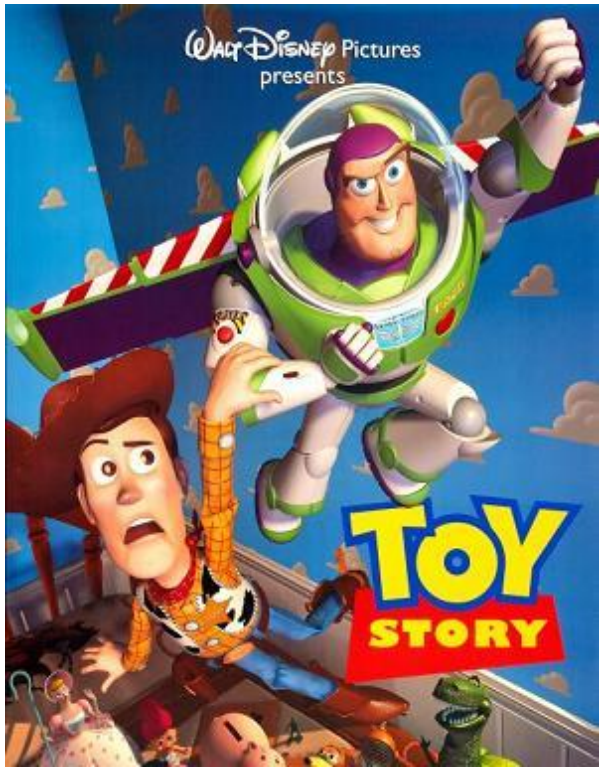
Interactive Motion Mapping for Real-time Character Control

Helge Rhodin[1]
James Tompkin[1,2]
Kwang In Kim[1,3]
Kiran Varanasi[1,4]
Hans−Peter Seidel[1]
Christian Theobalt[1]

[1]Max-Planck-Institute for Informatics
[2]Intel Visual Computing Institute
[3]Lancaster University
[4]Technicolor Research

Goal: Intuitive and Immediate Character Control

Computer games



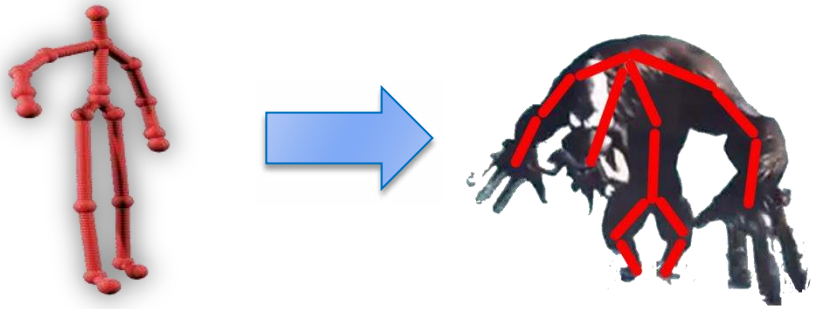
Rapid prototyping in animation

Real-time Character Control - Video Games

GTA 5

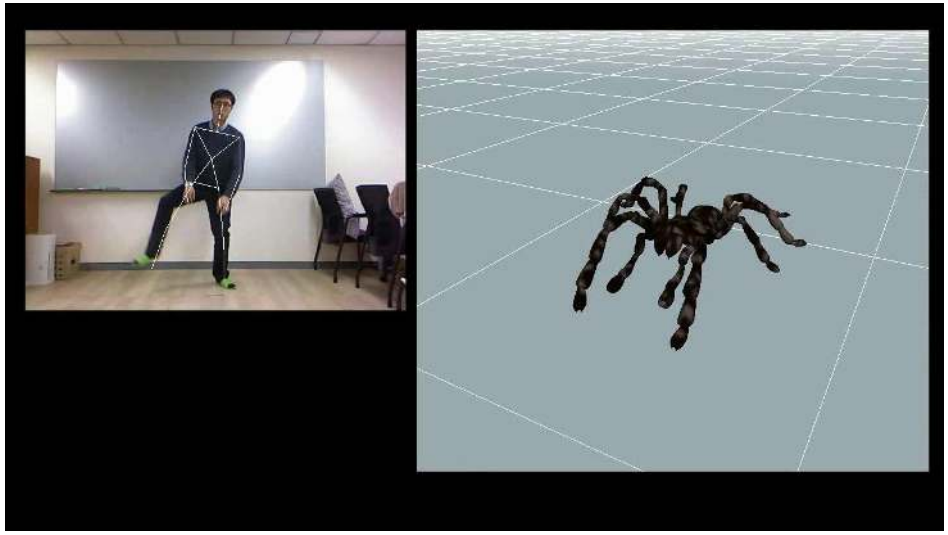
Project Spark

Game controller



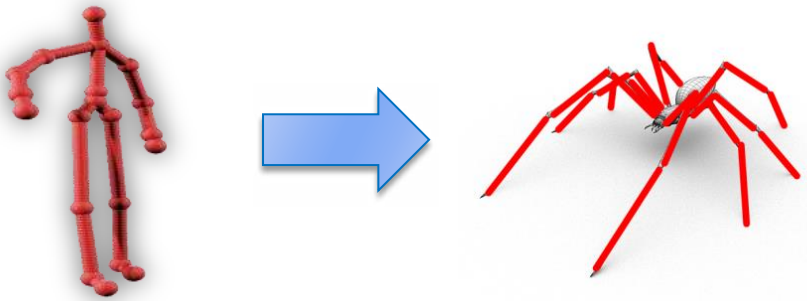
Motion retargeting

Real-time Character Control - Research



[Seol et al. 2013 "Creature Features"]

