Synthetic Occlusion Augmentation with Volumetric Heatmaps for 3D Human Pose Estimation

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BOSCH
Invented for life

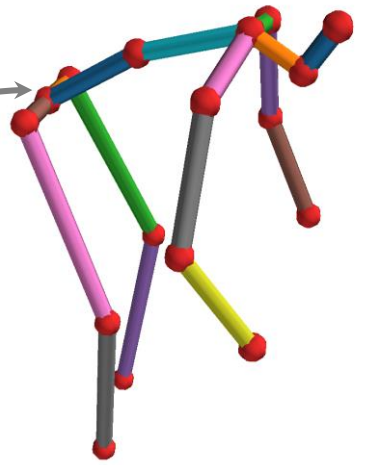
Visual Computing Institute

RWTH AACHEN UNIVERSITY

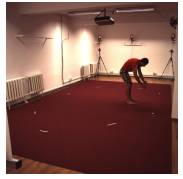
PoseTrack Challenge – 3D

```
[[   0.0    0.0    0.0]
 [ -96.9  -21.1  103.4]
 [ -43.0  456.4  150.3]
 [  42.6  902.6  249.0]
 [  96.0   22.1 -102.8]
 [  91.0  508.3 -100.2]
 [ 118.4  953.7   13.0]
 [   3.1 -262.6   13.2]
 [ -36.6 -502.0  -72.2]
 [ -96.7 -541.9 -162.8]
 [ -88.0 -651.5 -140.0]
 [  85.4 -439.5 -131.1]
 [ 278.0 -206.0 -121.3]
 [ 367.3   28.3 -184.0]
 [-139.0 -465.2   28.8]
 [-406.6 -322.4   42.9]
 [-414.1 -255.1 -202.1]]
```

pelvis



Approach



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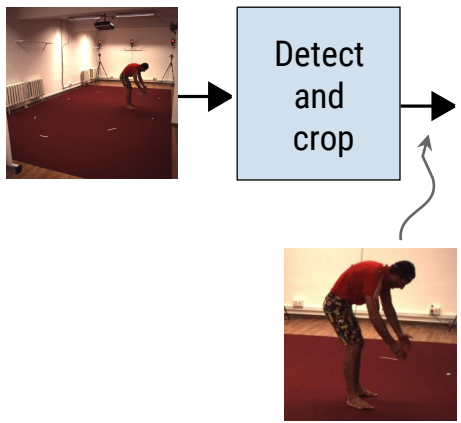

