CGI2021

Temporal Parameter-free Deep Skinning of Animated Meshes

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Presenter: A. Moutafidou

ΤΜΗΜΑ ΜΗΧΑΝΙΚΩΝ Η/Υ & ΠΛΗΡΟΦΟΡΙΚΗΣ
ΠΑΝΕΠΙΣΤΗΜΙΟ ΙΩΑΝΝΙΝΩΝ

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Outline

- Scope
- Introduction
- Related Work
- Temporal Deep Skinning
- Experimental Evaluation & Results
- Conclusions

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Scope

- A novel approach that assigns vertices to bone-influenced clusters and derives weights using deep learning.
- Takes as input vertex trajectories and outputs bones and bone weights.
- Then Linear Blend Skinning (LBS) method is used to calculate the approximate transformations & vertices.
- Outcome: The optimal set of transformations and vertices are derived in a few iterations (usually in five or less),
  - Due to the better initial positioning in the multidimensional variable space.
- No parameters need to be determined or tuned by the user during the entire process.

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Introduction

- A realistic character animation can be produced by following either of the two modern workflows:
  1. rigging a static mesh, apply transformations to bones along a timeline, correct erroneous deformations by adding bones, introduce additional per frame deformations to simulate nonlinear effects.
  2. use recent developments of computer vision and tracking techniques to derive mesh sequences that are reconstructed by markerless capture or by motion capture with dense markers.
- These mesh animation sequences must be converted to a representation that allows streaming and limited editing.
- Compression is performed by producing an approximation of the animation that consists of
  1. an initial pose (mesh)
  2. bones and skin weights
  3. a number of transformations for each bone and frame

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Related Work

- Previous approaches use static geometric information or motion metrics for bone extraction [12, 13, 14, 29, 5].
- Most competent FESAM with respect to error [14].
- Others have used Deep Learning with input geometric and structural characteristic of the rest pose [7, 22, 30].
- We use the vertex trajectory to determine the bone that should influence a particular vertex.

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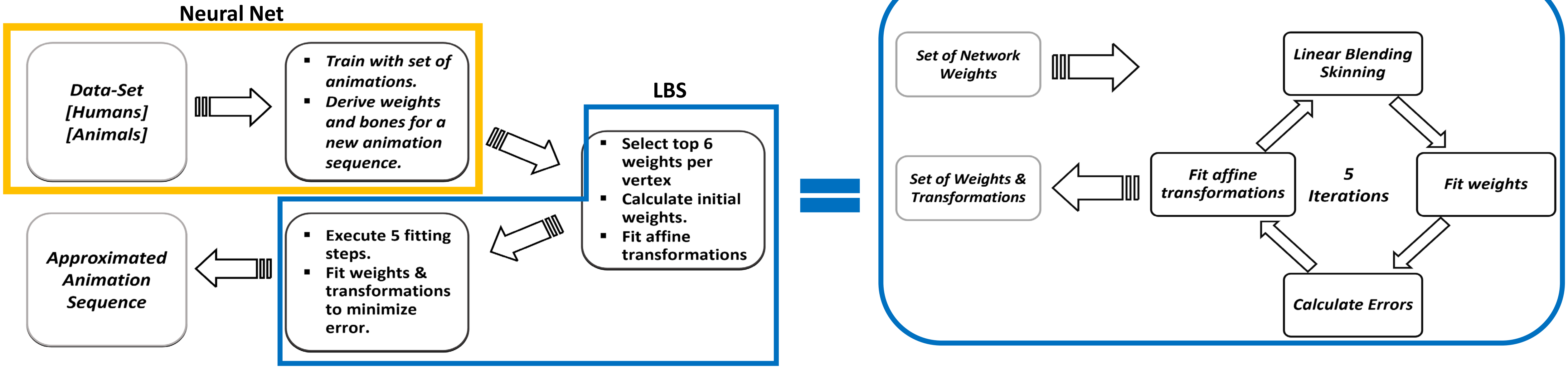
Temporal Deep Skinning (1/3)

- Our method captures vertex trajectories (temporal vertex sequences)
- How? Deep Learning (neural networks: LSTM, CNN & a hybrid of the two)



