

## Problem Statement:

- In the industrial scenario humans and robots often share the same workspace posing a lot of threats to human safety issues.
- We focus on:
  - Intuitive and natural human-robot interaction.
  - Safety considerations and measures in a shared work environment.
  - Realization of cooperative process.
  - Workflow optimization.

## Related Work:

- This work builds on top of our previous work Dittrich *et al.* [1] and Sharma *et al.* [2] in order to improve recognizing human body-parts.

## CRF Modeling:

- The CRF energy is defined as:

$$E(x) = E_{data}(x) + E_{smooth}(x)$$

where  $x$  is an arbitrary configuration for assigning a label to each pixel.

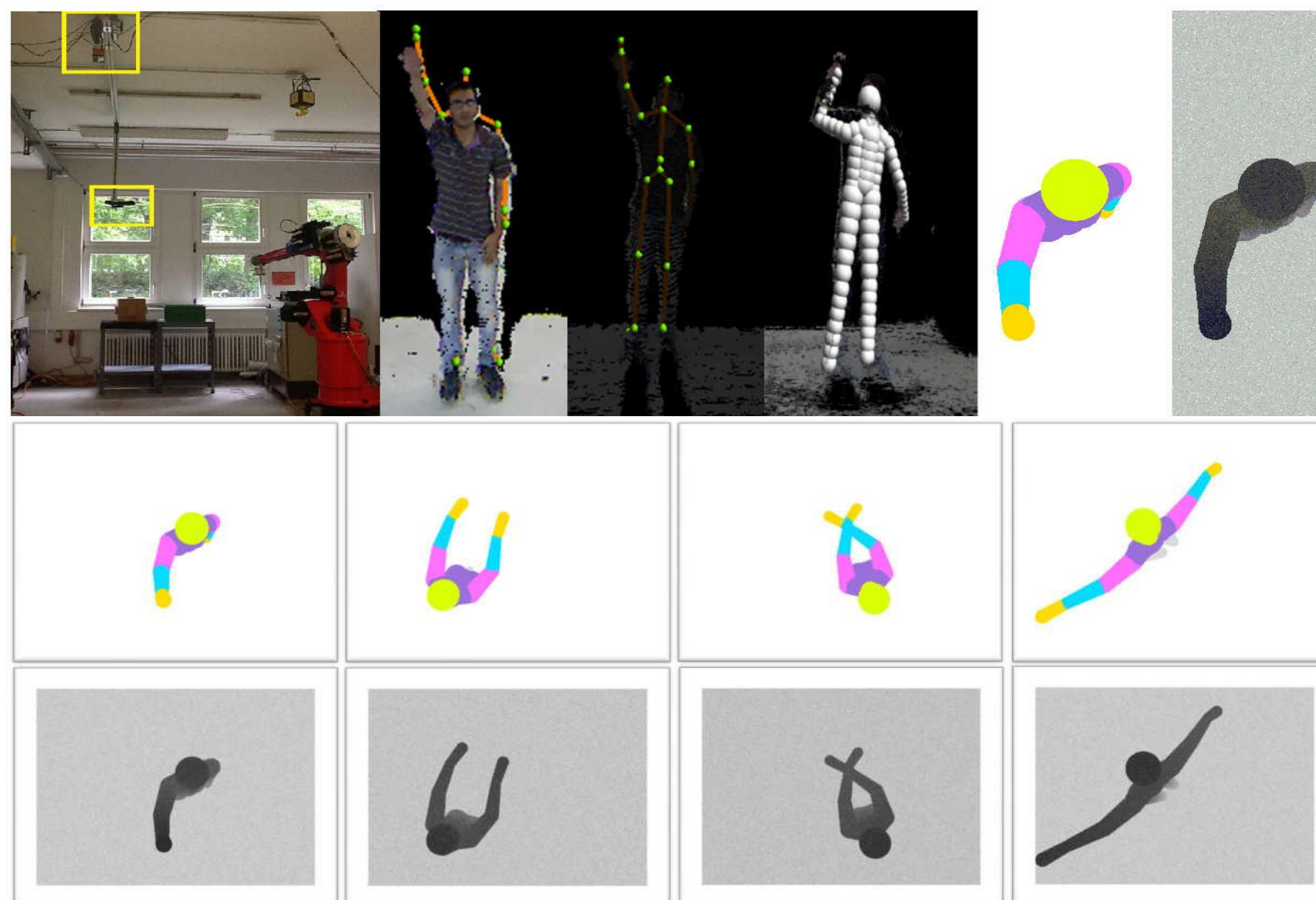
- We use a random decision forest (RDF) and a conditional random field (CRF) for pixelwise object class labeling of human body-parts using depth measurements obtained from KINECT RGB-D ceiling sensor.
- The CRF has only two parameters: the convex sum for the weighing of the data term and the pairwise regularization smooth term.
- The RDF predictions are simply injected as the data term in the energy formulation of the CRF, and then we do global optimization using the graph cuts algorithm.