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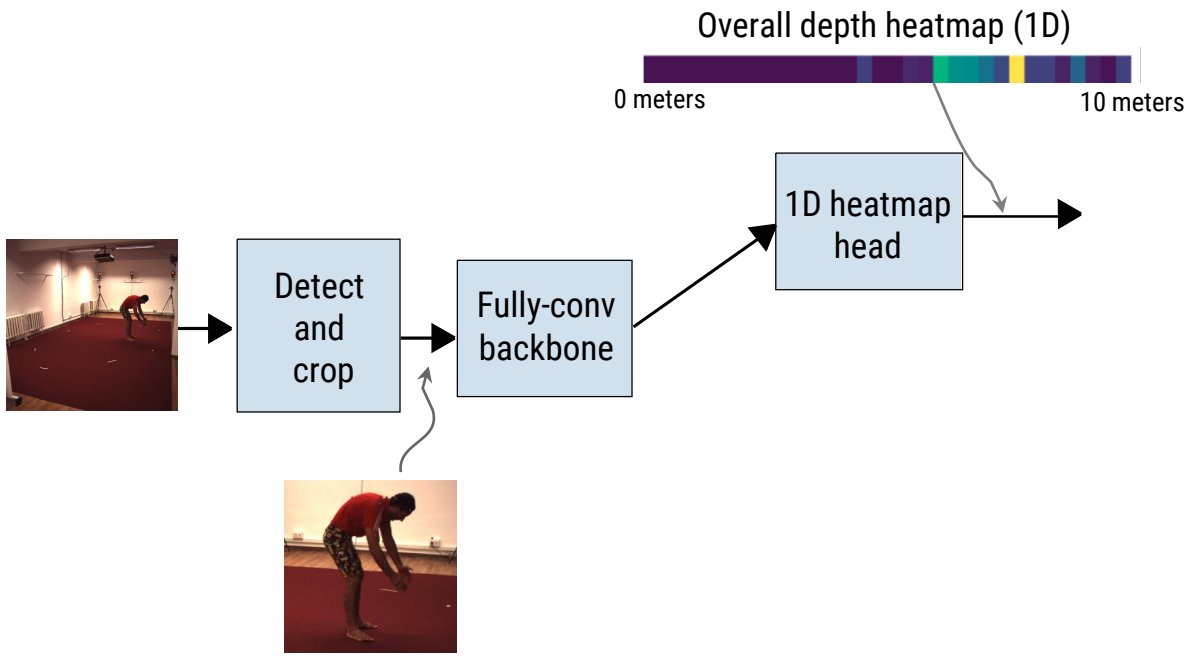
