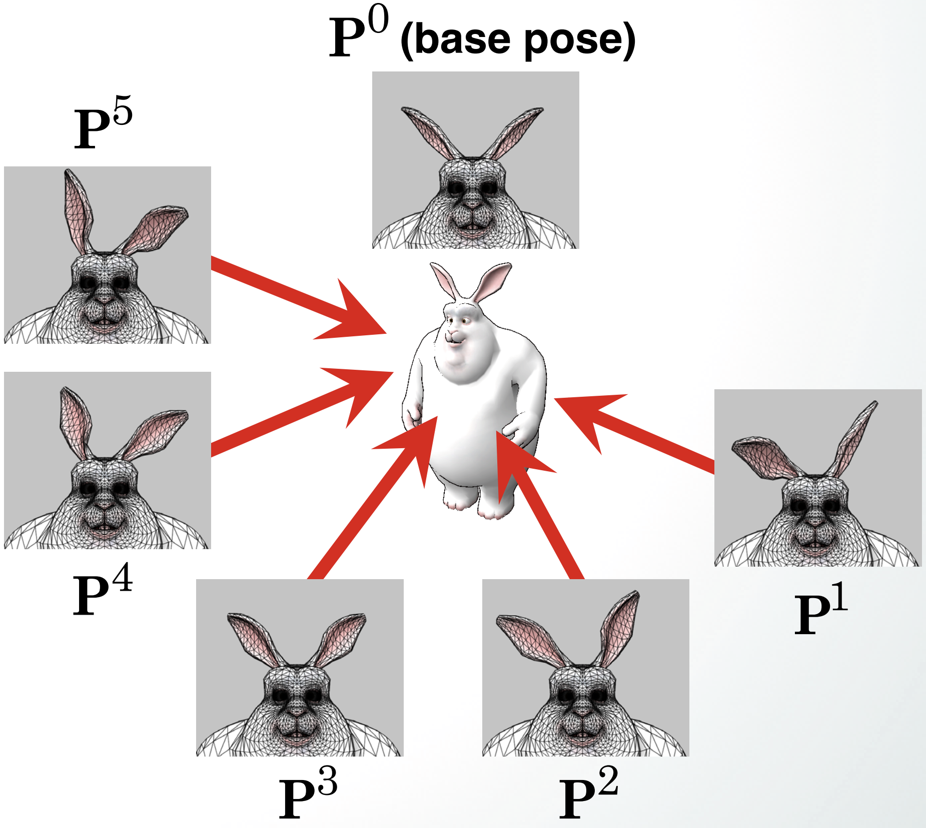
- **A skinned mesh**
  - Whose deformable rods are represented by **joint chains**



Joint chains

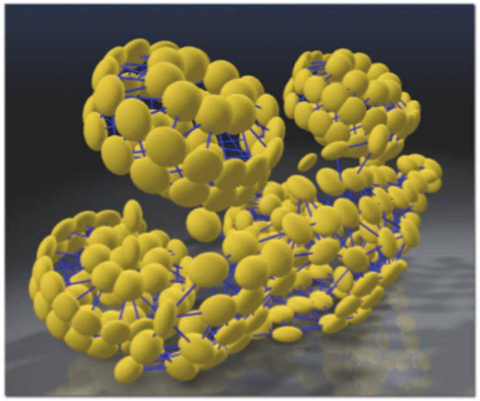
User inputs

- **A skinned mesh**
  - Whose deformable rods are represented by **joint chains**
- **Pairs of…**
  - Key example pose
  - Key view direction



Rod simulation framework

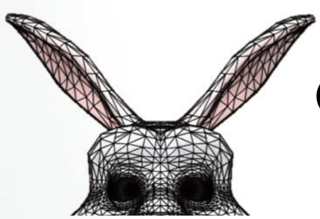
- **Oriented Particles**
  - [Müller and Chentanez, 2011]
  - Based on position-based dynamics



- **Simple distance constraint**
  - For ensuring inextensibility

Overview of the runtime operations

1. Calculate weights
2. Blend poses
3. Simulate



$\mathbf{P}^0$

(base pose)