[Chen et al. 2012 "KinÊtre"]



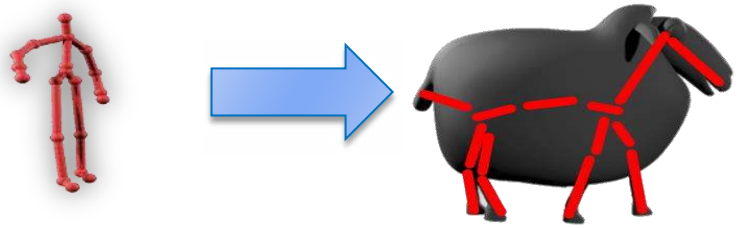
General character skeleton

Deformation by human skeleton

Challenges

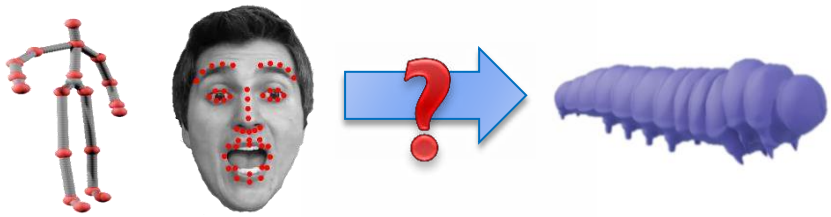
Existing approaches

- Skeleton based body control
- Cumbersome control definition

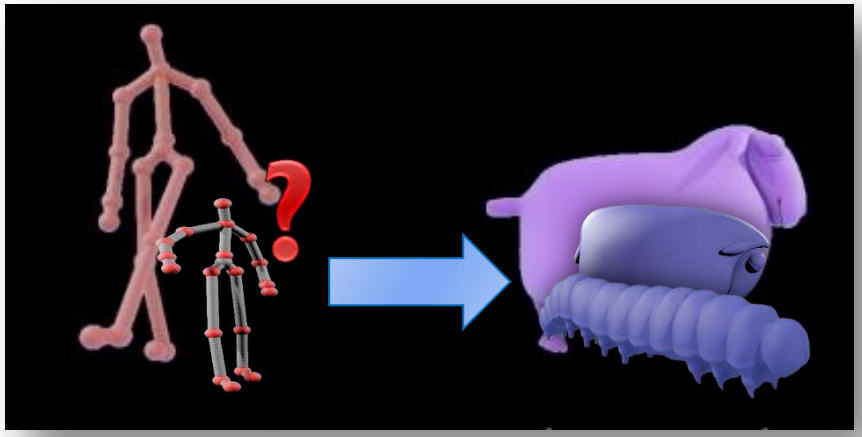


Remaining challenges

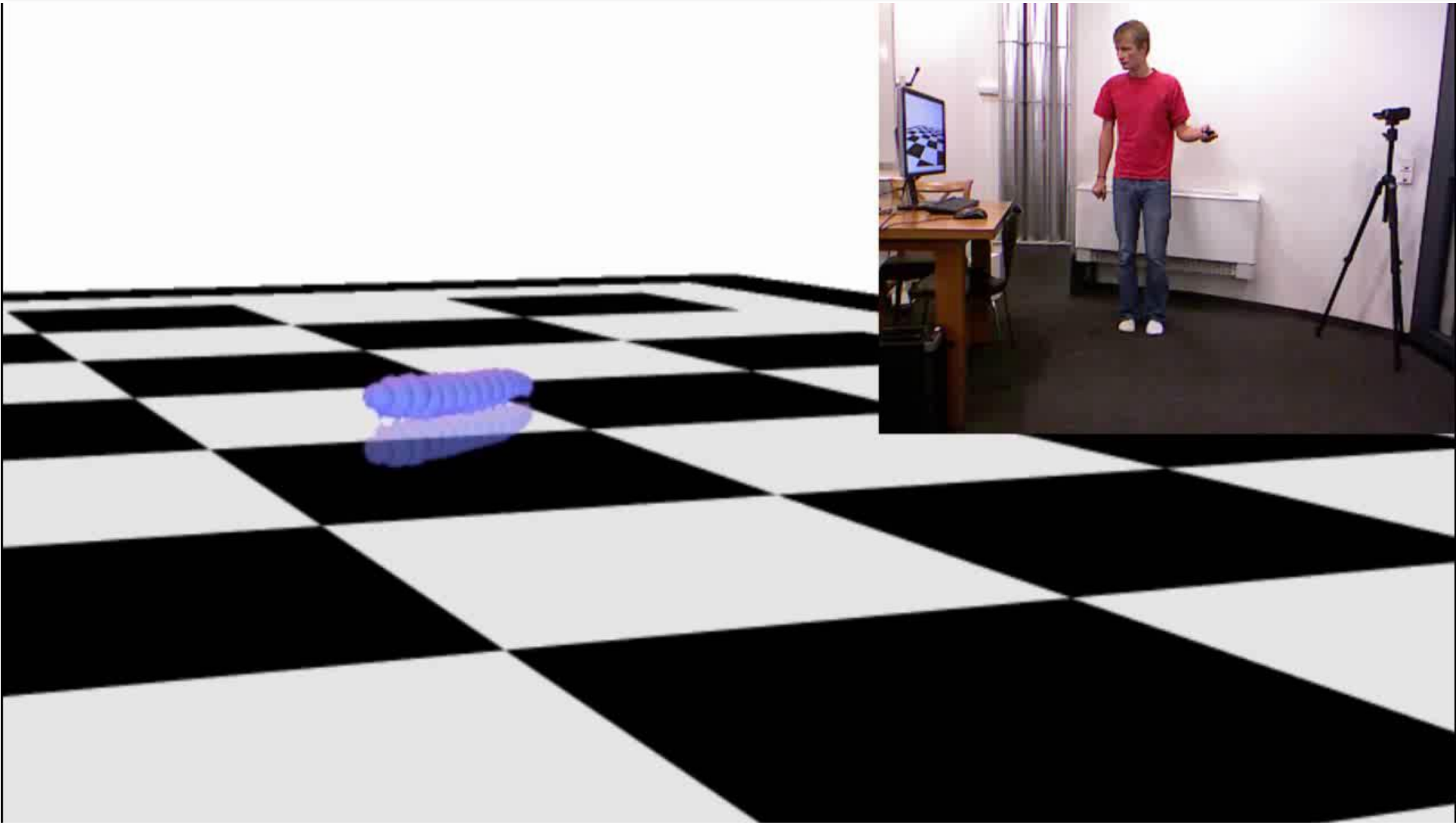
- Non-skeleton input and output (e.g. soft body of caterpillar)