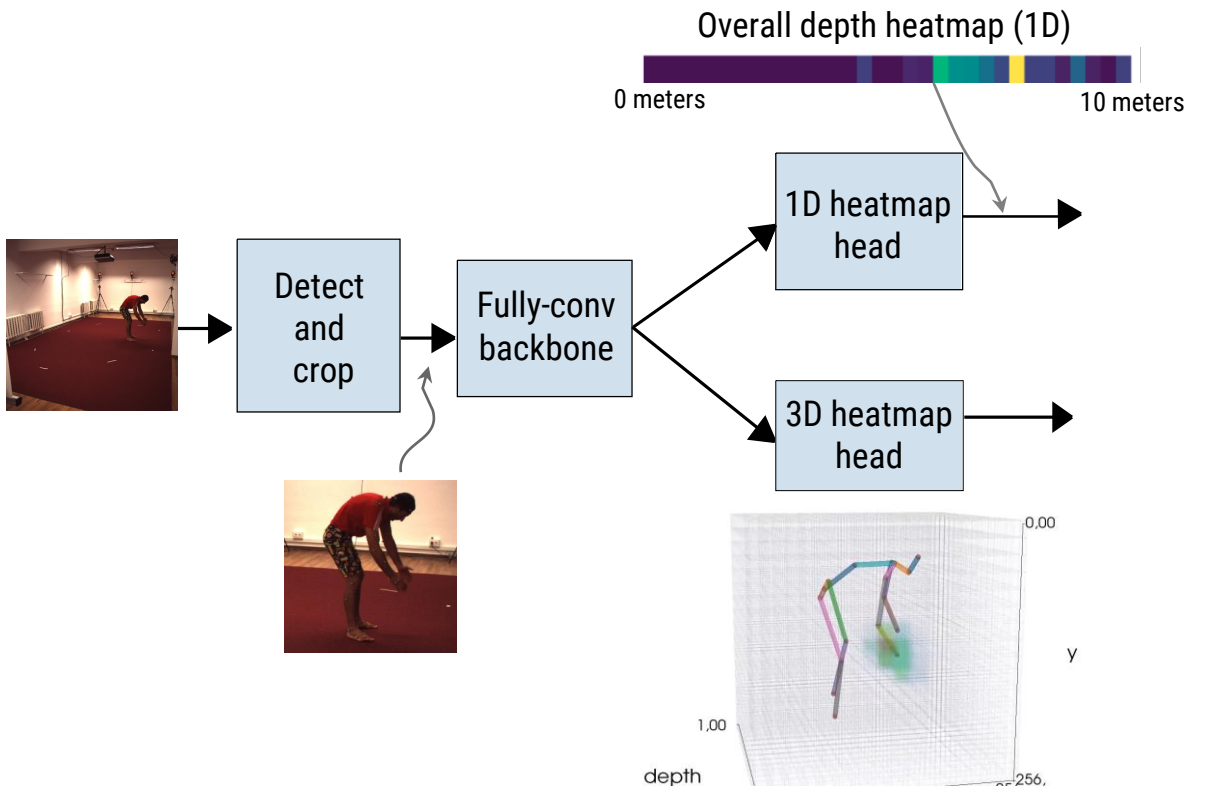
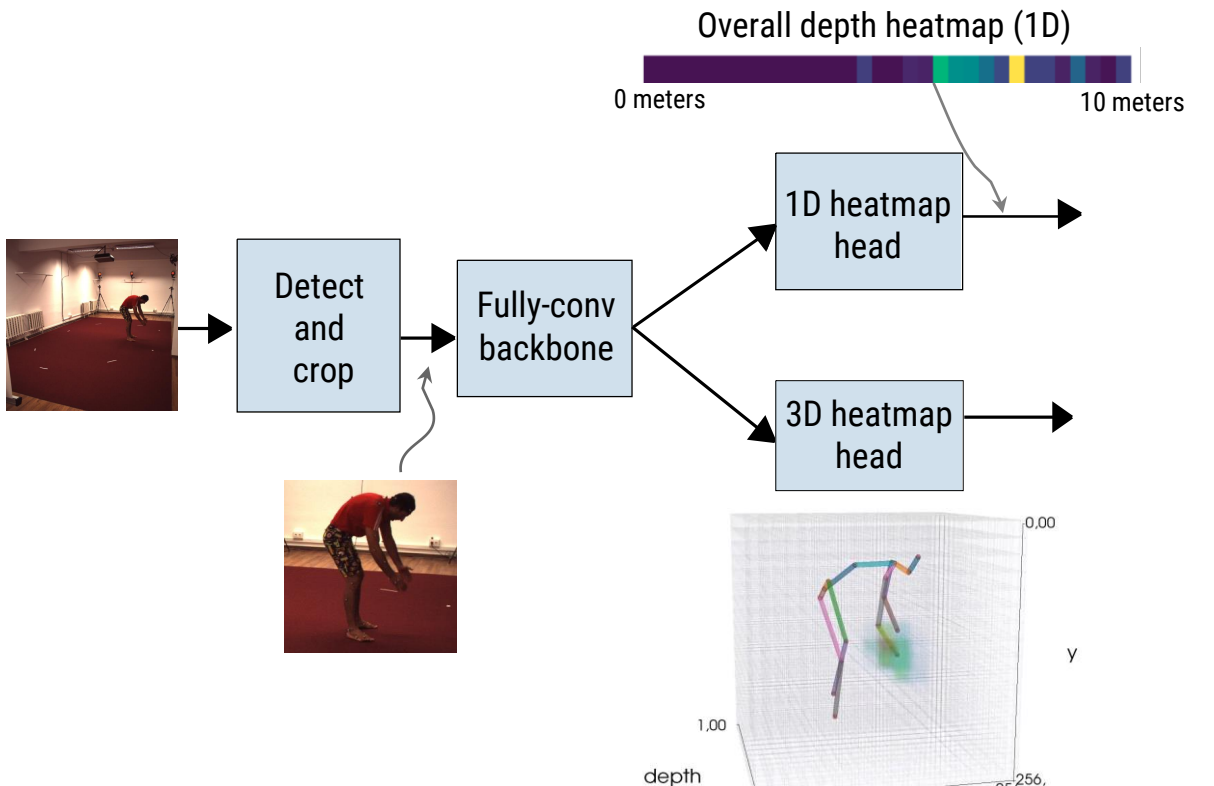