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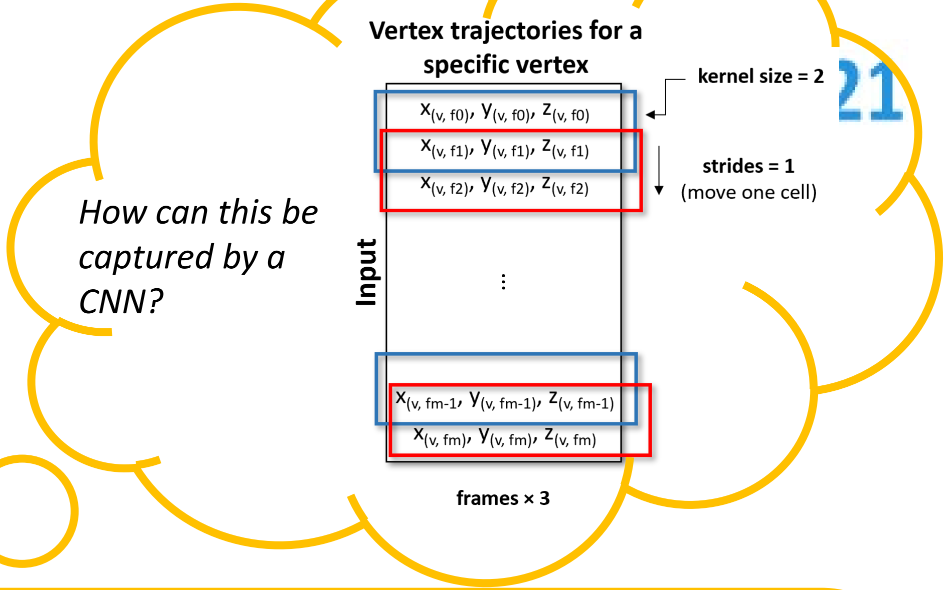