- Unreliable user input (user imprecision)
- Easy definition of control modality (interface for non-technical users)



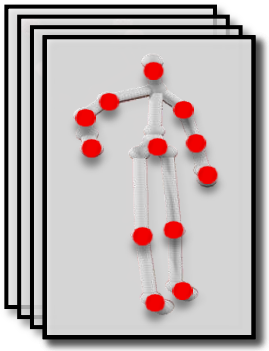
Goal – Control by Body Motion



Method Overview

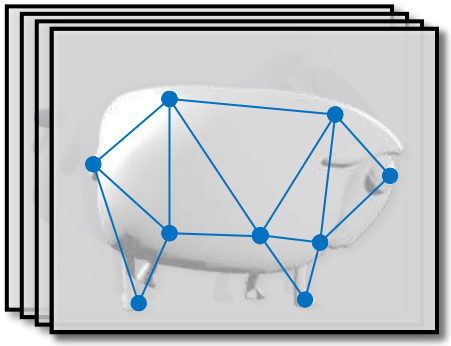
User's motion

Tracking



Input motion

Motion mapping



Character motion

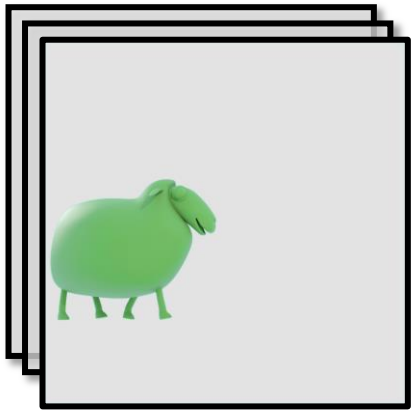
- Full-body
- Facial expressions
- Hand articulation