Overall depth heatmap (1D)
0 meters
10 meters
1D heatmap head
Detect and crop
Fully-conv backbone

Approach



Related:
Pavlakos, CVPR'17
Sun, ECCV'18

Approach



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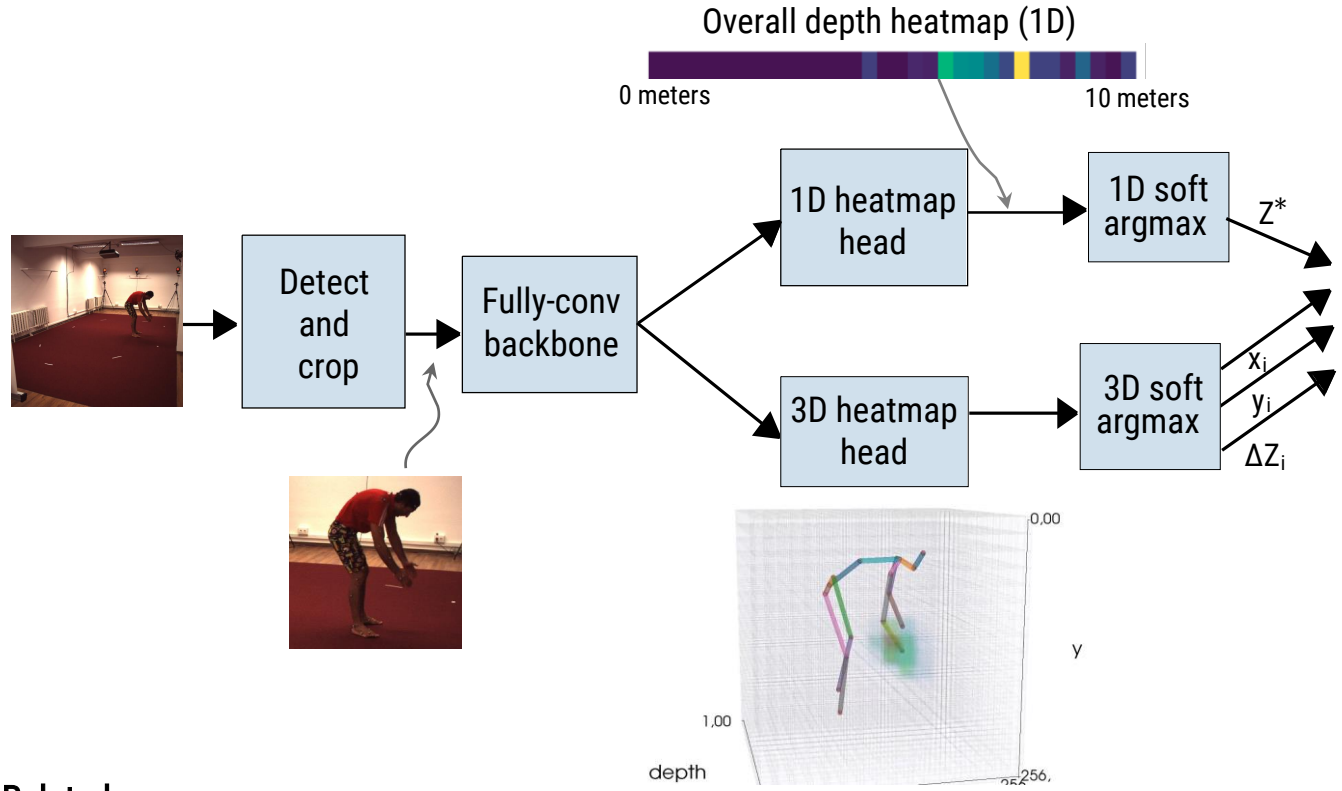