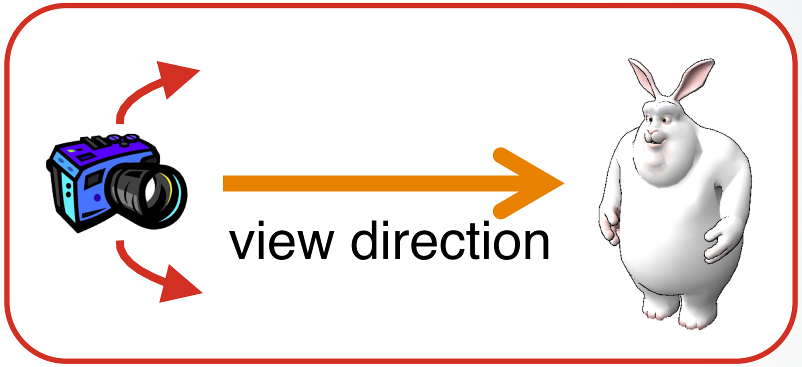
$\mathbf{P}^1$

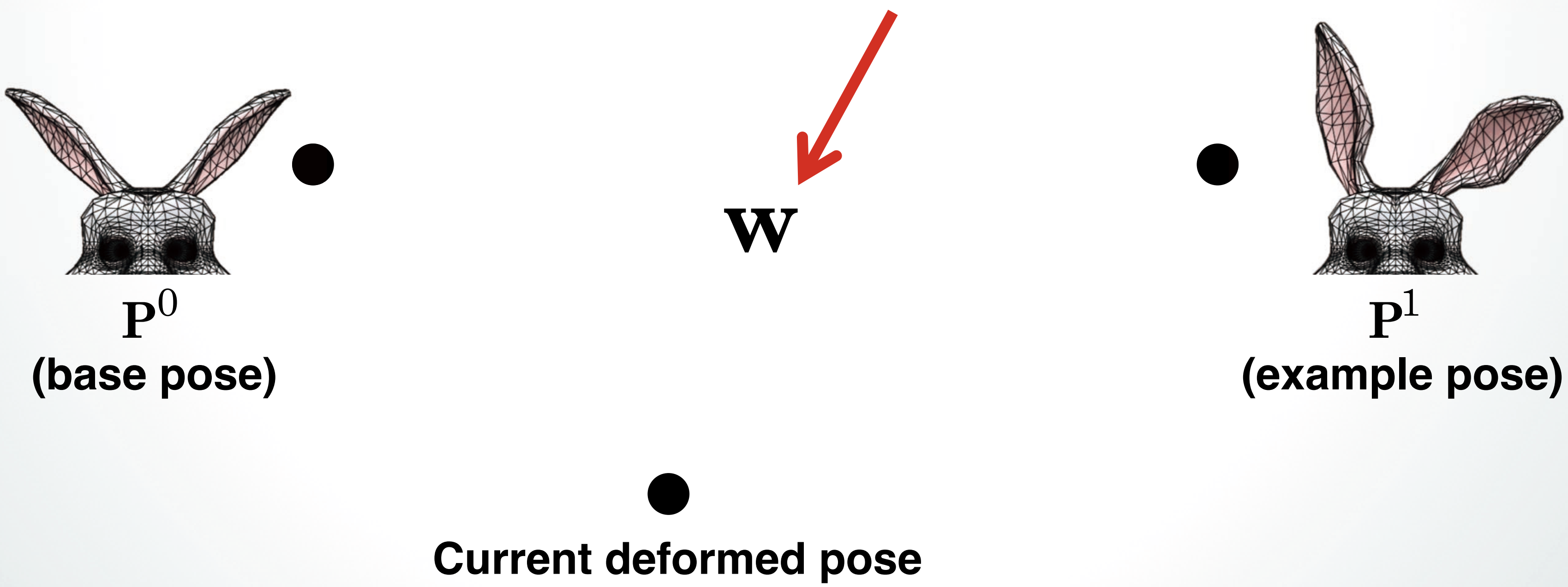
(example pose)

Current deformed pose

Overview of the runtime operations

1. **Calculate weights**
2. Blend poses
3. Simulate





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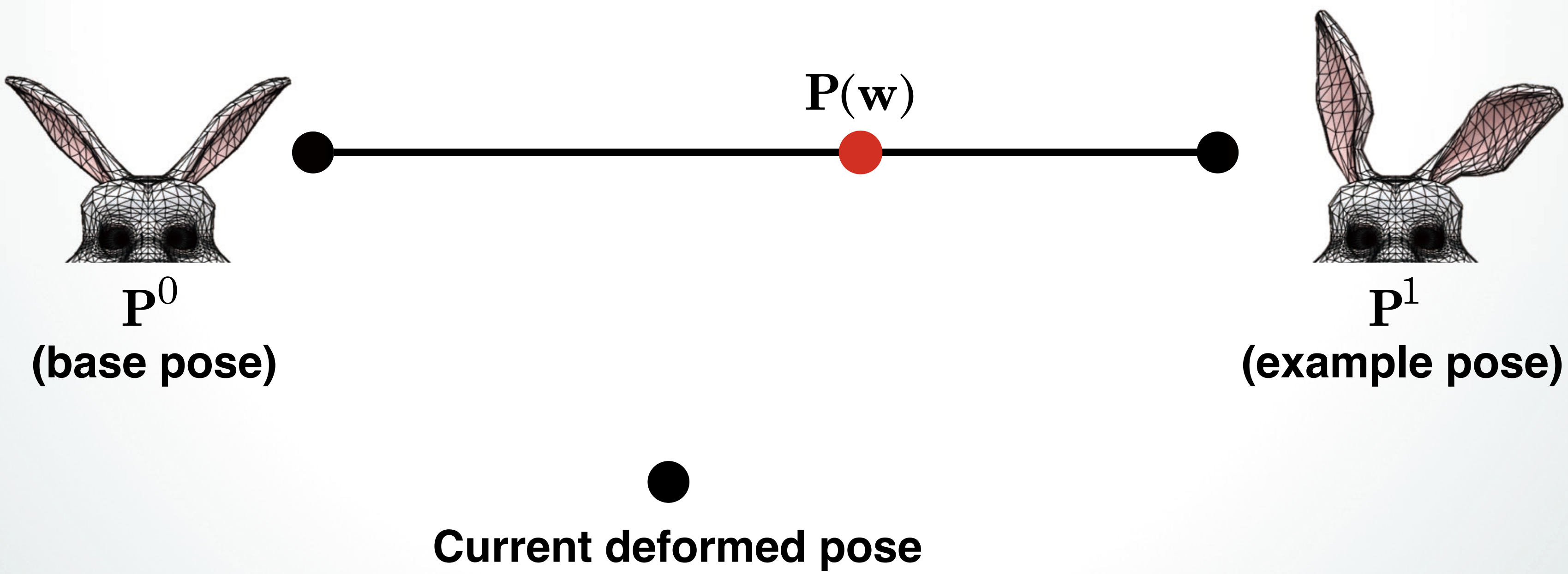