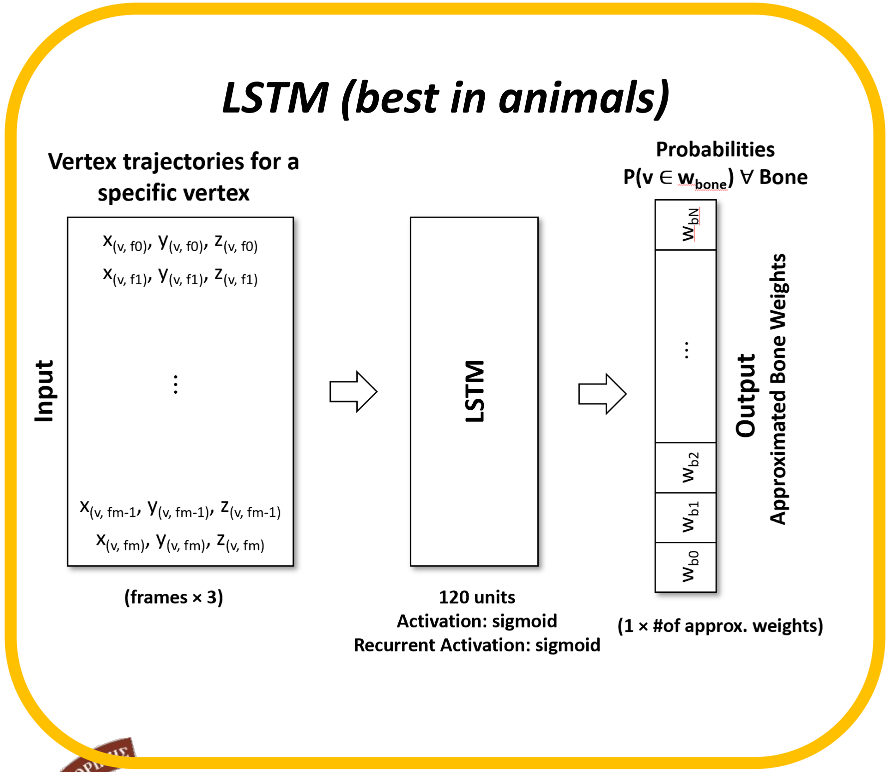
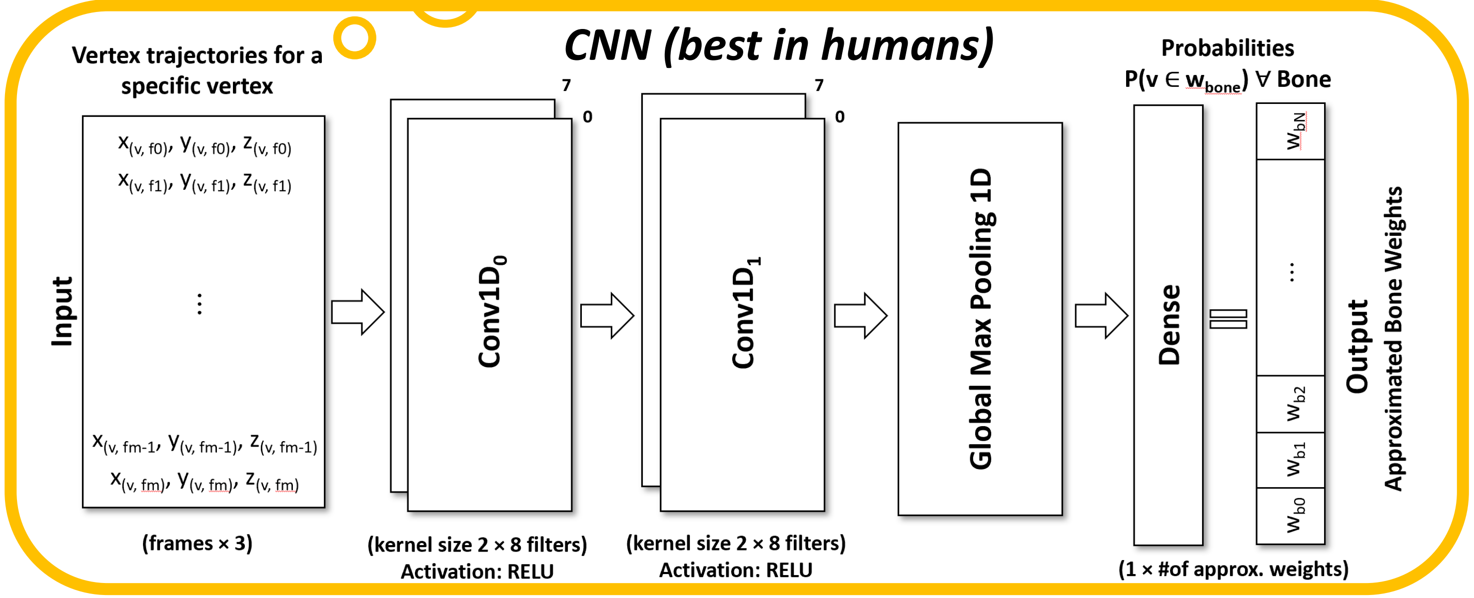
Temporal Deep Skinning (2/3)