- Point cloud

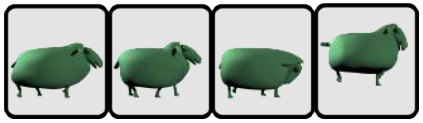
- Mesh

Method Overview – Learning and Synthesis

1. Input

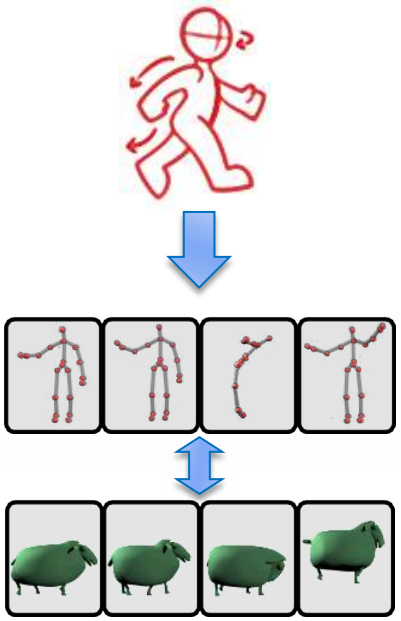


Example mesh animation



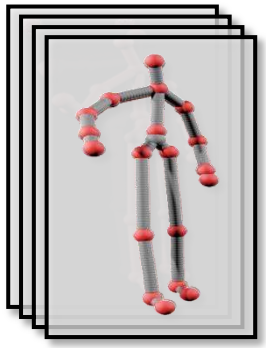
Key poses

2. Motion Mapping

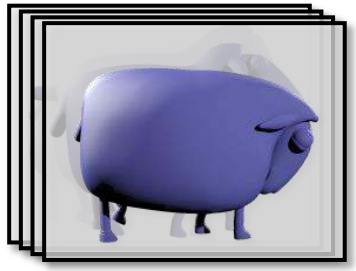


Example motions

3. Character Control



Input motion



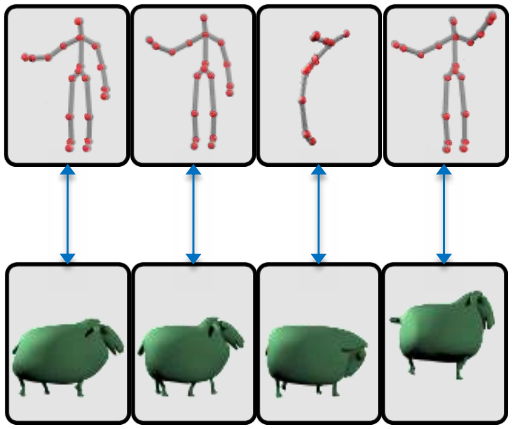
Character motion

Motion Mapping – Correspondence Definition

Goal: Easy and flexible control definition

Our approach

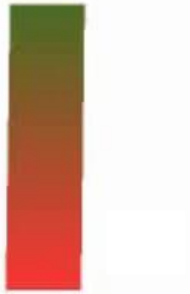
- Performance based
- Few pose examples
- Guided



The non-technical users is unaware of

- the expressiveness of his motion
- the allowed similarity of two control motions