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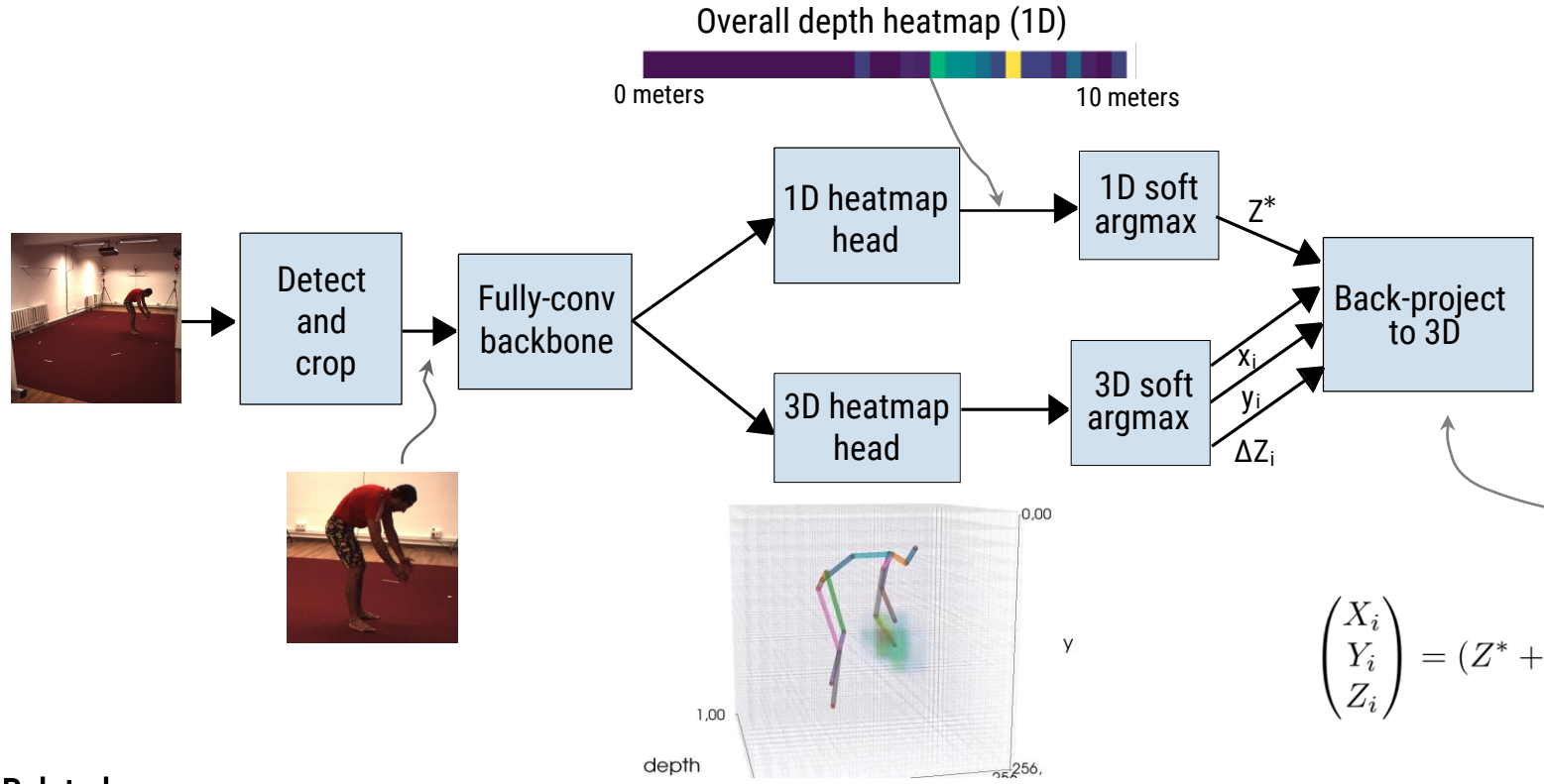

$$\begin{pmatrix} X_i \\ Y_i \\ Z_i \end{pmatrix} = (Z^* + \Delta Z_i) \begin{pmatrix} fs & 0 & W/2 \\ 0 & fs & H/2 \\ 0 & 0 & 1 \end{pmatrix}^{-1} \begin{pmatrix} x_i \\ y_i \\ 1 \end{pmatrix}$$

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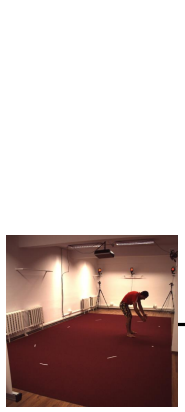
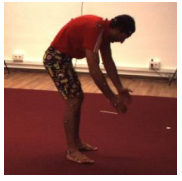
Approach