- Main 2 Neural Networks used:







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Temporal Deep Skinning (3/3)

- Evaluation Metrics for our method:
  - **Root Mean Square (ERMS)**: $ERMS = 100 \cdot \frac{\|A_{orig} - A_{Approx}\|_F}{\sqrt{3NP}}$
  - **Distortion Percentage (DisPer** - percentage of deformation, sensitive to the translation of the entire 3D model):

$$DisPer = 100 \cdot \frac{\|A_{orig} - A_{Approx}\|_F}{\|A_{orig} - A_{avg}\|_F}.$$

  - **Max average distance (MaxAvgDist** - represents the average of max distances over all frames):

$$MaxAvgDist = \frac{1}{P}\sum_{f=1}^{P} \max_{i=1,\ldots,N} \|v_{orig}^{f,i} - v_{Approx}^{f,i}\|$$

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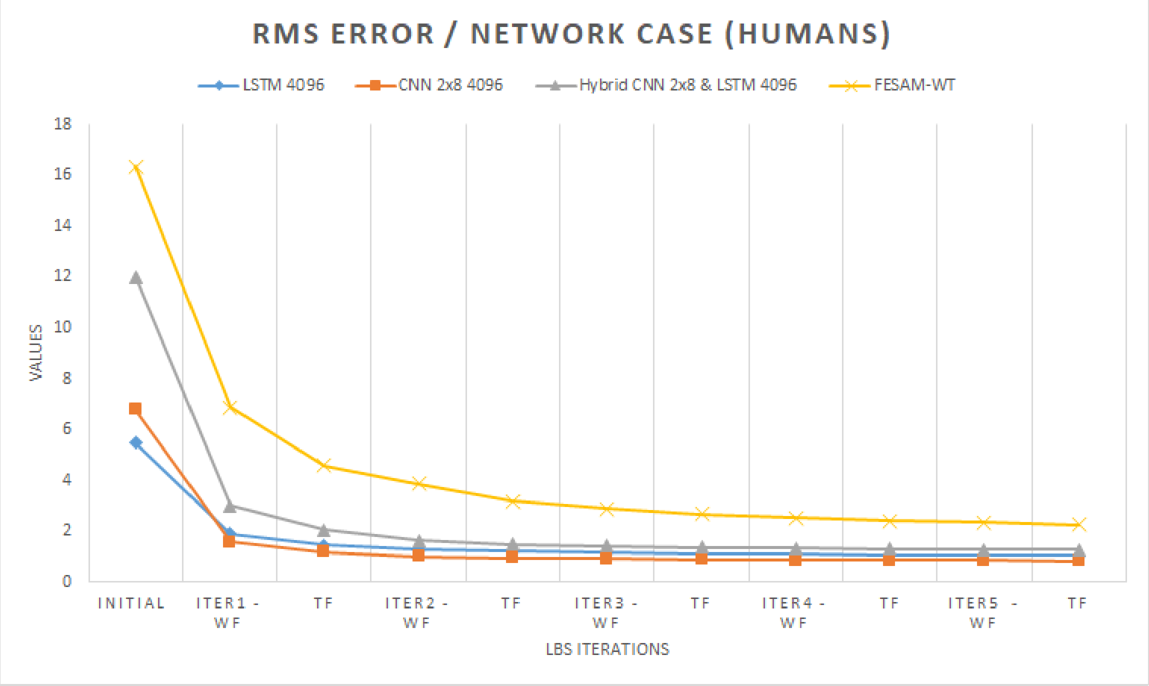
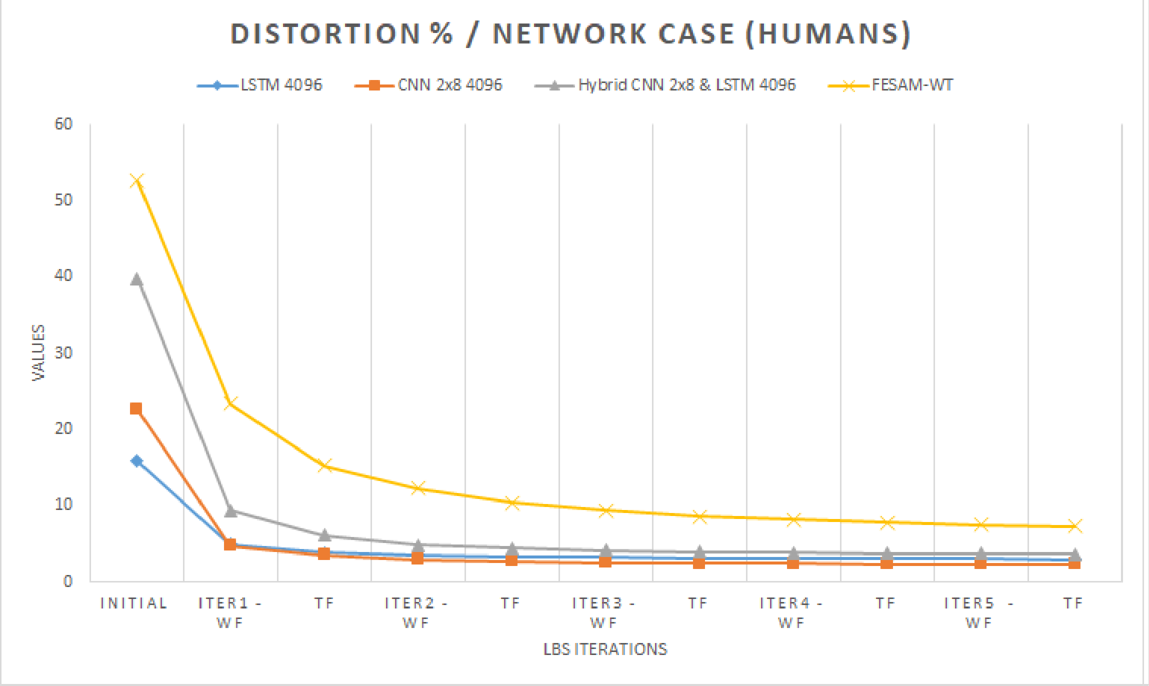
Experimental evaluation & Results (1/6)