Interactive Correspondence Definition



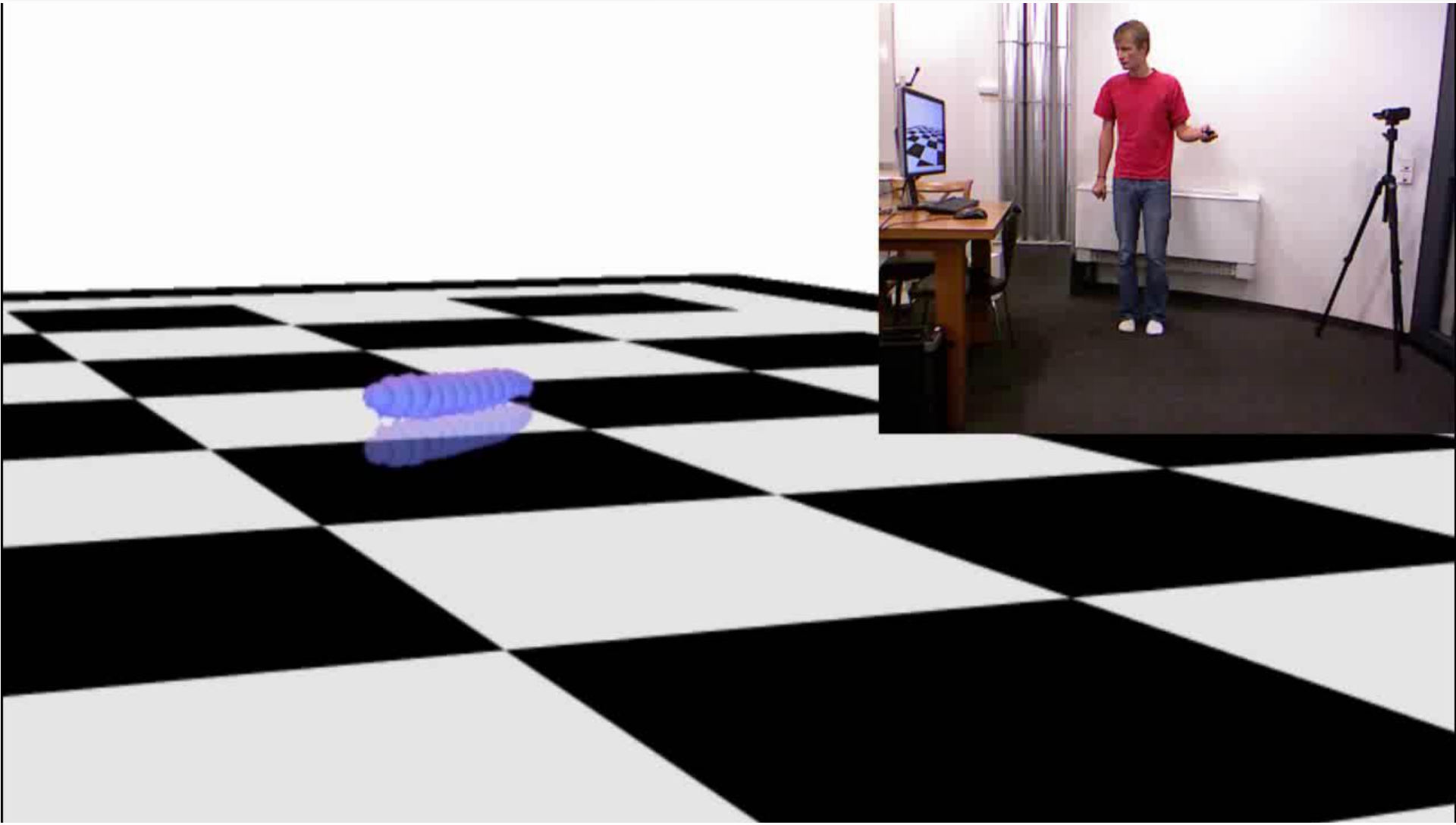
Confidence score

Input pose

Phase 3: press controller to choose correspondence frame 1 of 8

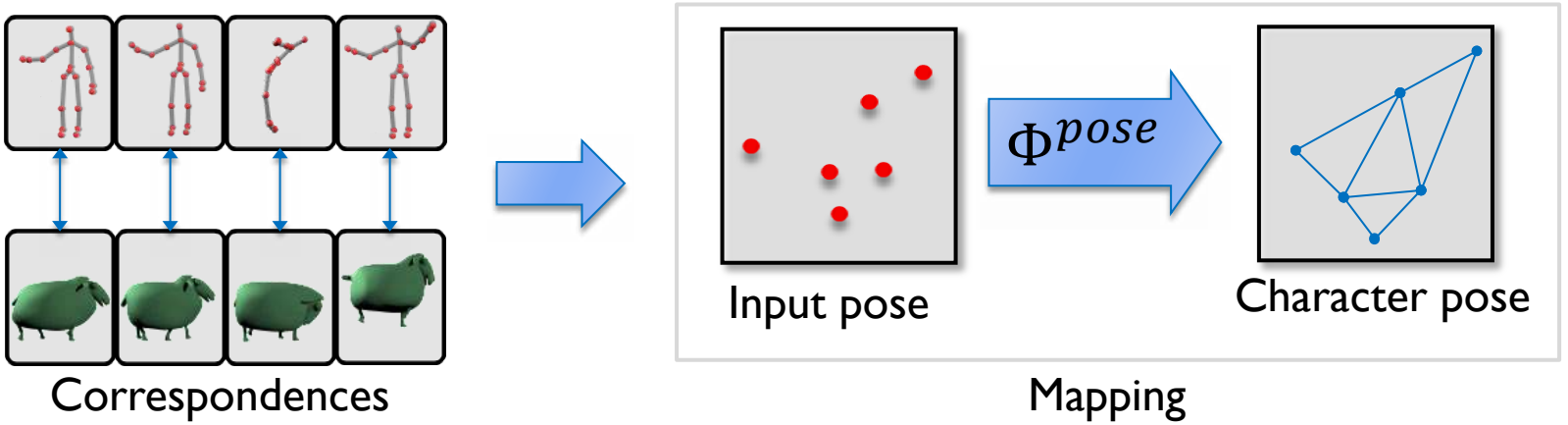
1-2. bend left & right 3. lift head 4. jump 5-8. crawl

Control by Body Motion

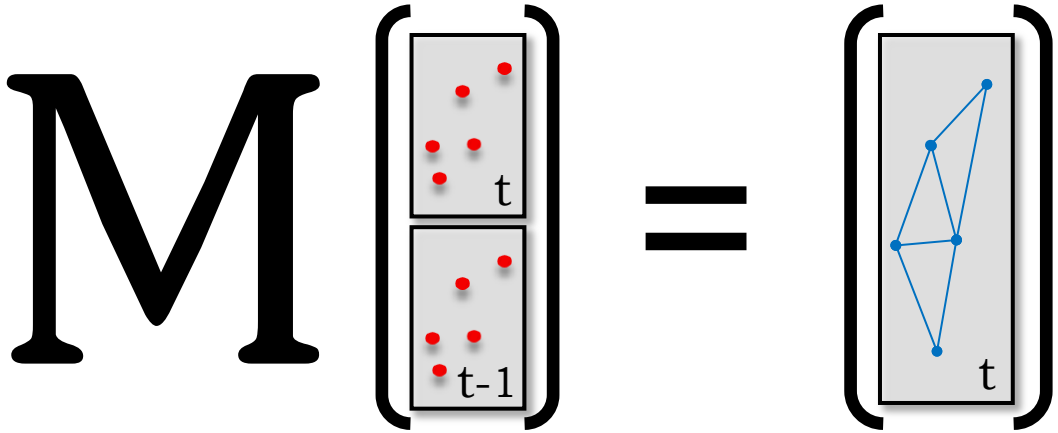


Motion Mapping

Mapping from input to target character



Implemented as linear map M x = y



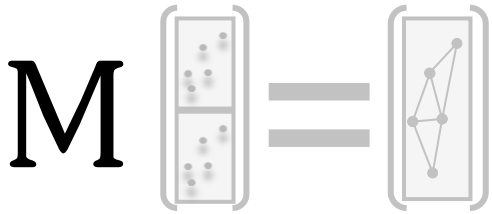
Bayesian Regression

Properties:

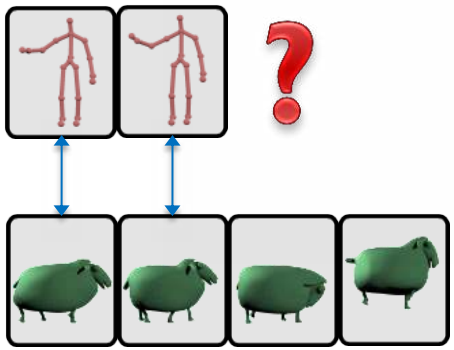
- Explicit noise model (here Gaussian)
- Predicts **most probable** character pose

Outcomes:

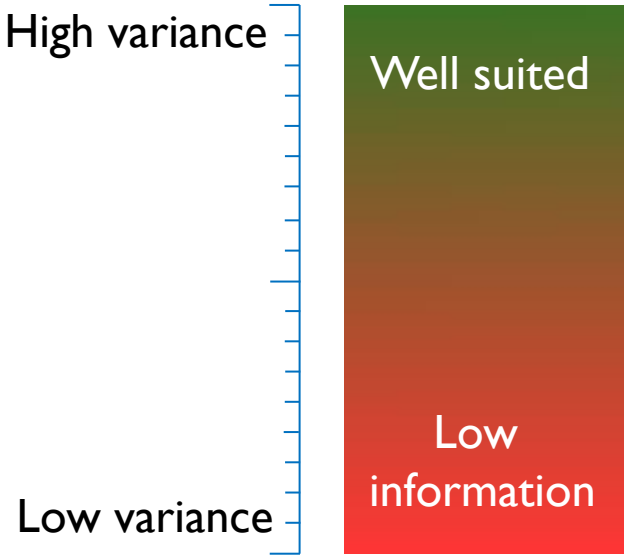
- Mapping Φ^{pose}



- Estimates **variance** of prediction:
  - Low variance ⇒ Well represented
  - High variance ⇒ Underrepresented



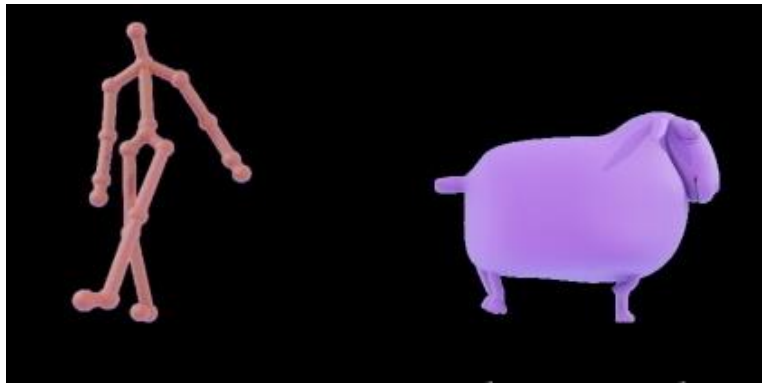
- Confidence bar

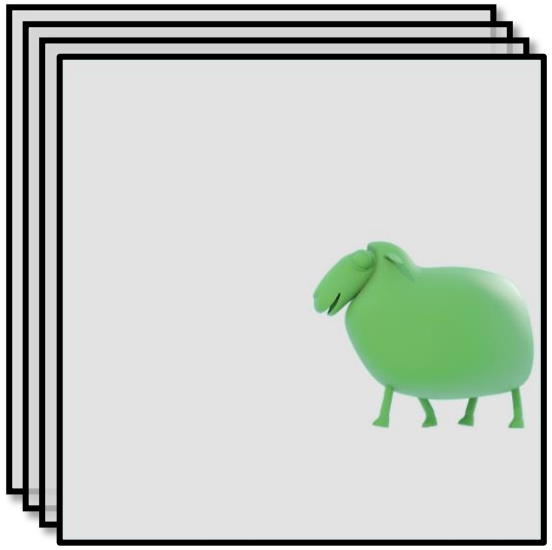


Processing of Example Motion – Range of Motion

Problem: Undesired character deformation

Solution: Exploit example motion





Example animation
(artist created)

→ "Range of motion"

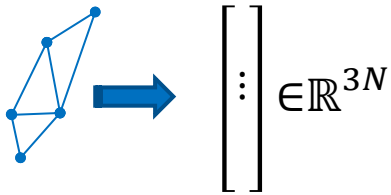
The Latent Volume

Goal: Prevent undesired character deformations

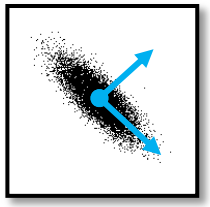
Approach: Approximate the character's range of motion by a high-dimensional box

Method:

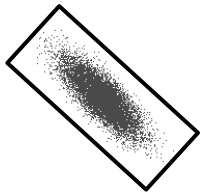
- Represent mesh in vector form



- Find orientation by principal component analysis



- Set bounds such that the example motion is included



Application of the Latent Volume

Real motion

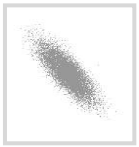
Our method

Source motion

No latent volume

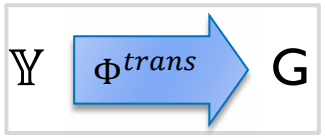
Processing of Example Motion – Global Motion

Example animation
(artist created)



Latent volume

"Range of motion"

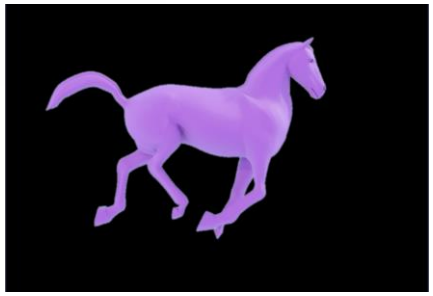


Pose ⇨ Global translation mapping

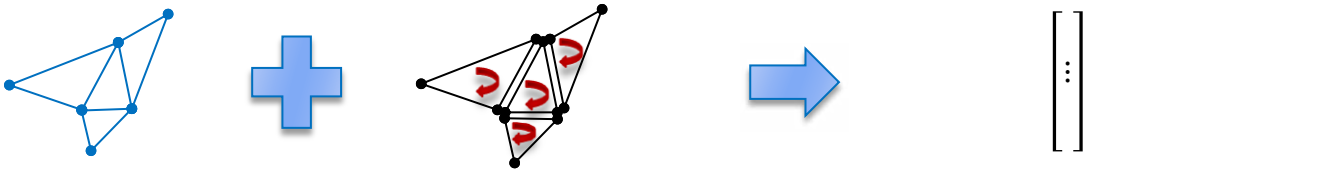
"Global motion"