## References:

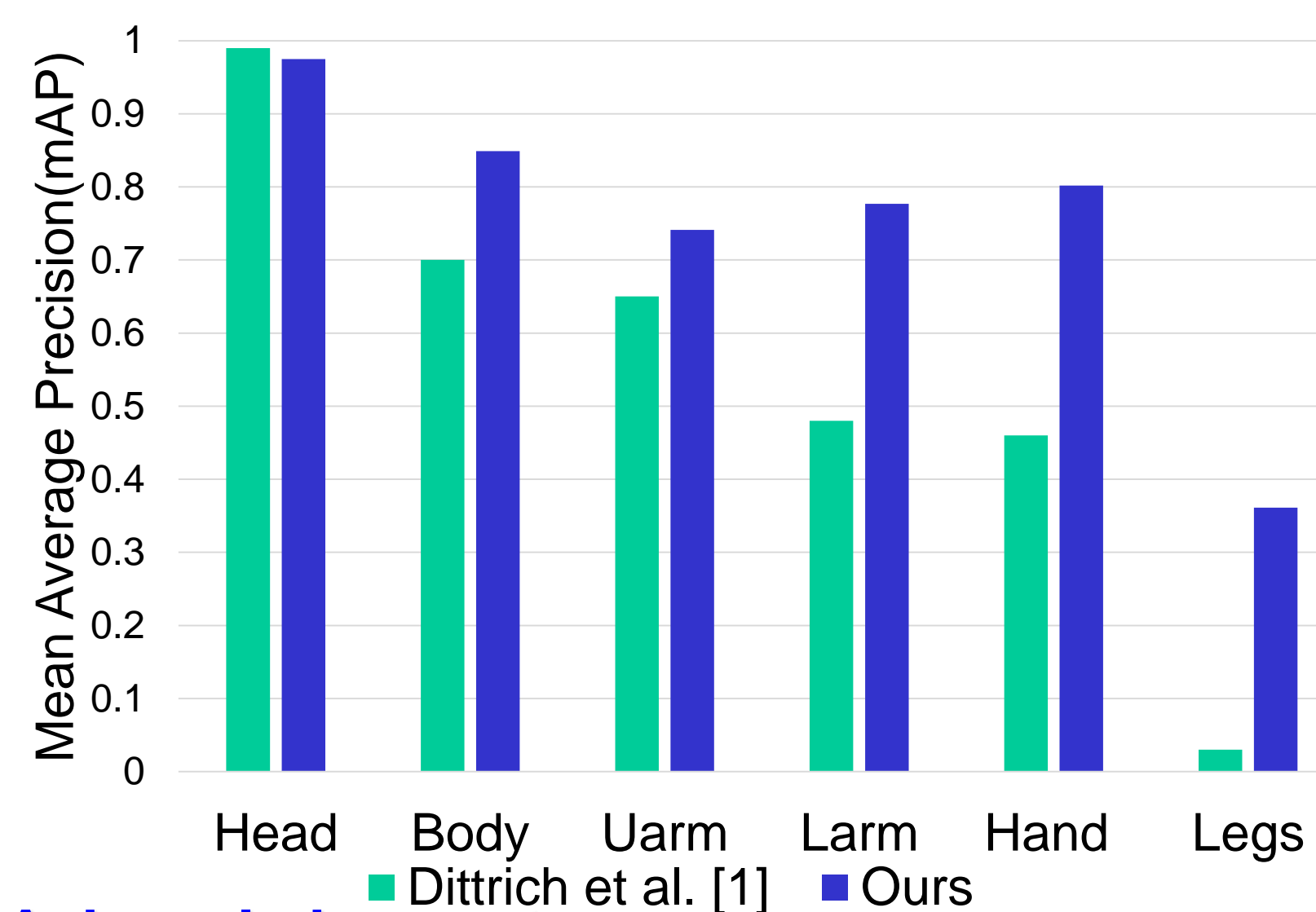
- [1] F. Dittrich, V. Sharma, H. Worn, S. Yayilgan. Pixelwise object class segmentation based on synthetic data using an optimized training strategy. In *ICNSC*, 2014
- [2] V. Sharma, F. Dittrich, S. Yayilgan, L. Van-Gool. Efficient Real-Time Pixelwise Object Class Labeling for Safe Human Robot Collaboration in Industrial Domain. To appear in *ICML Workshop*, 2015.
- [3] V. Sharma, S. Yayilgan, L. Van-Gool. Scene Modeling using a Density Function Improves Segmentation Performance. KU Leuven, *Tech. Report*, 2015.

