

Estimating 3d human pose from 2d shadow image

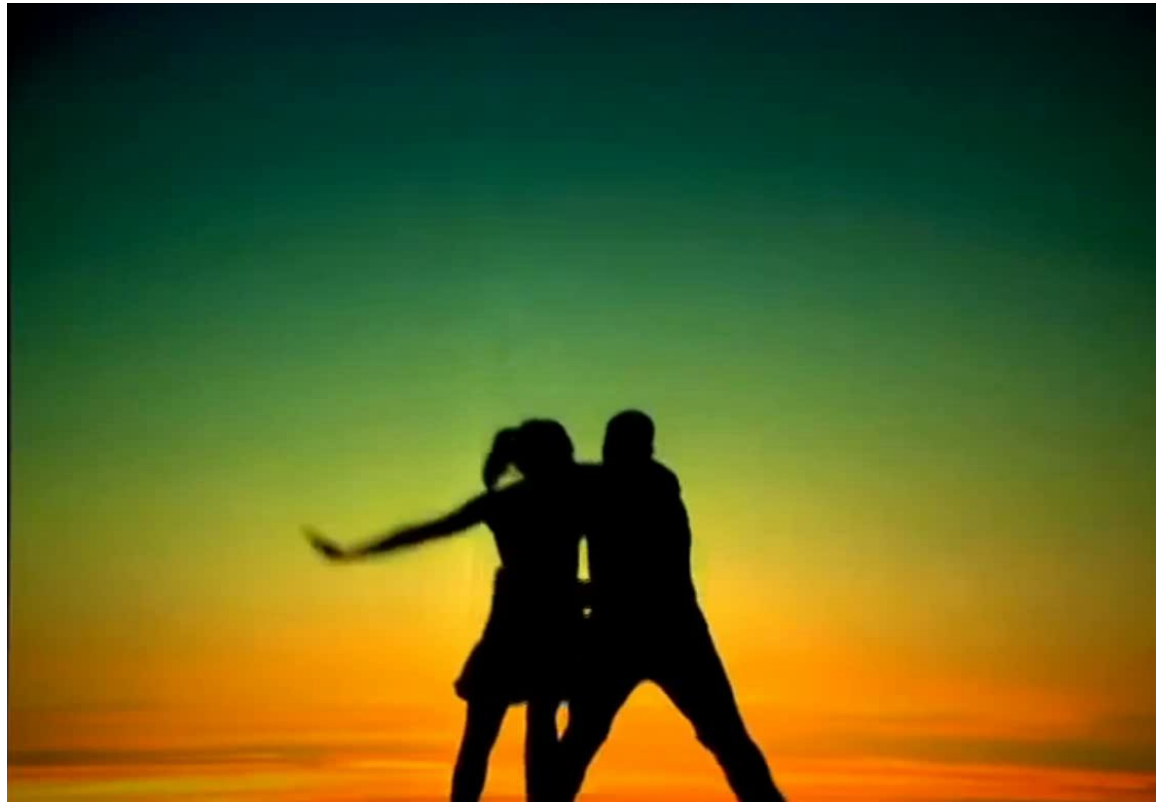
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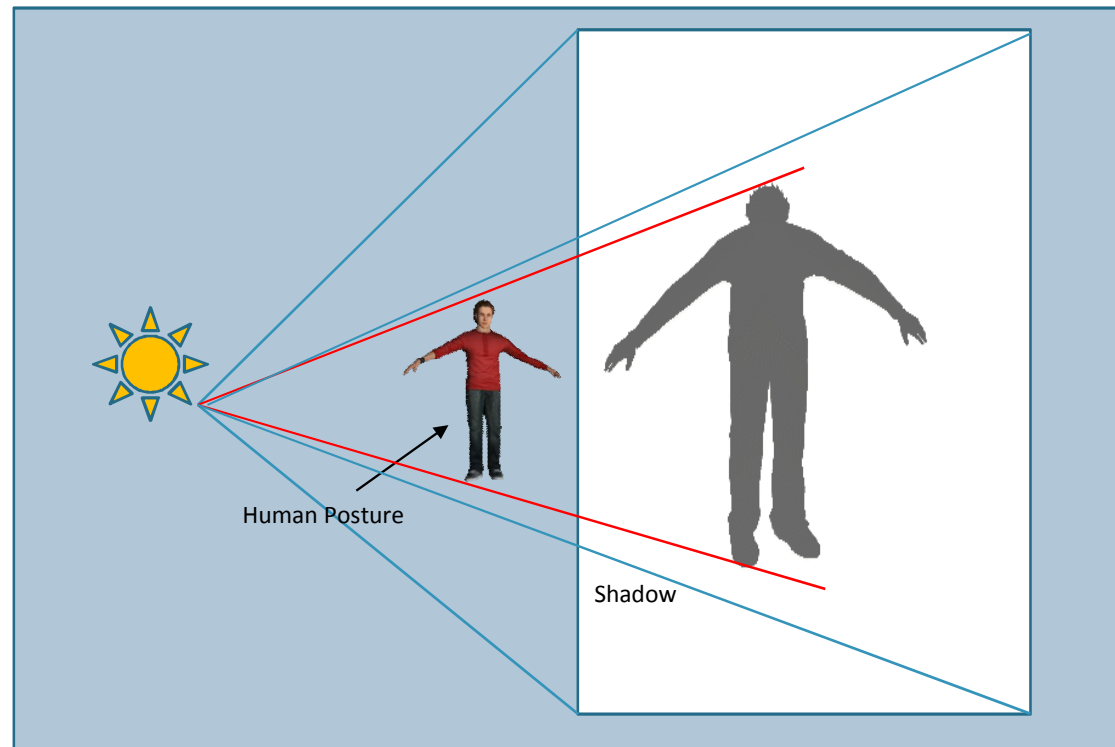