- **Visual comparison (humans):**
  Deep Skinning with FESAM-WT





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Experimental evaluation & Results (2/6)

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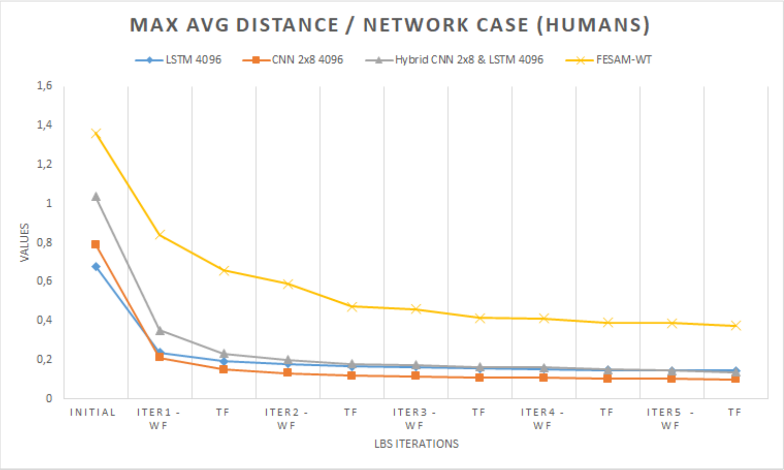
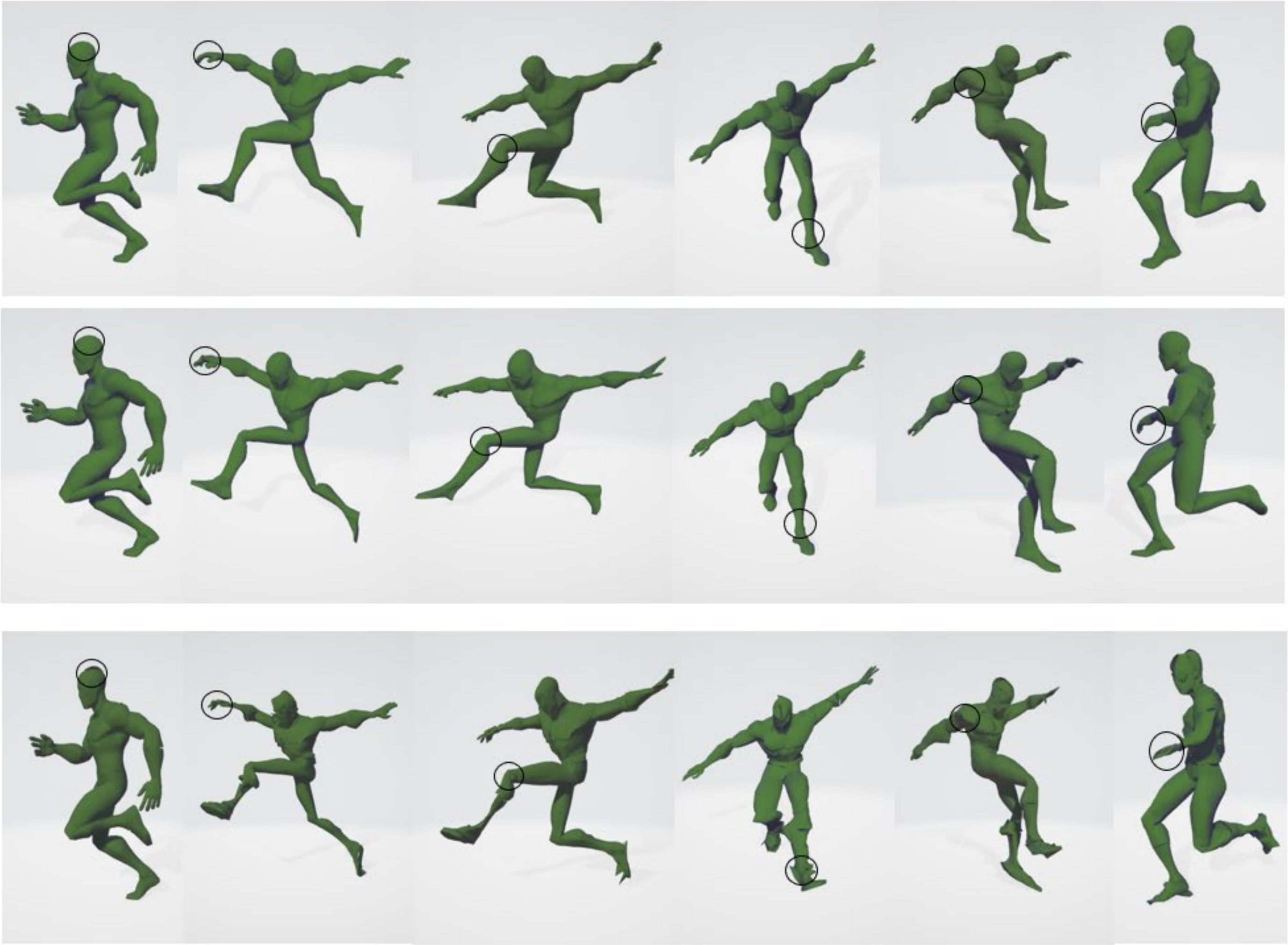
- **Visual comparison (humans):** Deep Skinning with FESAM-WT