Detect and crop



Fully-conv backbone

1D heatmap head

3D heatmap head

Overall depth heatmap (1D)

1D soft argmax

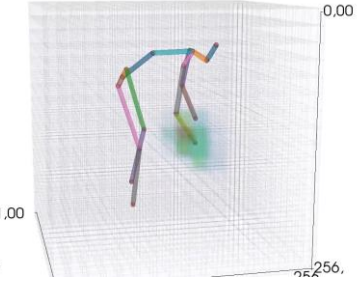
3D soft argmax

Z^*

x_i

y_i

ΔZ_i



Back-project to 3D

$$\begin{pmatrix} X_i \\ Y_i \\ Z_i \end{pmatrix} = (Z^* + \Delta Z_i) \begin{pmatrix} fs & 0 & W/2 \\ 0 & fs & H/2 \\ 0 & 0 & 1 \end{pmatrix}^{-1} \begin{pmatrix} x_i \\ y_i \\ 1 \end{pmatrix}$$

Ground truth

Subtract root pred.

L1 loss

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Sun, ECCV'18

Synthetic Occlusions

Pascal VOC objects

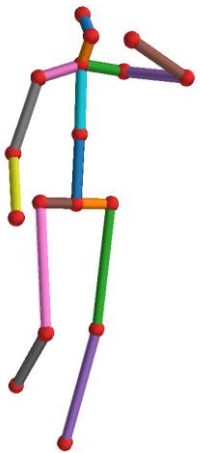
Sárándi *et al.*: How robust is 3D human pose estimation to occlusion? arXiv:1808.09316, IROS'18 Workshops

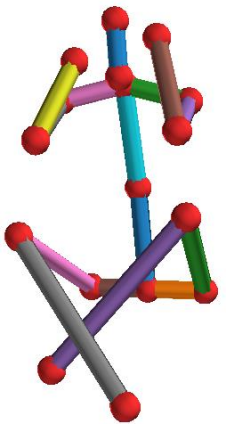
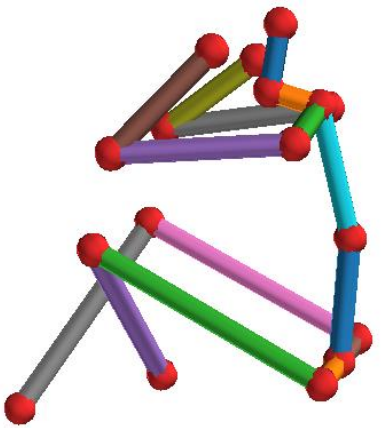
Synthetic Occlusions

\+ geometry and color =

Sárándi *et al.*: How robust is 3D human pose estimation to occlusion? arXiv:1808.09316, IROS'18 Workshops