## Data Collection:

- Human body-parts: *head, body, upper-arm (Uarm), lower-arm (Larm), hand and legs*.
- Poses and shape: *sitting, standing, walking, working, dancing, swinging, boxing, tilting, bending, bowing, and stretching* with combinations of angled arms, single and both arms and other combinations.
- Human height range: 160-190 cm.



## Comparison with Dittrich et al. [1]:

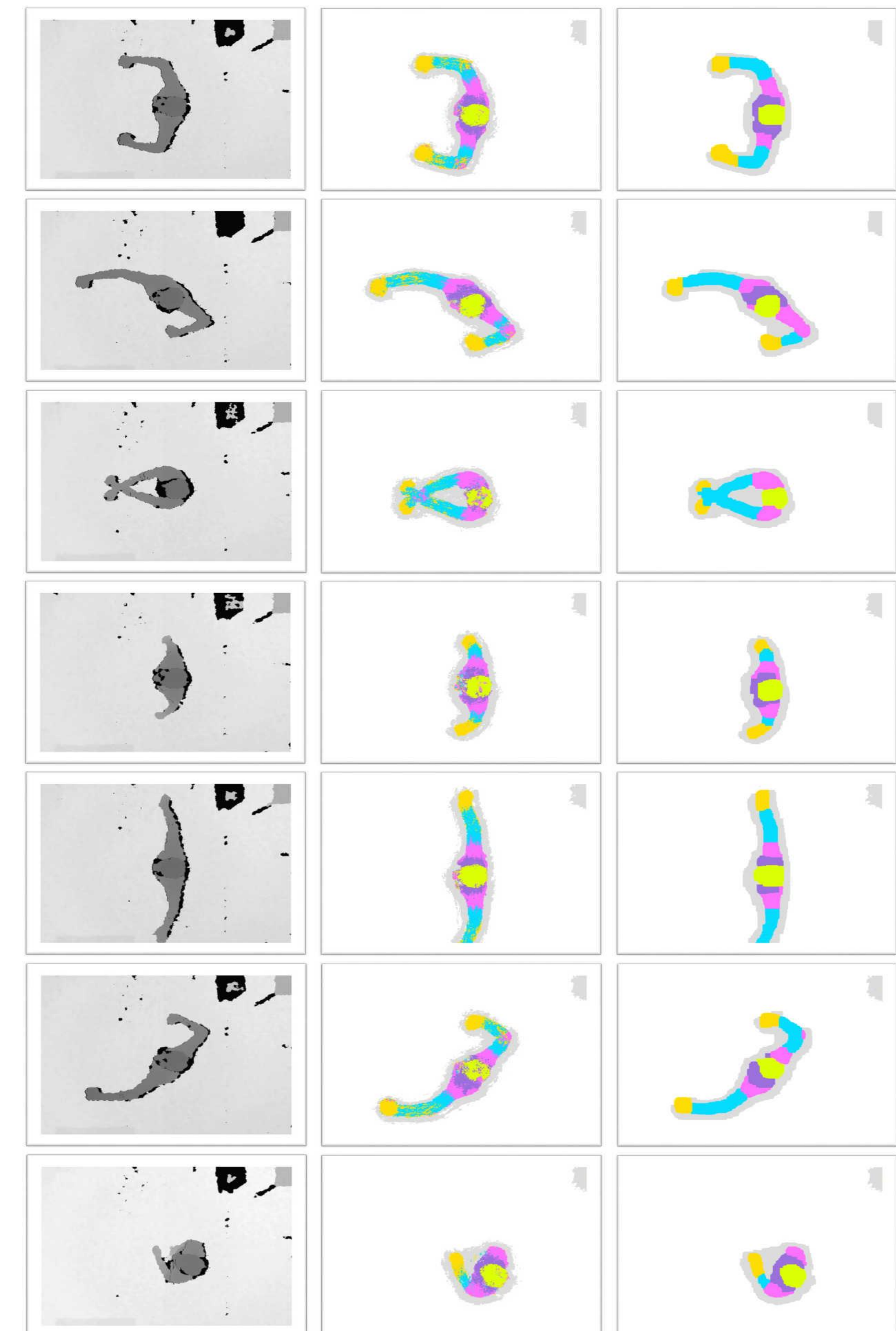


## Acknowledgements:

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## Segmentation Results:

- Segmentation results based on real-world test depth data.
- The first column shows the test data for various human poses and shapes, the second and third columns show the predictions obtained from RDF and CRF modeling.



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