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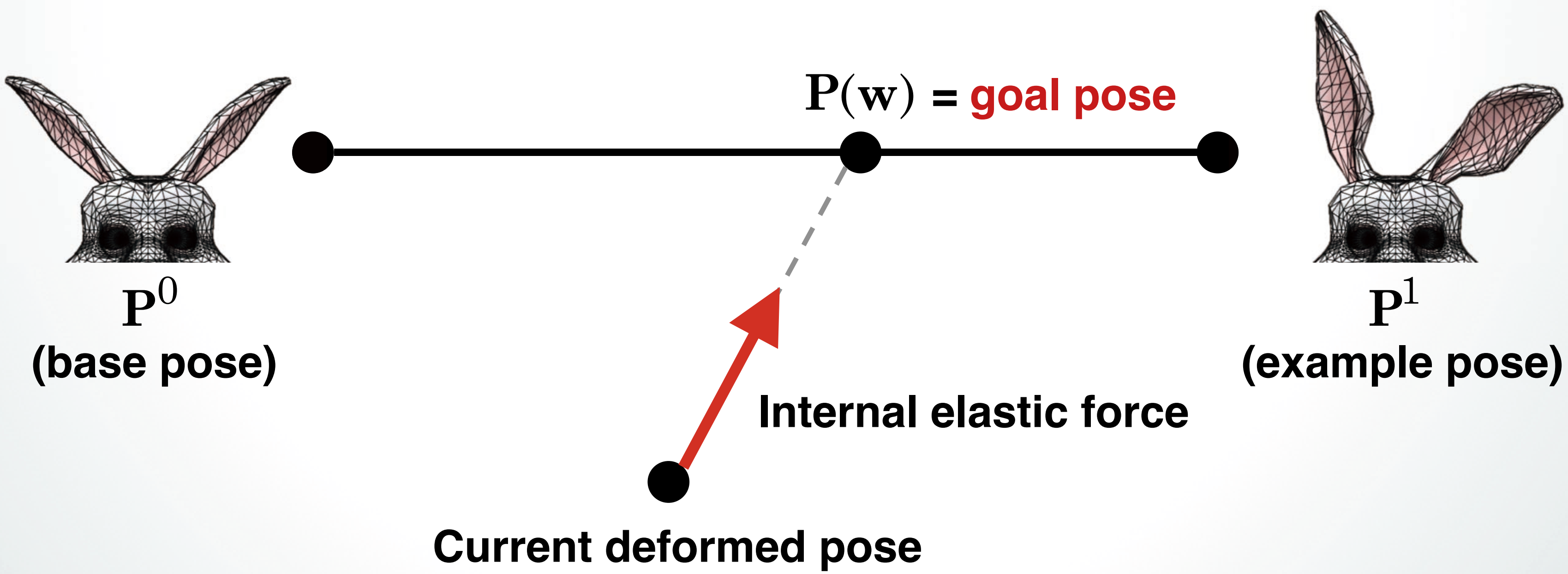
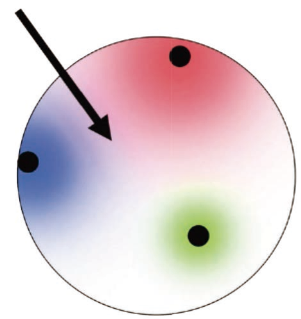
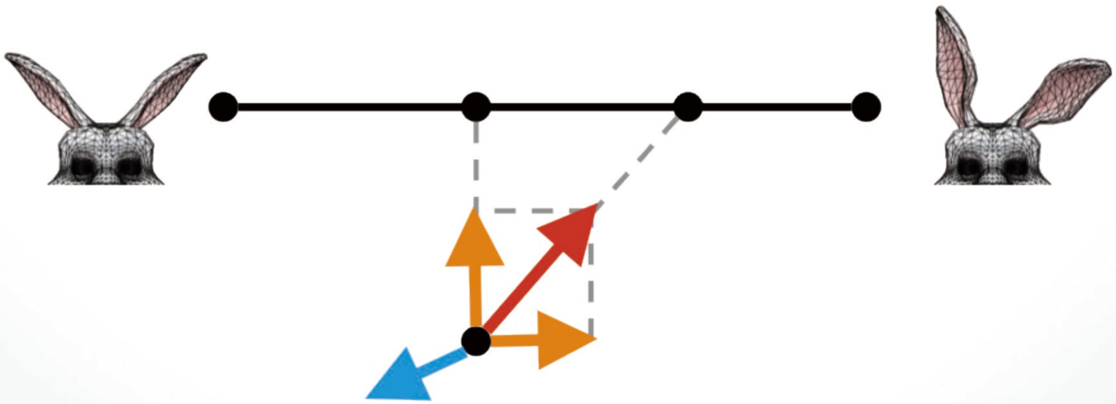