Introduction to Shadow Art

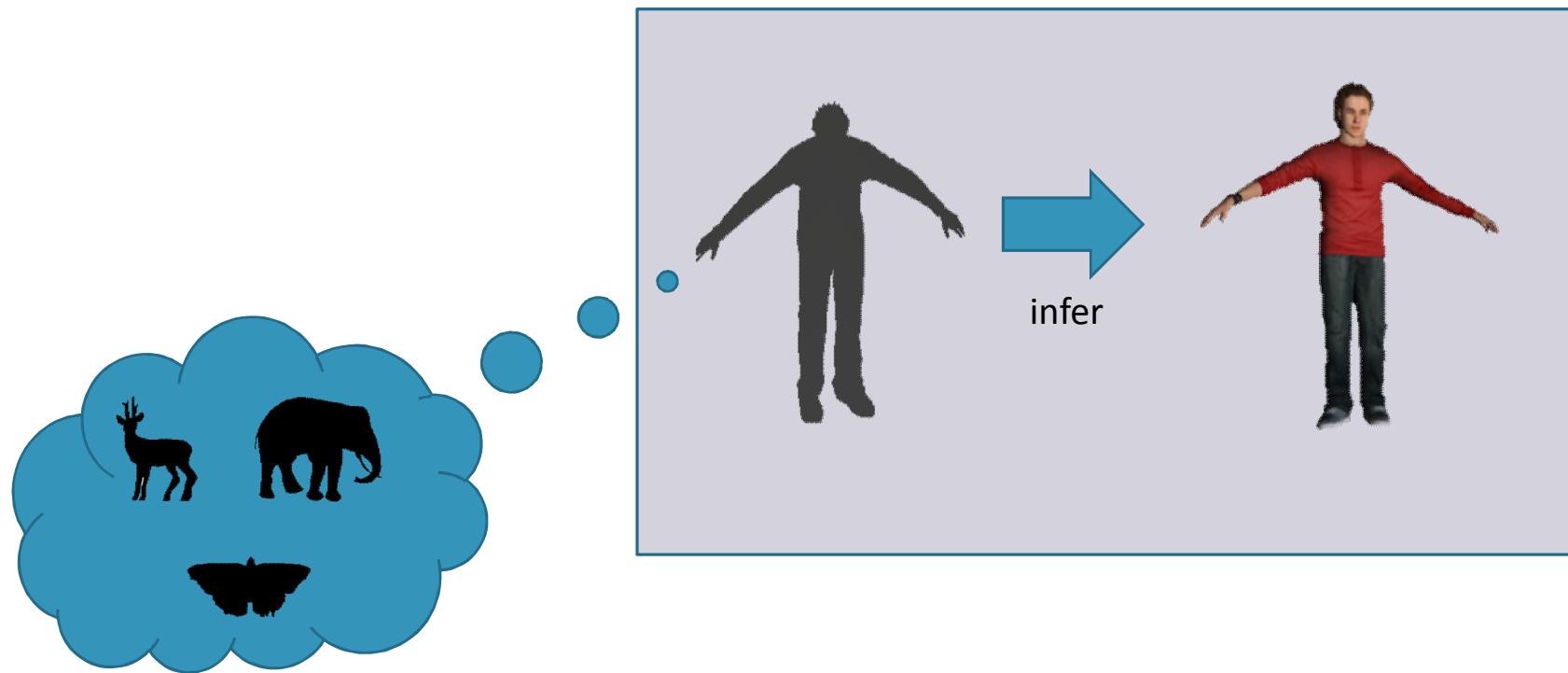


(Shadow Theatre Group)
1st Audition Britain's Got Talent

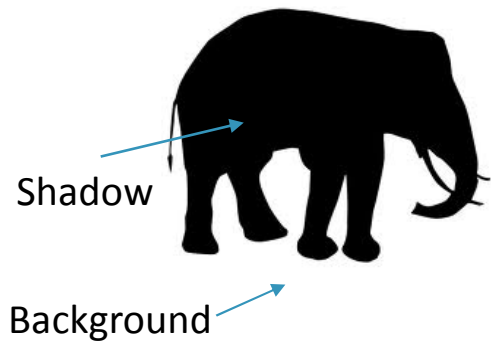
Fundamentals of shadow



Motivation

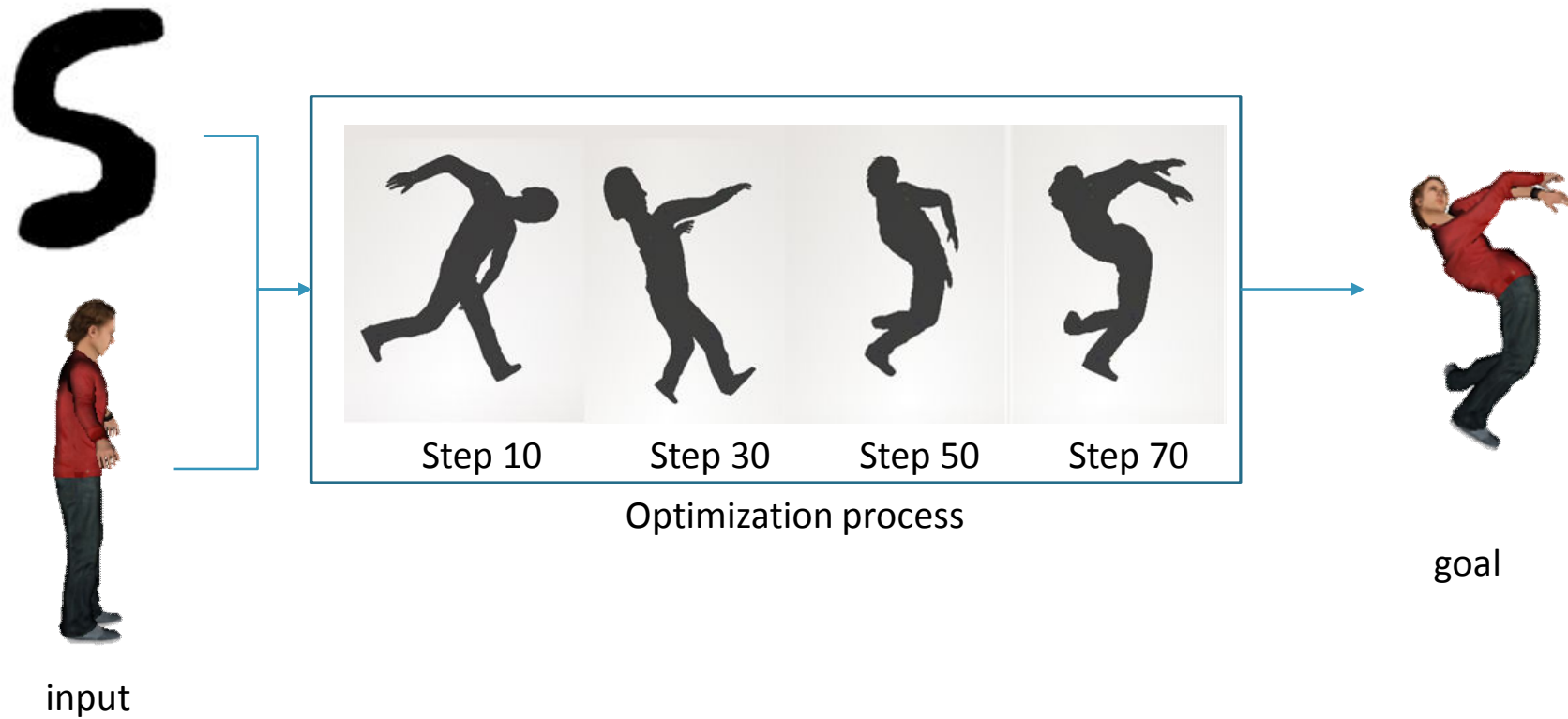


Challenges

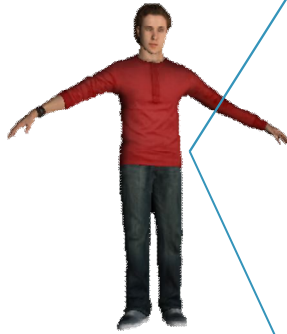


- Not in human shape
 - Cannot determine which body part corresponds to which part of the shadow
- Limited information
 - Black for shadows and white for the background