Shape Representation of Target Character

Problem: Direct mesh representation leads to deformations



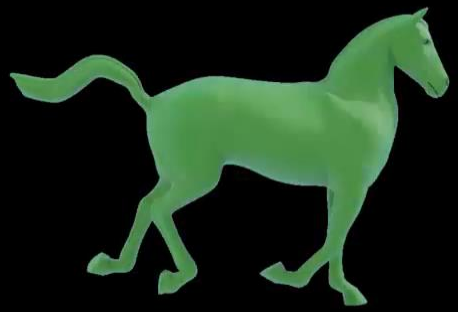
Solution: Variant of *deformation gradient* representation [Sumner et al. 2004]



- Models rotational motions more faithfully
- Reconstruction required to solve sparse linear system (real-time, 30 fps)

Results – Full-body Input on Horse

Source poses

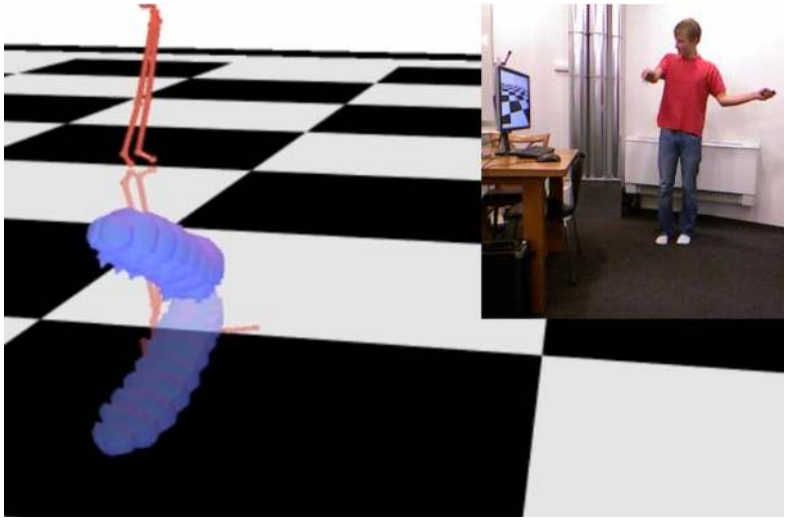


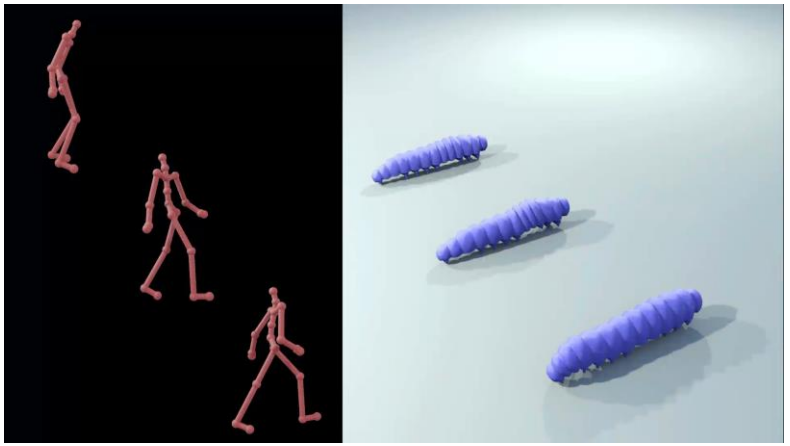
Target poses

Why a Linear Map?

Linear map

- Real time
- Superposition (additivity)
  $f(\mathbf{x}+\mathbf{y}) = f(\mathbf{x}) + f(\mathbf{y})$
- Transfer of intensity (homogeneity)
  $f(\alpha\mathbf{x}) = \alpha f(\mathbf{x})$