Technical details

- **Weight calculation**



- **Suppression of ghost momentum**



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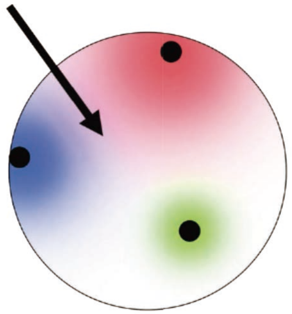
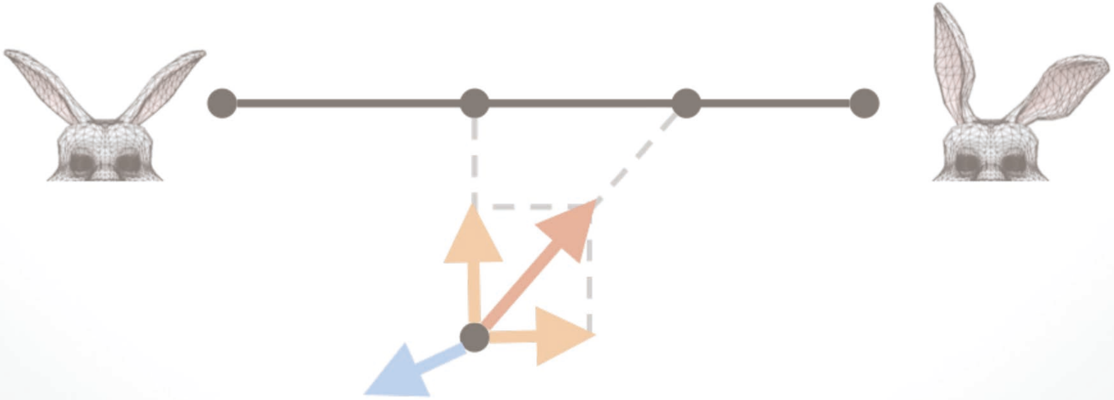
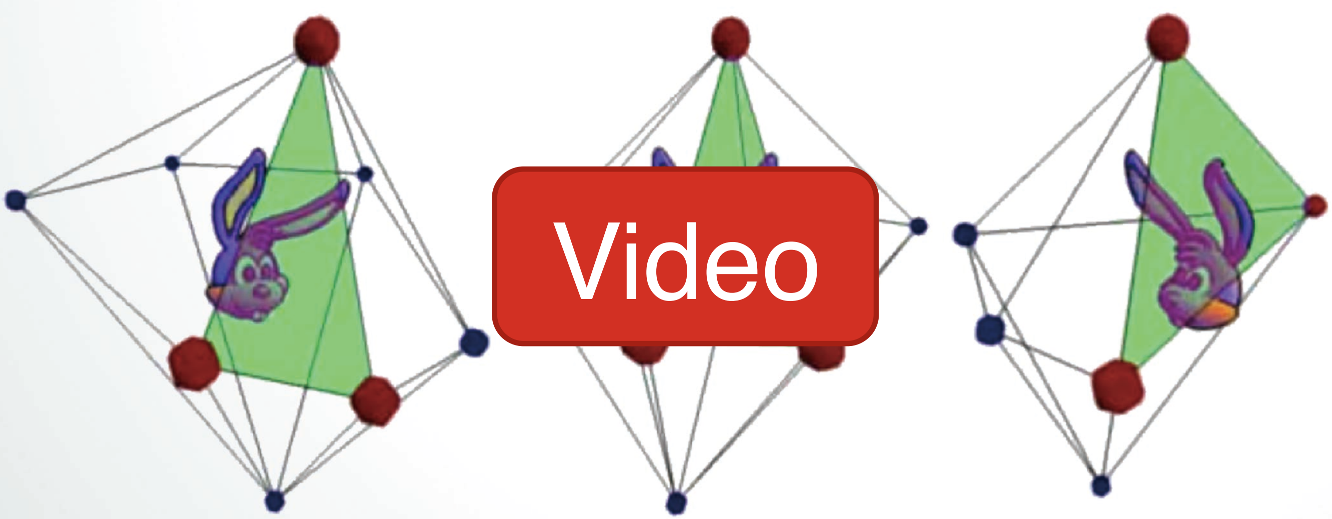


- Suppression of ghost momentum



Weight calculation

- **The algorithm of VDG [Rademacher, 1999]**
  - Wrapping the model with a triangle mesh
    - Each vertex corresponds to a key view direction



Weight calculation

- **The algorithm of VDG [Rademacher, 1999]**
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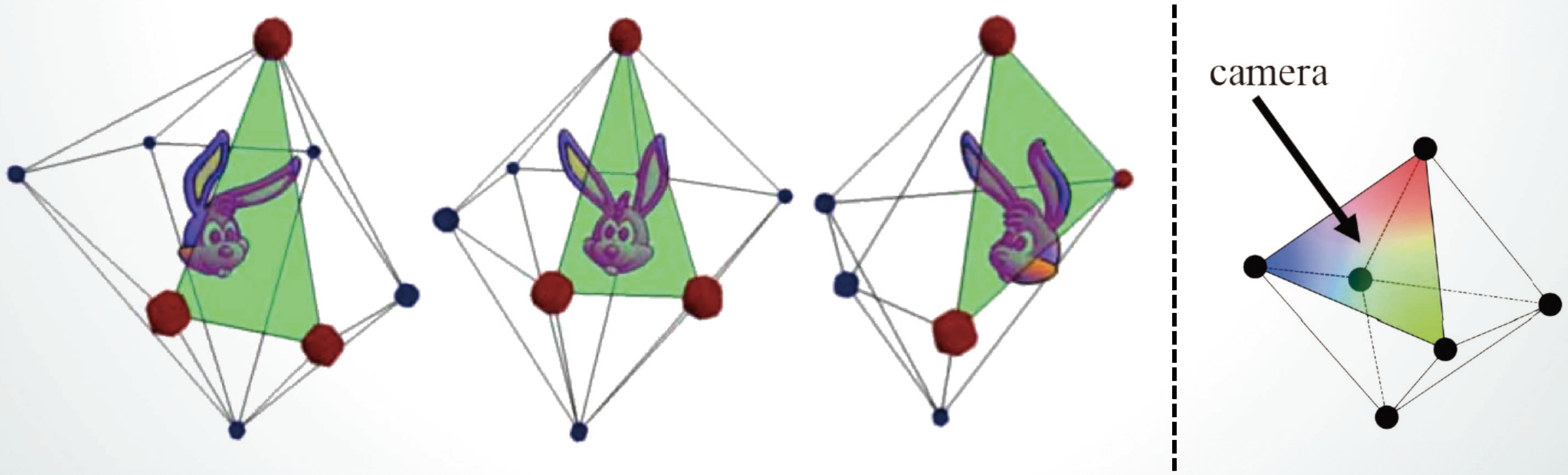
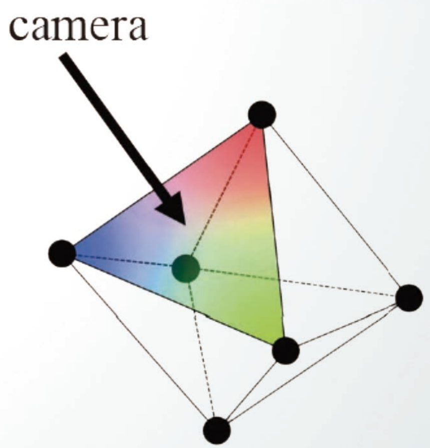


Weight calculation

- **The algorithm of VDG [Rademacher, 1999]**
  - Wrapping the model with a triangle mesh
    - Each vertex corresponds to a key view direction
  - Linear interpolation on a triangle
  - Difficulties
    - Necessary to give **at least 4 inputs**
    - No **base (default) pose**