Results



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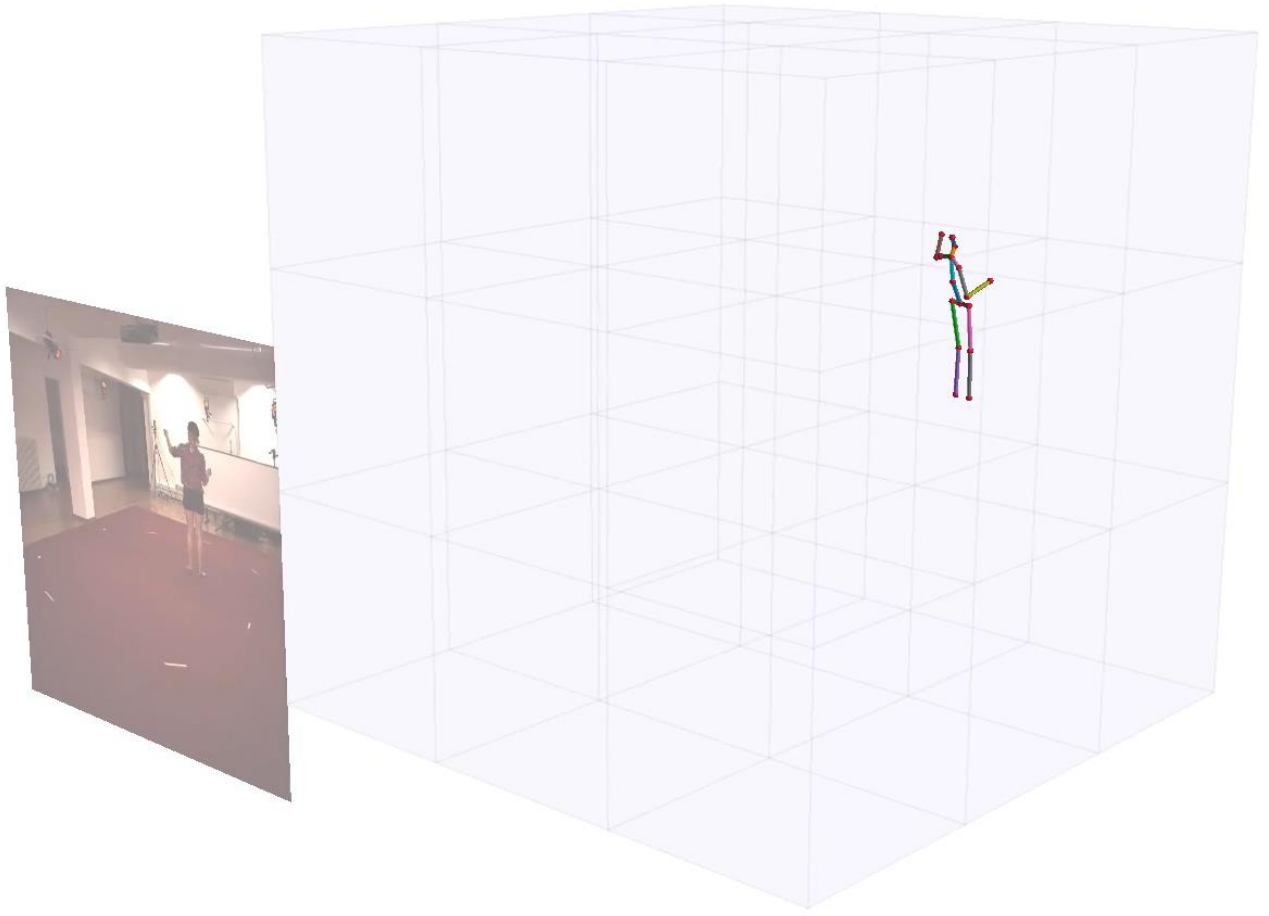
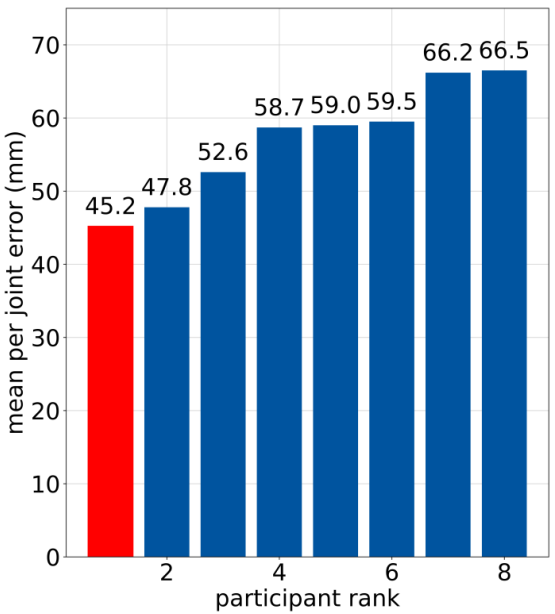