Original Frames

Deep Skinning

FESAM



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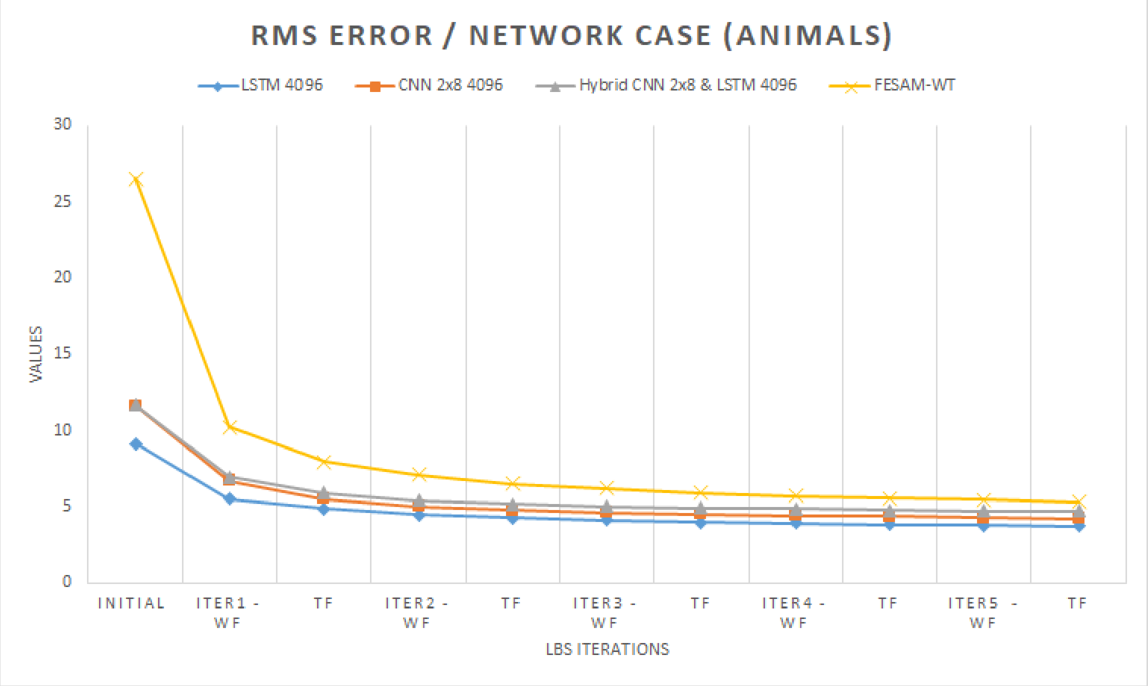
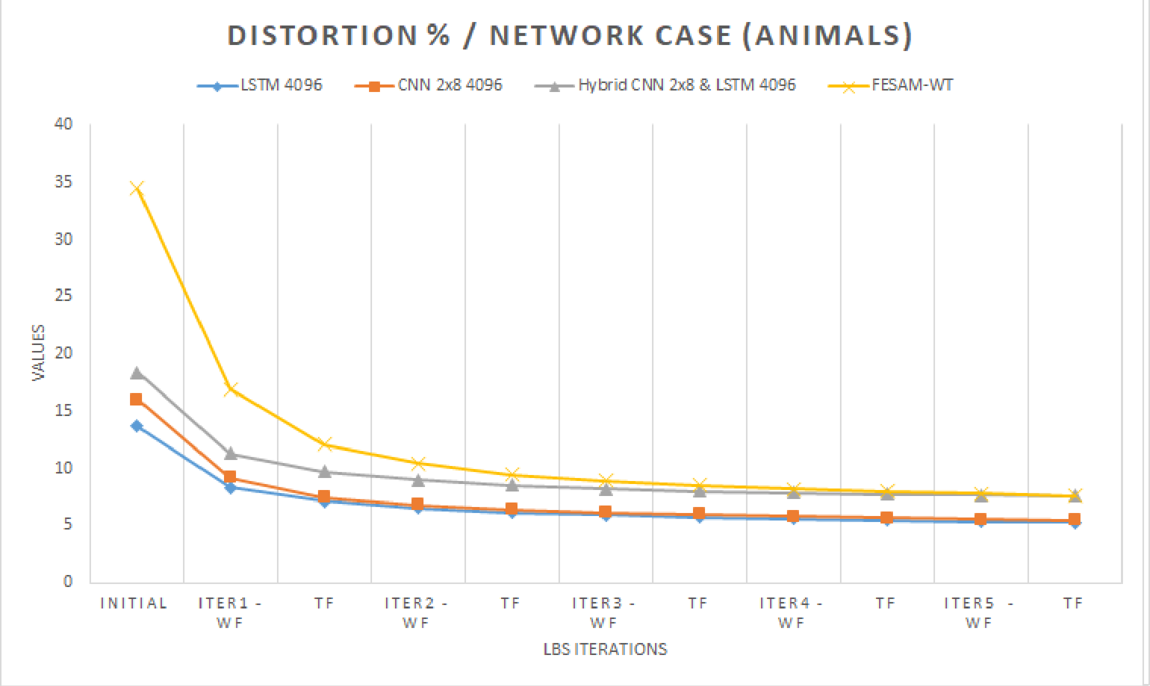
Experimental evaluation & Results (3/6)

- **Visual comparison (animals):**
  Deep Skinning with FESAM-WT





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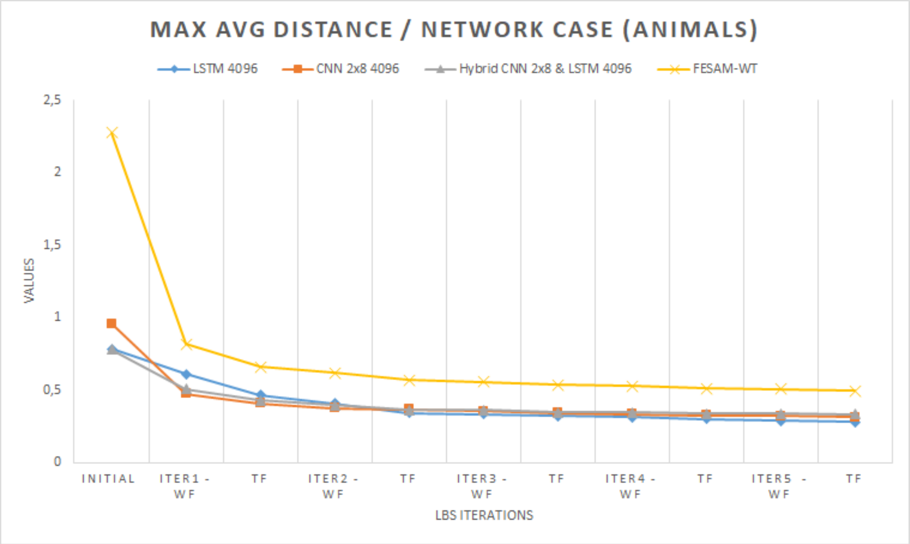
Experimental evaluation & Results (4/6)