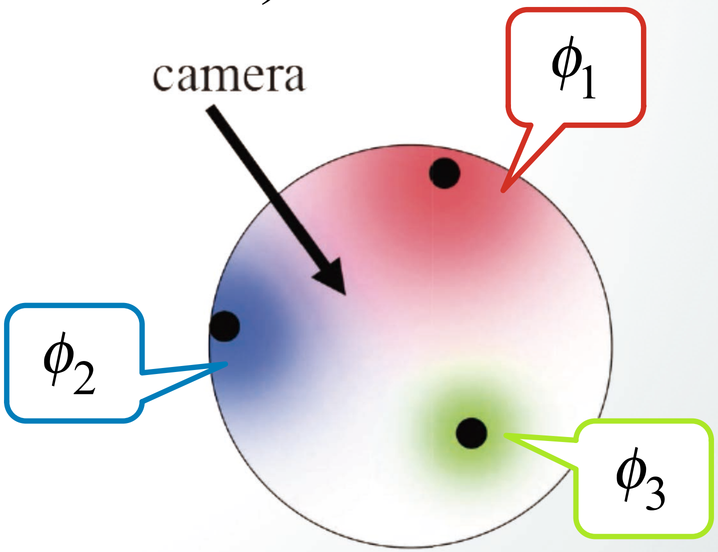
Weight calculation

- **Our algorithm (scattered interpolation)**
  - Consider **Gaussian weights** on a sphere

$$w_i = \phi_i\left(\left|\theta - \theta_i\right|\right) = \exp\left(-\left(\left|\theta - \theta_i\right|/\alpha_i\right)^2\right) \quad \left(i = 1,2,\ldots\right)$$

$$w_0 = \max\left(0,\ 1 - \sum\nolimits_{i=1} w_i\right)$$

$$\mathbf{P}\left(\mathbf{w}\right) = \frac{\sum_{i=0} w_i \mathbf{P}^i}{\sum_{i=0} w_i}$$



Weight calculation

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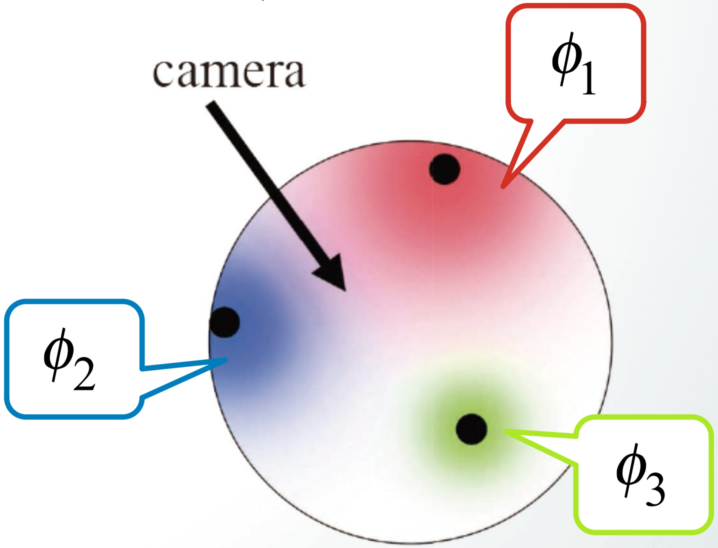
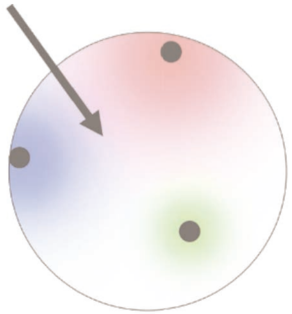
$$w_0 = \max\left(0,\ 1 - \sum_{i=1} w_i\right)$$

  - Arbitrary number of inputs
  - Base (default) pose
  - Influence control by α_i