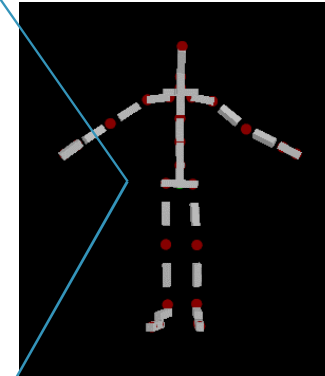
Optimization problem



Optimization Variables



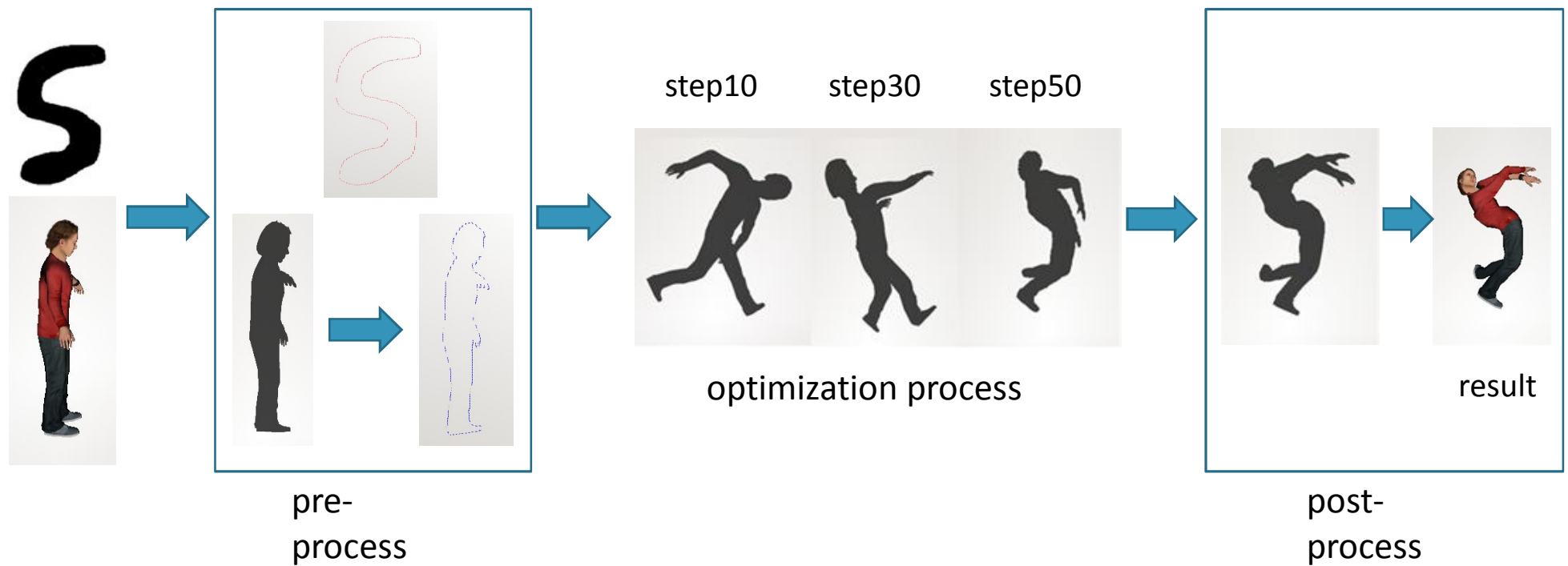
PELVIS	_____	Hips
SPINE_1	_____	Spine
SPINE_2	_____	Spine1
CHEST	_____	Spine2
NECK	_____	Neck
HEAD	_____	Head
HEAD_DUMMY	_____	HeadDummy
LEFT_SHOULDER	_____	LeftShoulder
UPPER_LEFT_ARM	_____	LeftArm
LOWER_LEFT_ARM	_____	LeftForeArm
LEFT_PALM	_____	LeftHand
LEFT_FINGER_DUMMY_3	_____	LeftHandDummy
RIGHT_SHOULDER	_____	RightShoulder
UPPER_RIGHT_ARM	_____	RightArm
LOWER_RIGHT_ARM	_____	RightForeArm
RIGHT_PALM	_____	RightHand
RIGHT_FINGER_DUMMY_3	_____	RightHandDummy
UPPER_LEFT_LEG	_____	LeftUpLeg
LOWER_LEFT_LEG	_____	LeftLeg
LEFT_FOOT	_____	LeftFoot
LEFT_TOE	_____	LeftToe
LEFT_TOE_DUMMY	_____	LeftToeDummy
UPPER_RIGHT_LEG	_____	RightUpLeg
LOWER_RIGHT_LEG	_____	RightLeg
RIGHT_FOOT	_____	RightFoot
RIGHT_TOE	_____	RightToe
RIGHT_TOE_DUMMY	_____	RightToeDummy