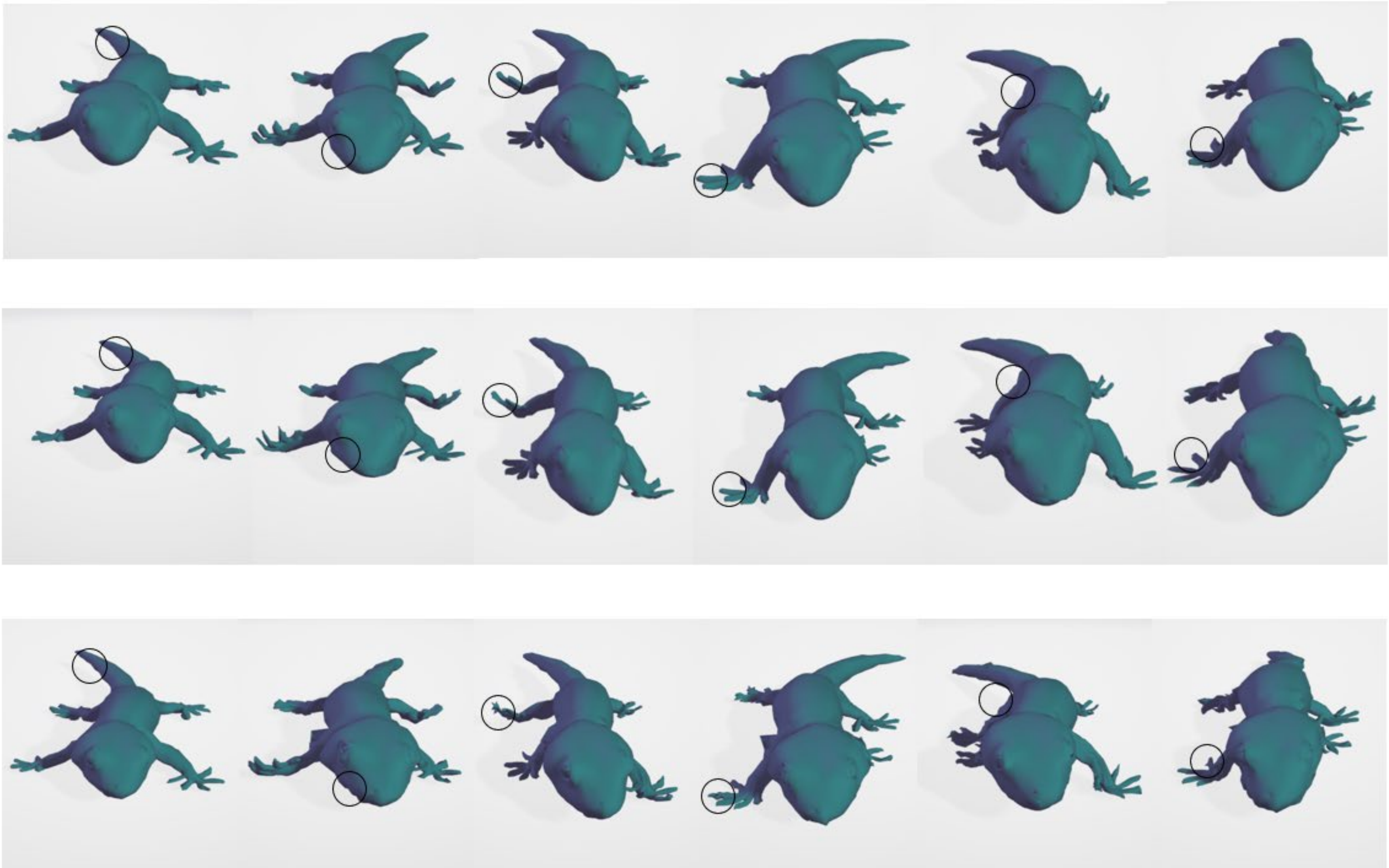
- **Visual comparison (animals):** Deep Skinning with FESAM-WT