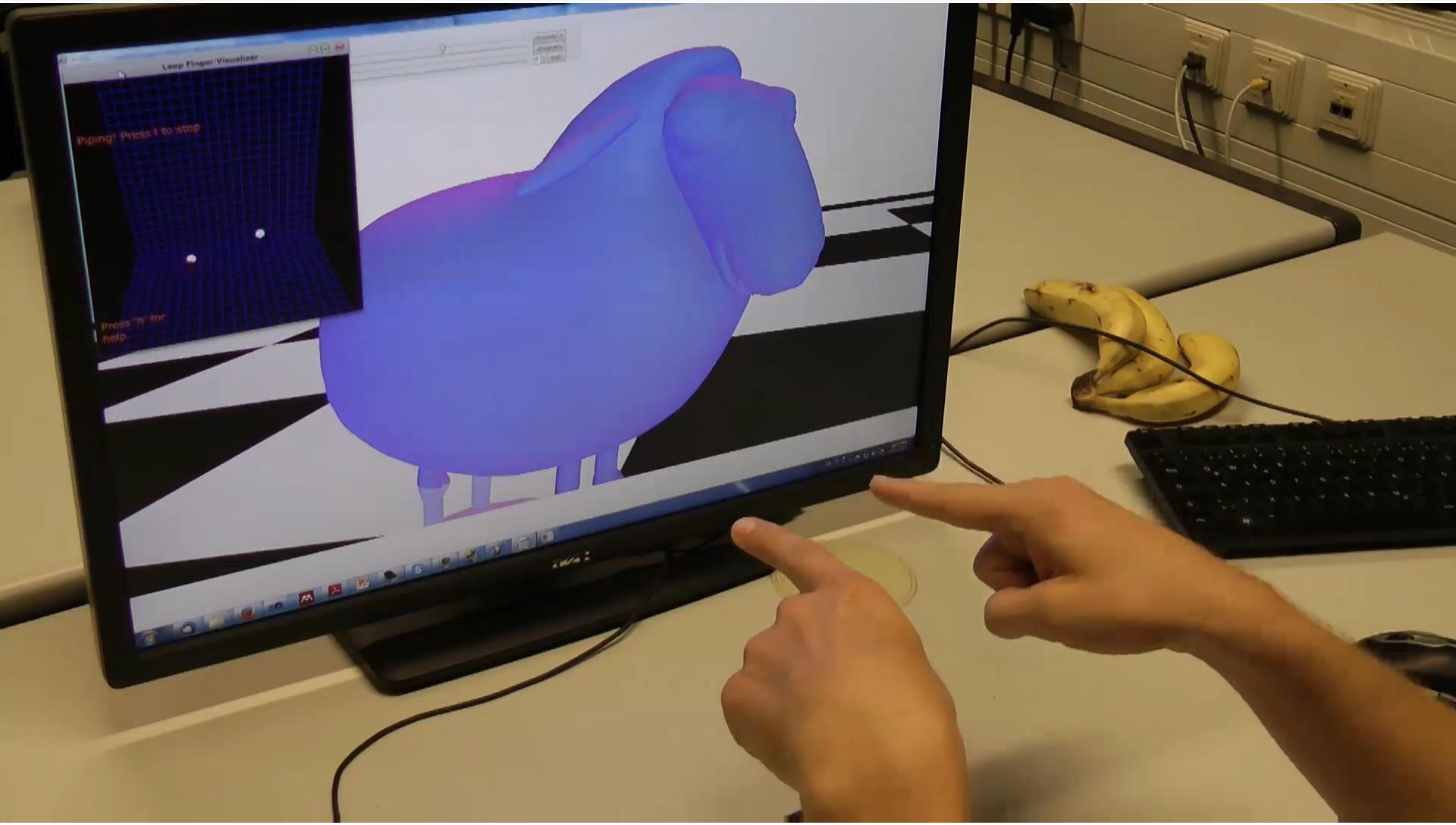
Results – Full-body Input on Sheep

Results - Facial Expression Input

Source motion

Synthesized output

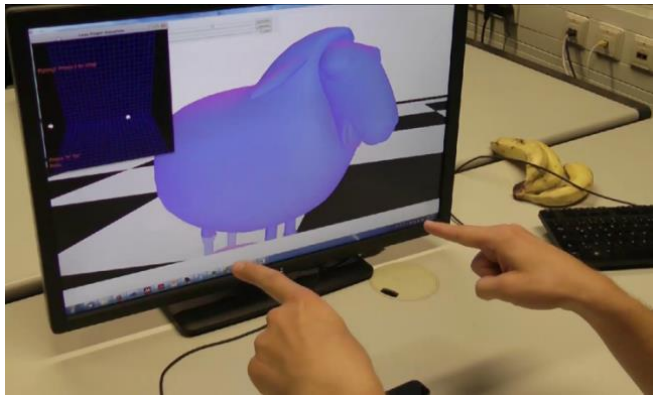
Results - Hand Motion



Discussion

Human coordination is limited

- Controllable degrees of freedom
- Observable degrees of freedom



Granularity of control

- The mapping is learned from only 4-8 correspondences

Summary – Algorithmic Contributions

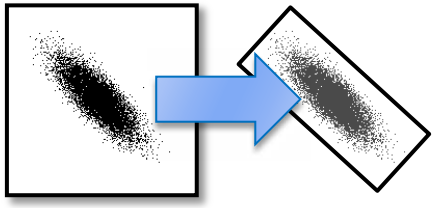
Challenge

- Non-skeletal characters
- Unreliable user input
- Easy definition of the control

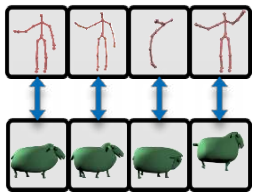
Solution

- Character representation in shape space
- Bayesian regression

- Latent volume



- Guided correspondence through confidence measure
- Sparse correspondences

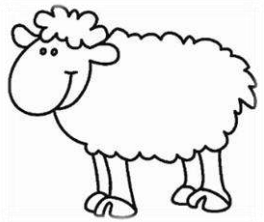


Summary – Achievements

- Robust real-time character control that is independent of a skeleton

- Interface is accessible to non-technical users

- Ongoing cooperation with animation artists indicates the applicability to character animation



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http://gvv.mpi-inf.mpg.de/projects/DirectMotionMapping