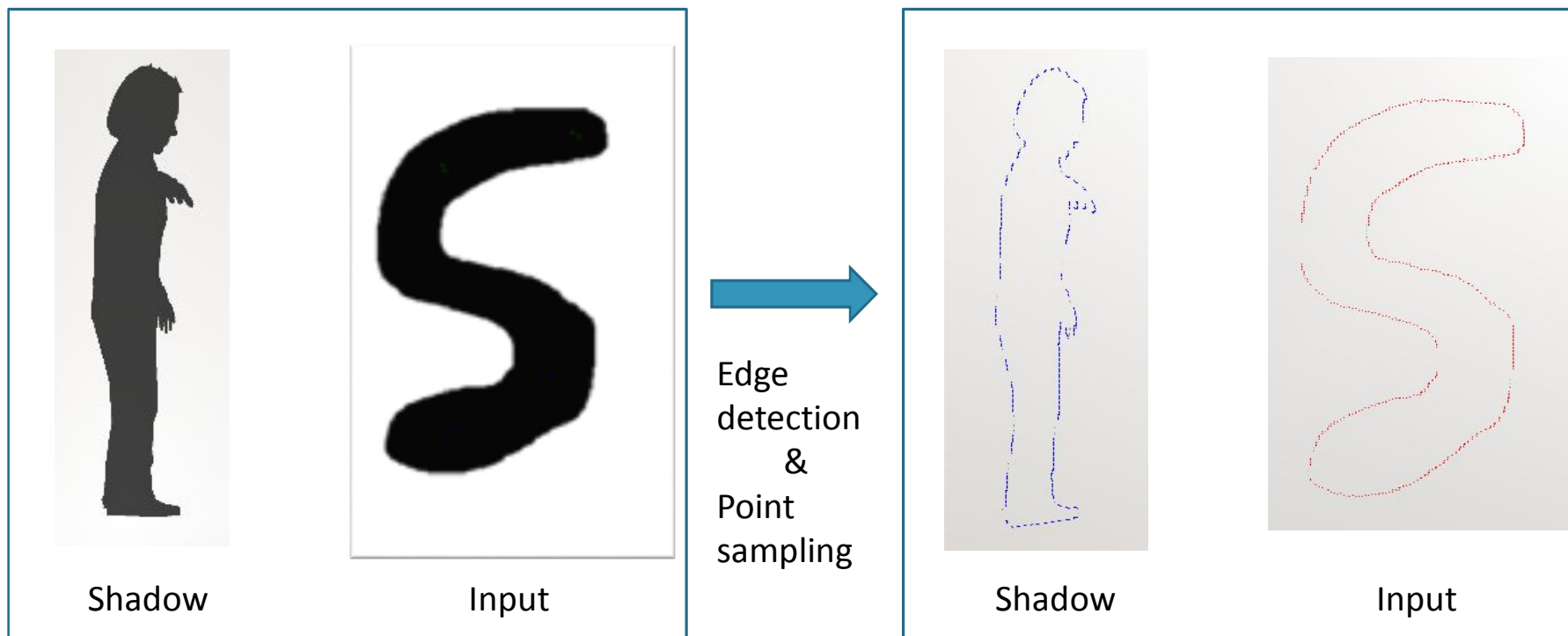
Energy

$$E(\text{elephant}, \text{person}) = \omega * E_{shape} + E_{cons}$$

System Overview



Preprocessing



E_{shape} : Shape similarity metric

Hausdorff Distance

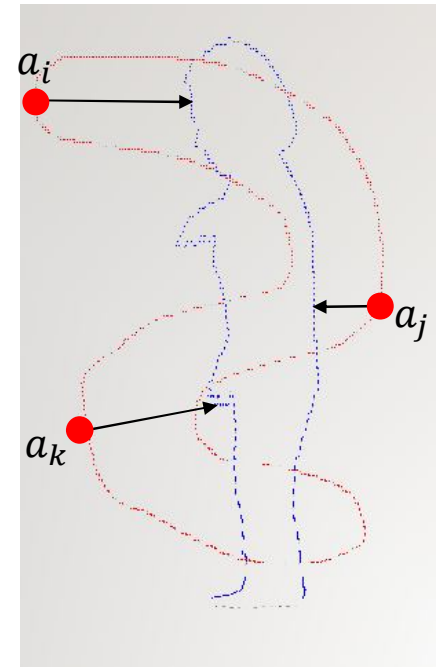
Given Two Point Set

$$A = \{a_1, a_2, a_3, \dots, a_n\},$$

$$B = \{b_1, b_2, b_3, \dots, b_n\}$$

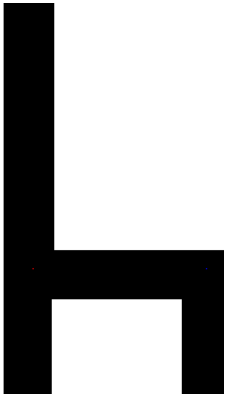
$$h(A, B) = \max_{a \in A} \{ \min_{b \in B} \|a - b\| \}$$

$$HD(A, B) = \max(h(A, B), h(B, A))$$



$h(A, B)$

Multiple Solution

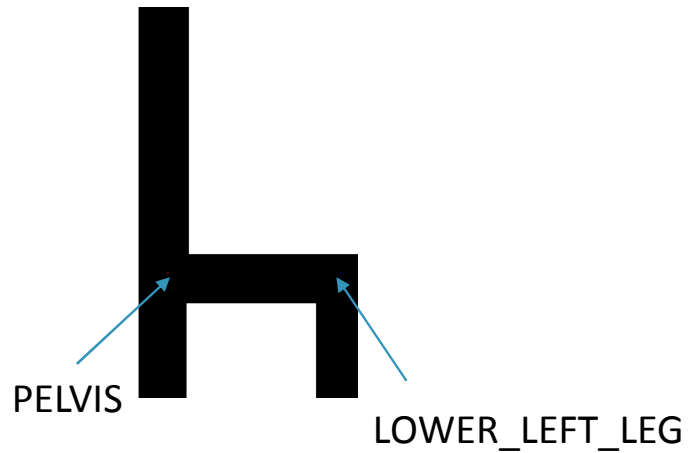


Input