Original Frames

Deep Skinning

FESAM



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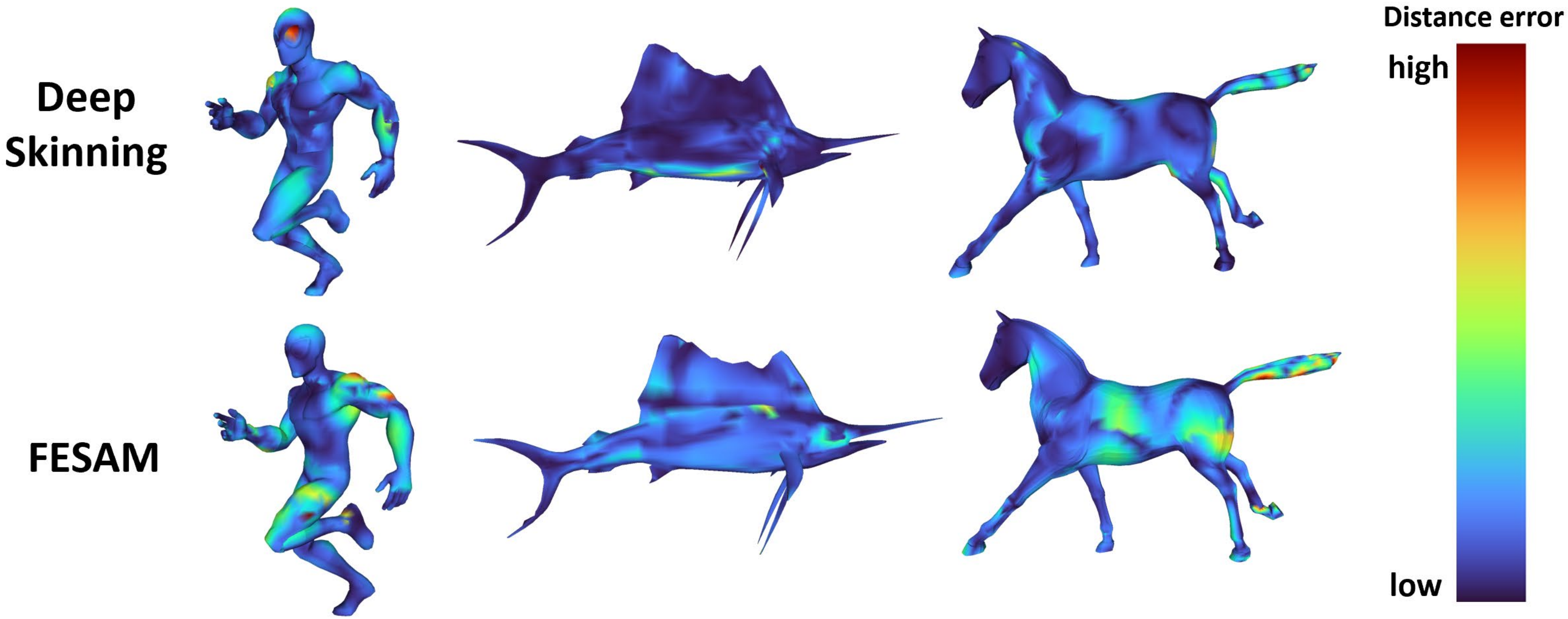
Experimental evaluation & Results (5/6)

- Error comparison in a particular frame between Deep Skinning and FESAM-WT



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Experimental evaluation & Results (6/6)

- Comparative evaluation (ERMS metric & CRP) of our method with some well-known methods:
  - **Method I:** James, D.L., Twigg, C.D.: Skinning mesh animations. In: ACM SIGGRAPH 2005 Papers, SIGGRAPH '05, 99{407. Association for Computing Machinery, New York, NY, USA (2005)
  - **Method II:** Kavan, L., McDonnell, R., Dobbyn, S., Zara, J., O'Sullivan, C.: Skinning arbitrary deformations. In: Proceedings of the 2007 Symposium on Interactive 3D Graphics and Games, I3D '07, p. 53{60. Association for Computing Machinery, New York, NY, USA (2007)
  - **Method III:** Kavan, L., Sloan, P.P., O Sullivan, C.: Fast and Efficient Skinning of Animated Meshes. Computer Graphics Forum (2010)
  - **Method IV:** Sattler, M., Sarlette, R., Klein, R.: Simple and efficient compression of animation sequences. In: Proceedings of the 2005 ACM SIGGRAPH/Eurographics Symposium on Computer Animation, SCA '05, p. 209{217. Association for Computing Machinery, New York, NY, USA (2005)
  - **Method V:** Alexa, M., Müller, W.: Representing animations by principal components. Comput. Graph. Forum 19 (2000)

Approximation Error ERMS															
Input Data			Our Method		Method I		Method II		Method III		Method IV		Method V		Compression Rate	
Dataset	N	F	Bones	ERMS	Bones	ERMS	Bones	ERMS	Bones	ERMS	Bones	ERMS	Bones	ERMS	OURS	I-IV
Horse-gallop	8,431	48	26	0.15	30	2.3(0.3)	30	4.9(2.9)	30	1.3	30	2.4	-	2E-5	92.5	92.3
Elephant-gallop	42,321	48	18	0.35	25	2.6(0.5)	25	15(6.5)	25	1.4	25	2.3	-	6E-5	93.59	93.51
Camel-gallop	21,887	48	16	0.22	23	3.1(0.5)	23	4.7(2.2)	23	1.4	23	2.8	-	2E-4	93.45	93.33
Samba	9,971	175	17	0.60	30	8.6(3.6)	30	11.4(6)	30	1.5	30	4	-	0.2	97.6	97.4

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Conclusions

- Introduced an innovative approach that derives pseudo-bones and weights for an animated sequence using deep learning on a training set of fully rigged animated characters
- A variety of neural network models were considered
  - trained to detect vertex motion patterns and mesh geometry characteristics
  - Used to assign vertices to pseudo-bones
- Setting or tuning any parameters regarding the mesh structure or the kinematics of the animation is not needed
- After a comparative evaluation: we conclude that the approximation error of our method is always smaller than the error of previous approaches

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The full paper will be available in the LNCS conference proceedings and through the following link:

http://www.cgrg.cs.uoi.gr/single-publication?ID=48

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