Results

1st place
in the Challenge



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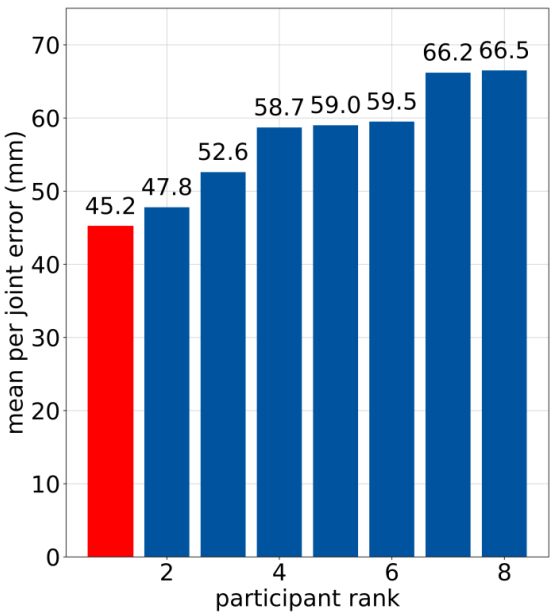
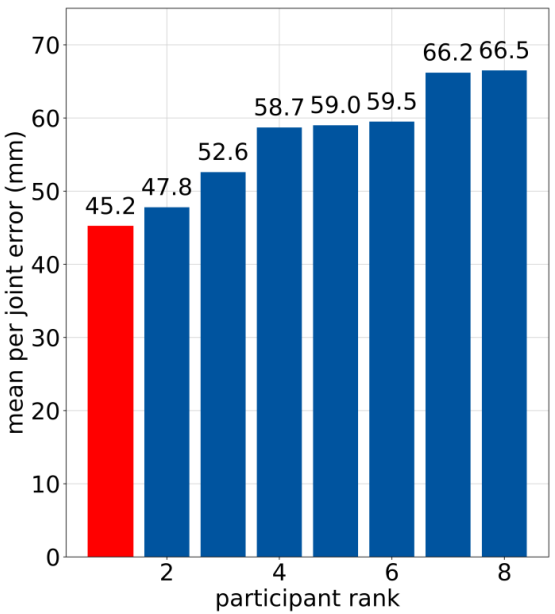


Best result on the full H3.6M
if no extra 2D pose datasets are used

Method	Extra pose data in training?	
	no	yes
Tekin (CVPR'16)	125.0	–
Zhou (CVPR'16)	113.0	–
Zhou (ECCV'16)	107.3	–
Sun (ICCV'17)	92.4	59.1
Martinez (ICCV'17)	–	62.9
Zhou (ICCV'17)	–	55.9
Pavlakos (CVPR'18)	71.9	56.2
Sun (ECCV'18)	64.1	**49.6**
Ours (no occl. augm., $p_{occ} = 0\%$)	65.7	–
Ours ($p_{occ} = 50\%$)	55.4	–
Ours ($p_{occ} = 100\%$)	**54.2**	–

Results

1st place in the Challenge



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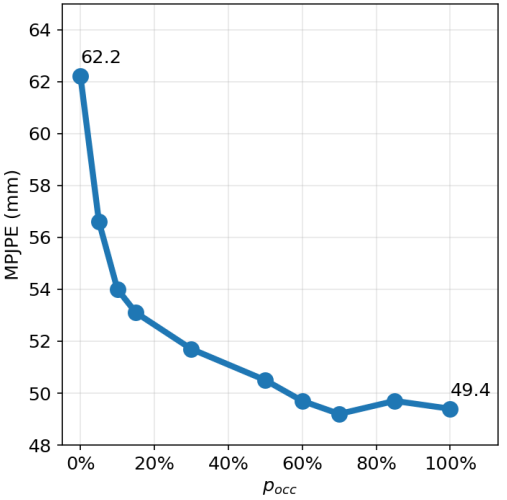
Effect of occlusion augmentation



(evaluated on challenge validation set)

Conclusion

- Human3.6M has little appearance variation
  - Overfitting → data augmentation helps
- Simple, fast architecture, good performance
  - Heatmaps directly from backbone net
  - Soft-argmax on low-res heatmaps (16×16×16)
  - ~200 fps inference (Titan X GPU, excl. detection)
  - 1st place in 3D PoseTrack Challenge

Thank you!

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