Shadow
(chair shape)



Solution1		Solution2	
A blue outline of a person sitting on a chair, with red bounding boxes highlighting the backrest, seat, and legs.	A photograph of a person in a red shirt and dark pants sitting on a chair, viewed from the side.	A blue outline of a person in a dynamic pose, with red bounding boxes highlighting the backrest, seat, and legs.	A photograph of a person in a red shirt and dark pants in a dynamic pose, viewed from the side.

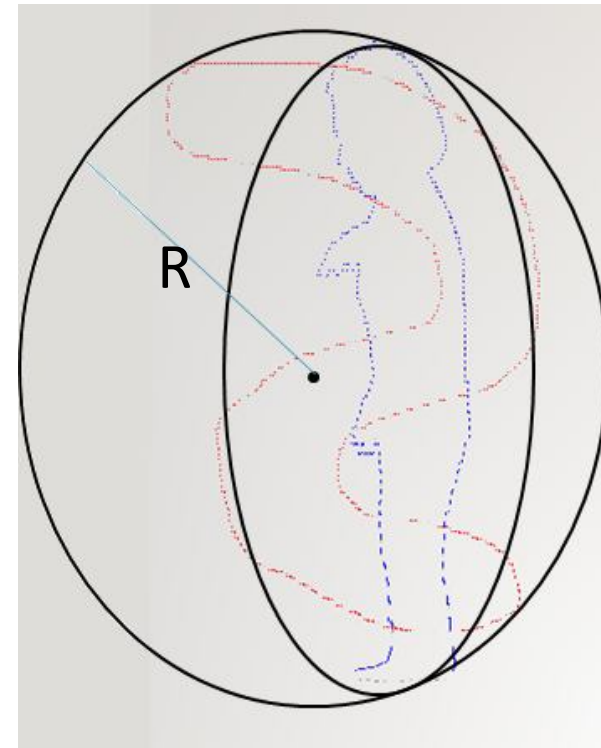
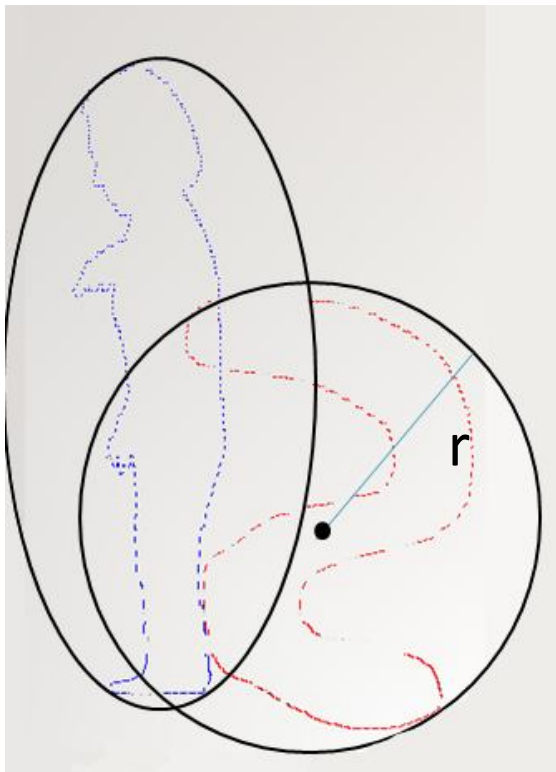
E_{cons} : Constraints