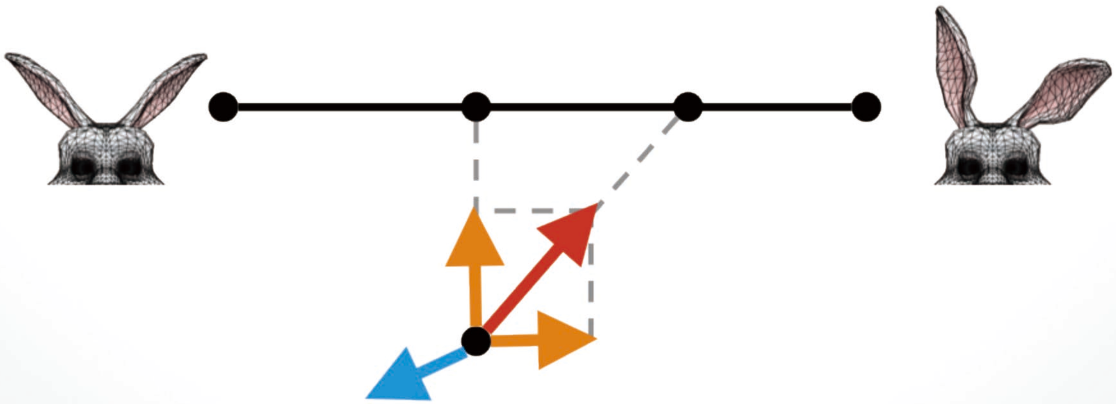


Technical details

- Weight calculation

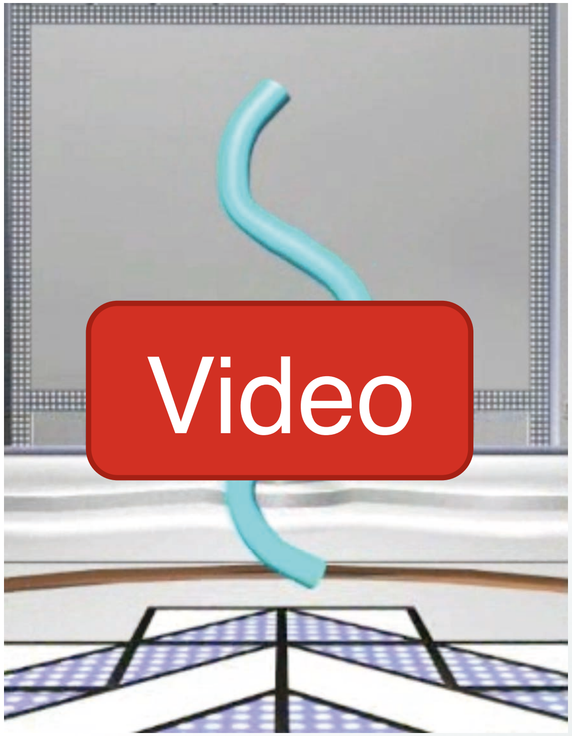


- **Suppression of ghost momentum**



Problem: ghost momentum

- **Ghost momentum**
  - The rod increases **undesired momentum** as the view direction changes
  - It looks “alive”

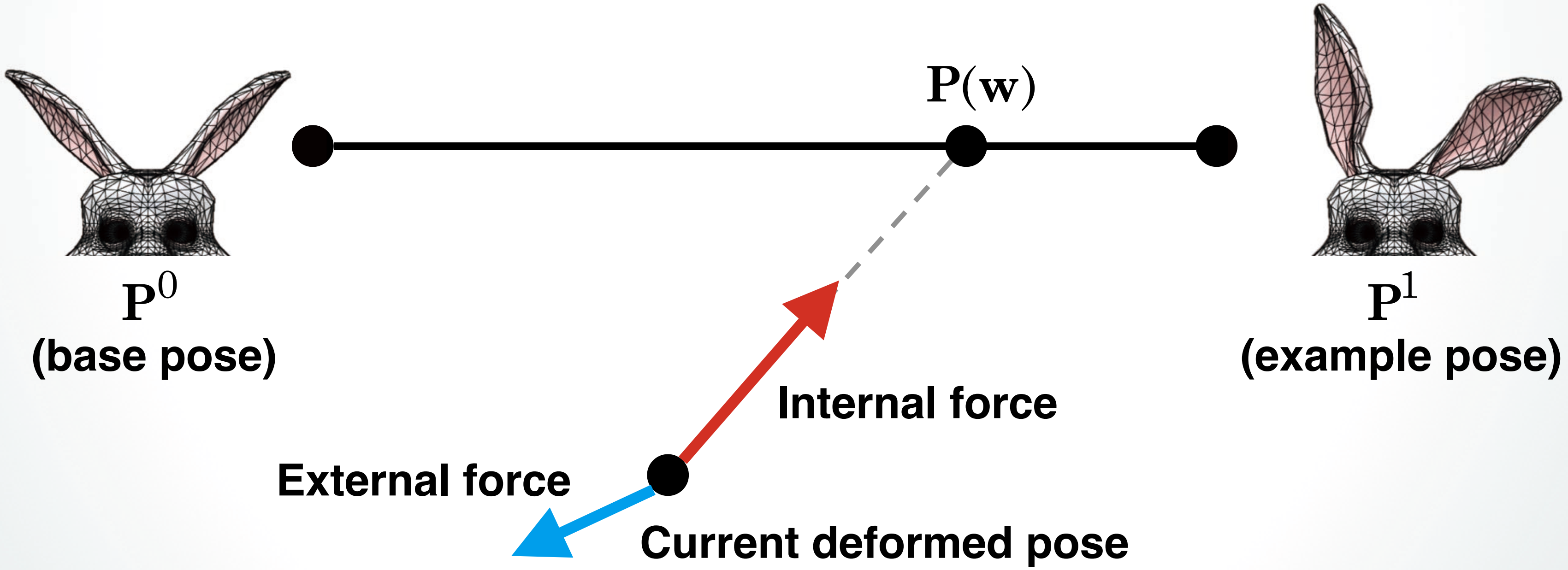


Problem: ghost momentum

- **A possible naïve approach**
  - Suppressing ALL momentum
    - Simple damping technique
  - Undesirable
- **Our solution**
  - Damping ONLY the ghost momentum
    - "**Suppression algorithm**"