$$E_{cons} = \sum_{i=1}^{N_c} \|p_i - q_i\|$$

$(i \in 1, 2, \dots, N_c, \text{ for all constraints})$
 p : constraint position in input image
 q : joint position in shadow

Initialization



Optimization

Optimization algorithm:
Covariance Matrix
Adaptation(CMA)

Variable:
Joint angles

$$E = \omega * E_{shape} + E_{cons}$$



Optimization(End)

Optimization algorithm:
Covariance Matrix
Adaptation(CMA)

Variable:
Joint angles

$$E = \omega * E_{shape} + E_{cons}$$



Additional process

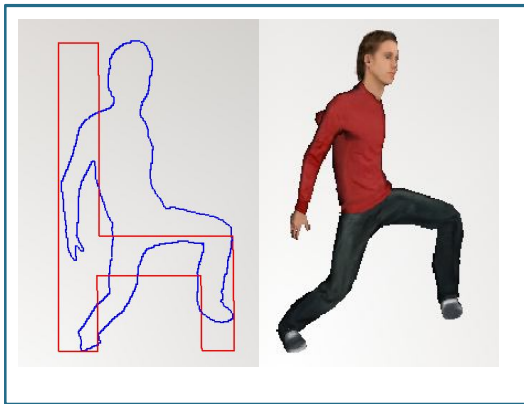
1. Joint angle varies randomly as CMA generation evolves
 - may result in rigged model to deform dramatically

2. For efficiency in computing, give initial pose
 - which constraints are nearly satisfied by inverse kinematics

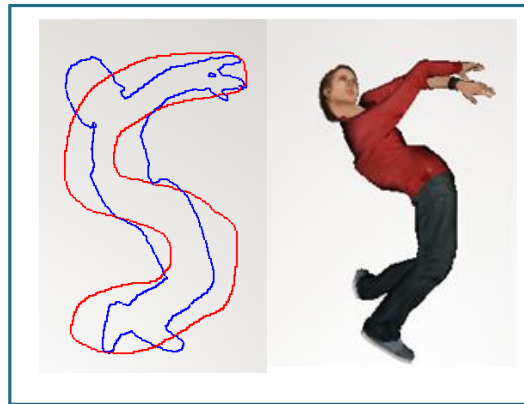
Future Work

- Multiple human model can collaborate to make shadows
 - for more complex image
- Estimate motion of the human model
 - for animated shadows or a sequence of shadow images

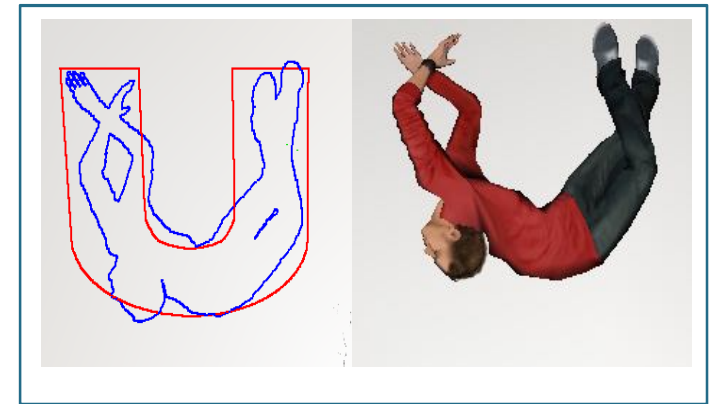
Result



Chair



Character 'S'