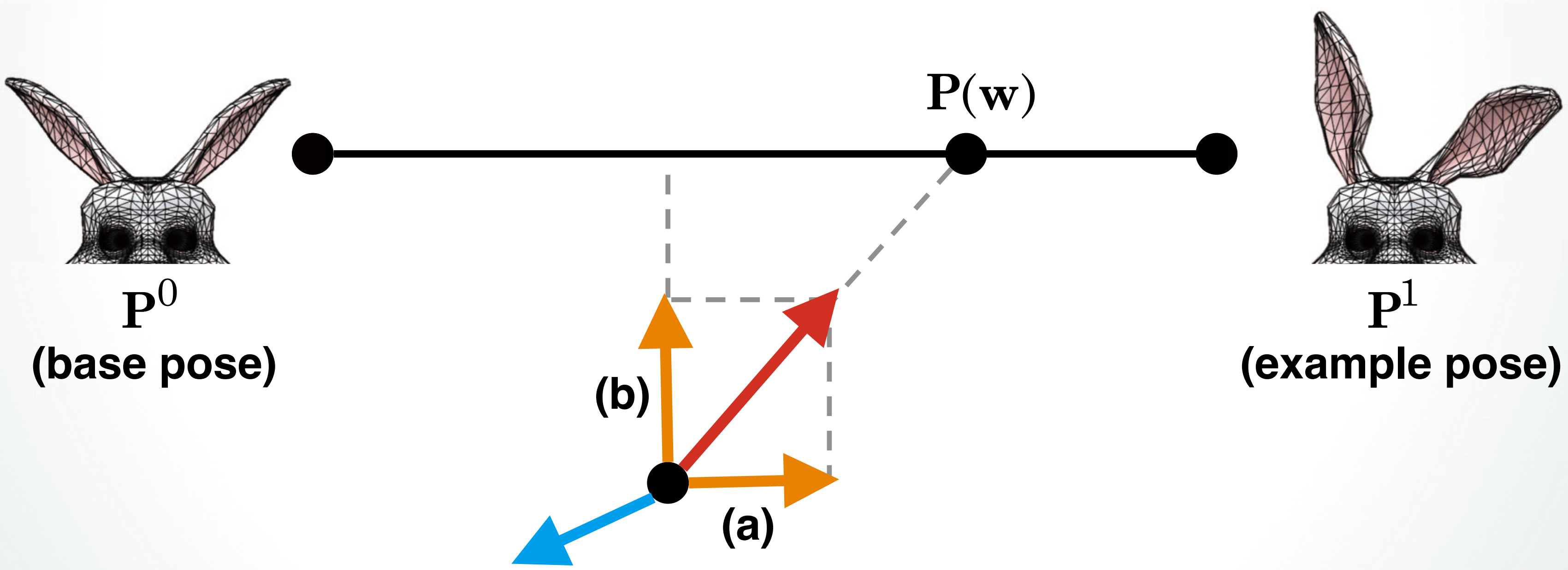
Suppression algorithm

- Separate velocity and position update



Suppression algorithm

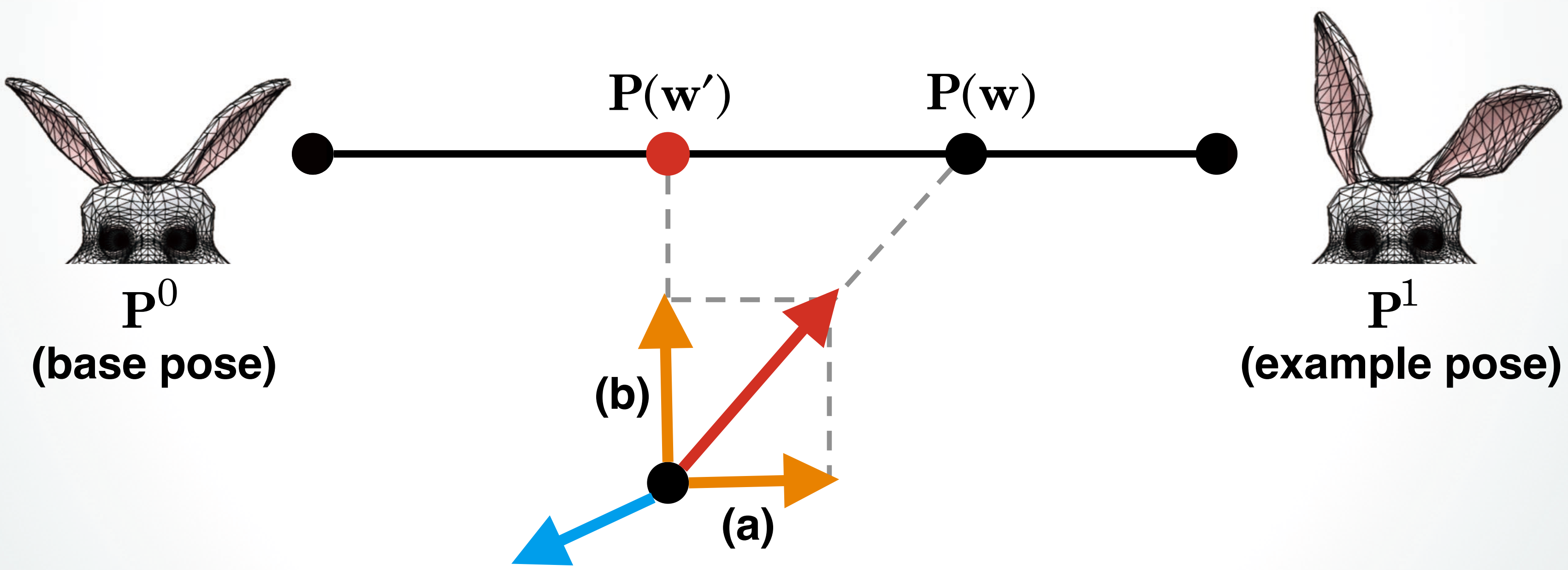
- **Separate velocity and position update**



(a): force that causes the ghost momentum
(b): force that doesn't cause the ghost momentum