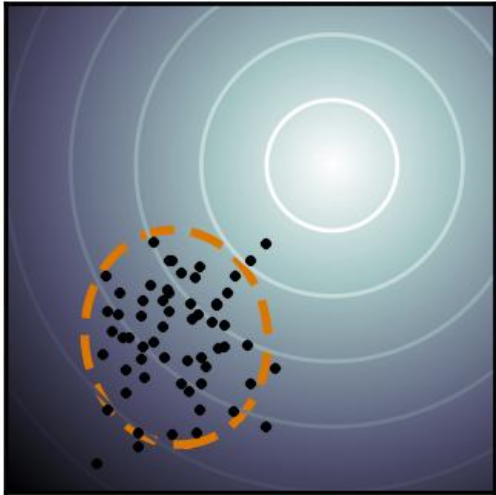


Character 'U'

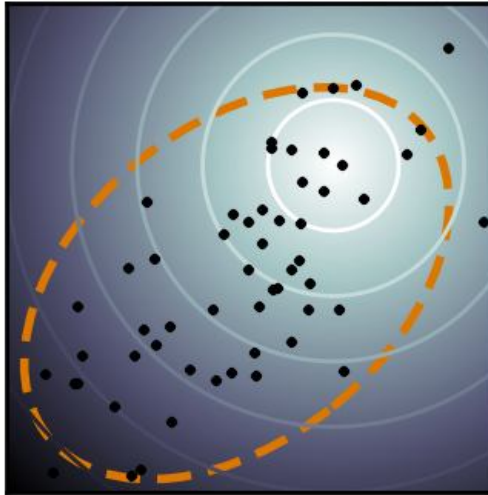
Thank you



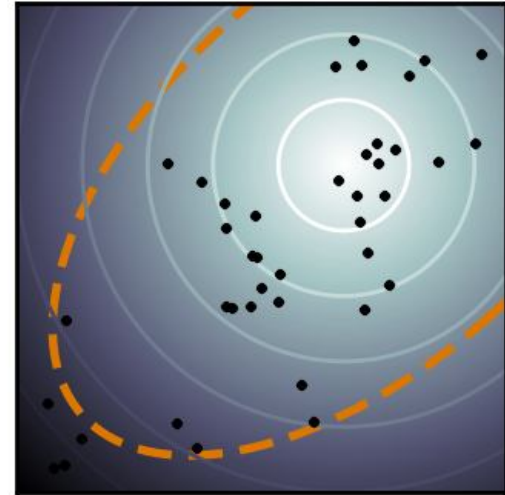
Generation 1



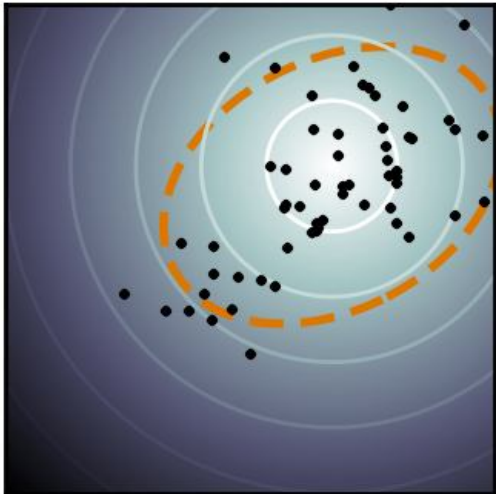
Generation 2



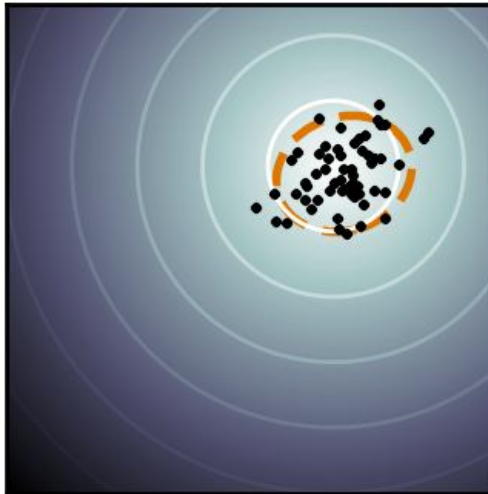
Generation 3



Generation 4



Generation 5



Generation 6