Suppression algorithm

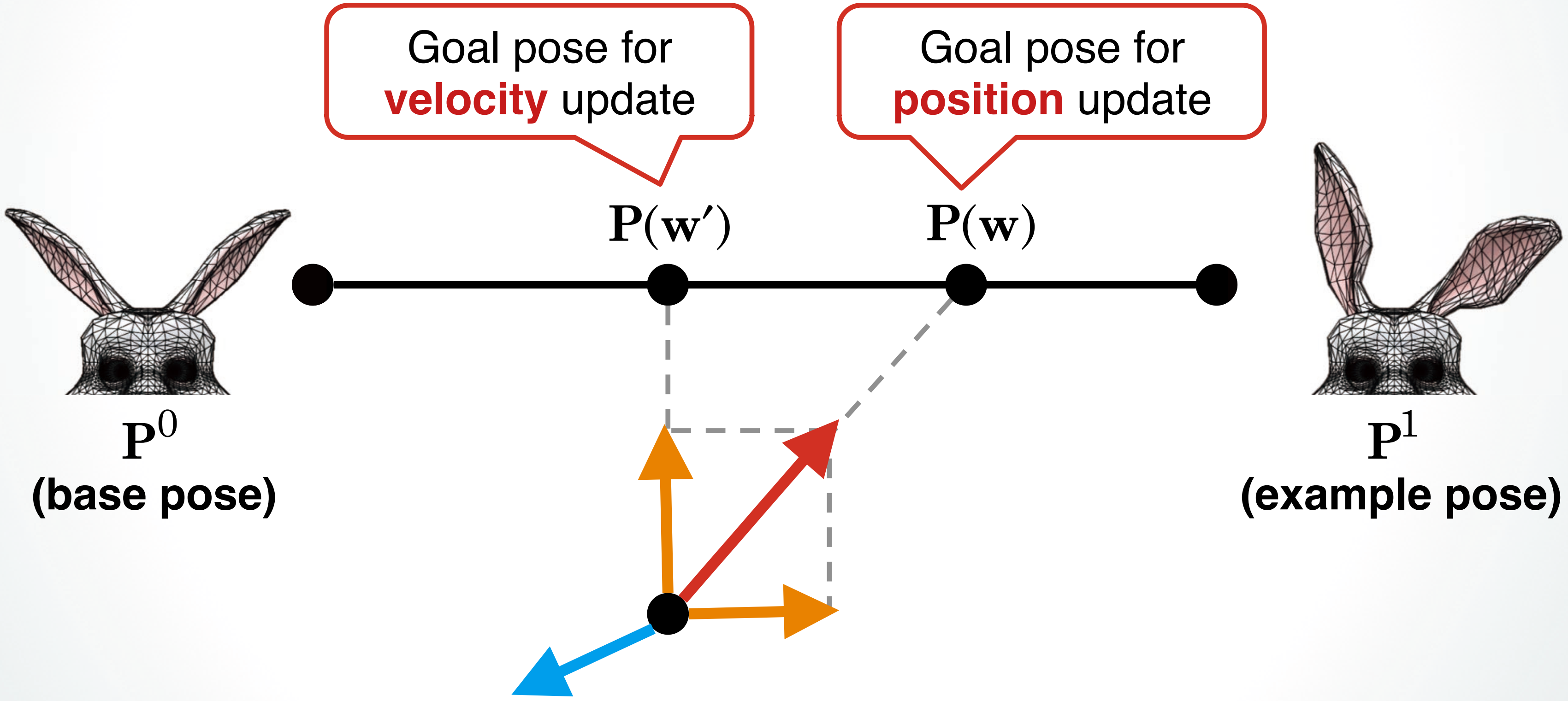
- **Separate velocity and position update**



(a): force that causes the ghost momentum
(b): force that doesn’t cause the ghost momentum

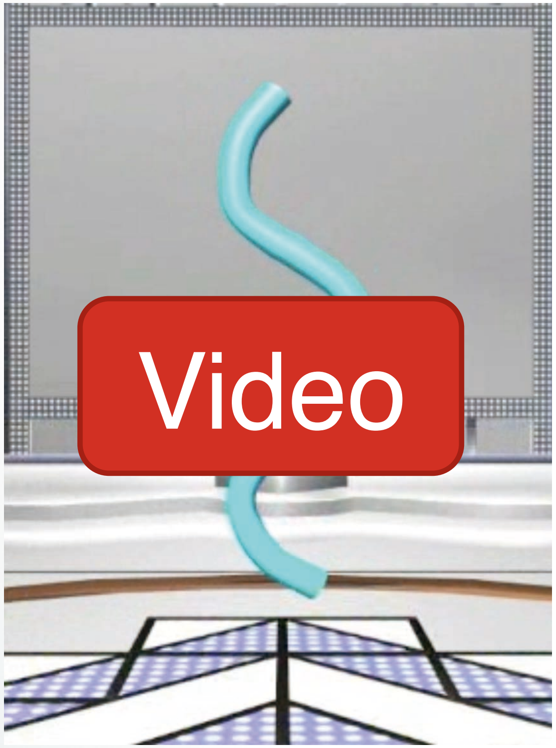
Suppression algorithm

- **Separate velocity and position update**

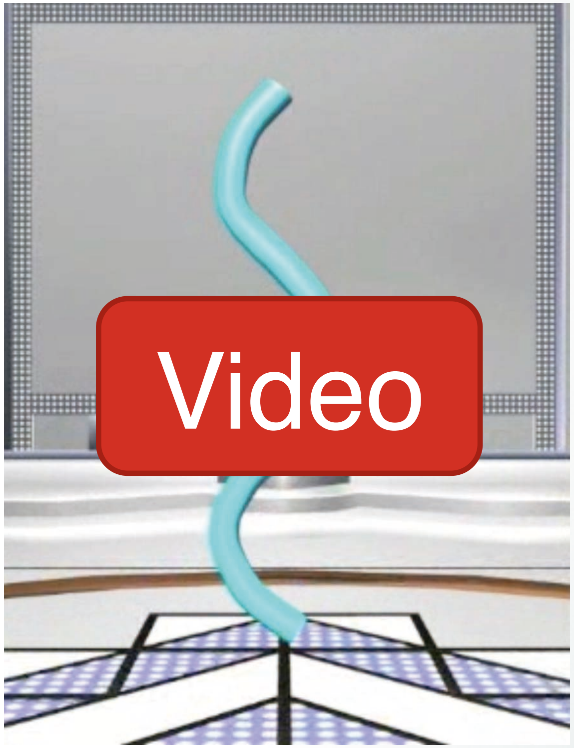


Suppression algorithm

- **Comparison**



Without suppression



With suppression

Suppression algorithm

- **Comparison**
  - Failure case (still ghost momentum remaining)

Without suppression

With suppression

Suppression algorithm

- **Limitations**
  - Cannot completely remove the momentum
    - Ghost momentum still remains
  - No theoretical ground
    - But practically useful?
  - Doubled computational costs
    - Simulation runs twice (for position and velocity)

CONCLUSION

Conclusion

- **Concept**
  - – View-dependent control of simulated rods
- **Techniques**
  - – Calculating weights from view directions
  - – Suppressing ghost momentum
- **Limitations**
  - – Suppression algorithm is not complete
    - Empirically (not theoretically) derived algorithm
  - – Not physically accurate

Thank you for listening

- **Characters used in our experiments**
  - Hatsune Miku © Crypton Future Media, Inc.
  - Big Buck Bunny © Blender Foundation
- **3D models by Yamamoto, Kio, and Blender Foundation**