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N-View Human Silhouette Segmentation in Cluttered, Partially Changing Environments

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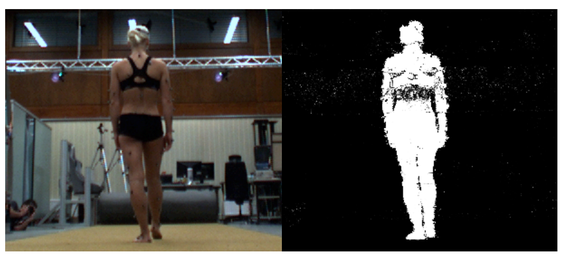
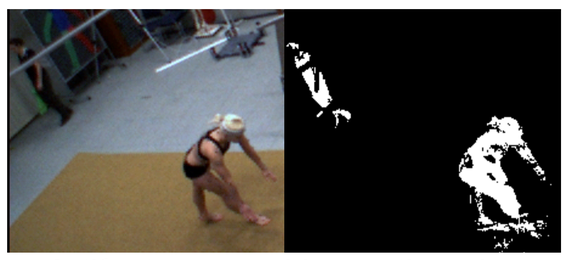
Problem statement:

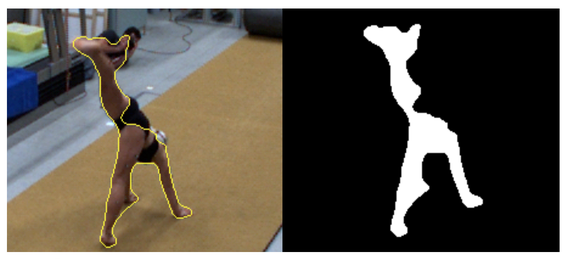
- Segmentation of humans in front of cluttered, partially changing background is a challenging task; typical probems:



- Holes due to similar color distributions of fore- and background.

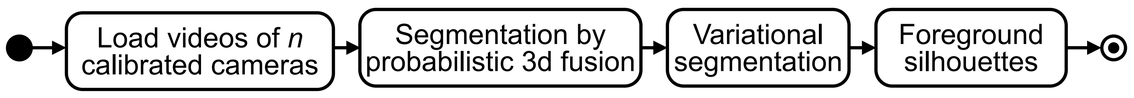


- Artifacts caused by motions in the background.



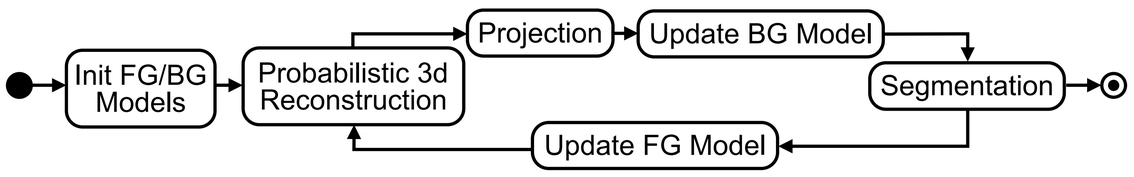
- Sprawling segmentation results due to ambigious color distributions.

Contribution:



- Increase of segmentation quality by fusion via Dempster-Shafer theory of evidence:
  - **Part I:** Segmentation by probabilistic 3d fusion.
  - **Part II:** Variational segmentation.

Part I: Segmentation by probabilistic 3d fusion:



- **Intermediate result:** Probabilistic 2d segmentation which is interpreted as a self-contained feature channel.

Part II a): Feature fusion with Dempster-Shafer theory:

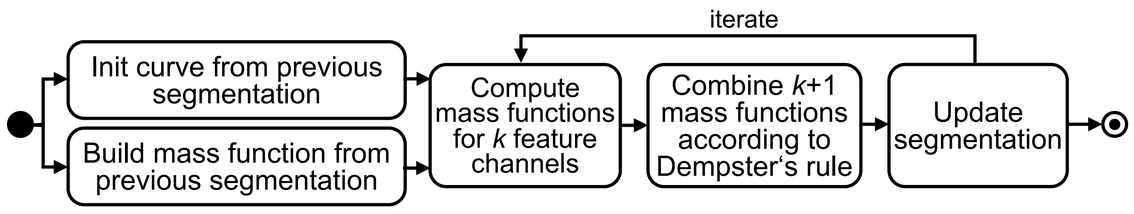
- Define masses m_j to model belief of fore- and background based on k feature distributions (e.g. color distributions).
- Create combined mass function from the FG segmentation arising from probabilistic 3d fusion and k features in the 2d image domain.

$$\mathrm{m_{new}} = \mathrm{m} \otimes \mathrm{m_{fg}} = \mathrm{m_1} \otimes \mathrm{m_2} \otimes \ldots \otimes \mathrm{m_k} \otimes \mathrm{m_{fg}}$$

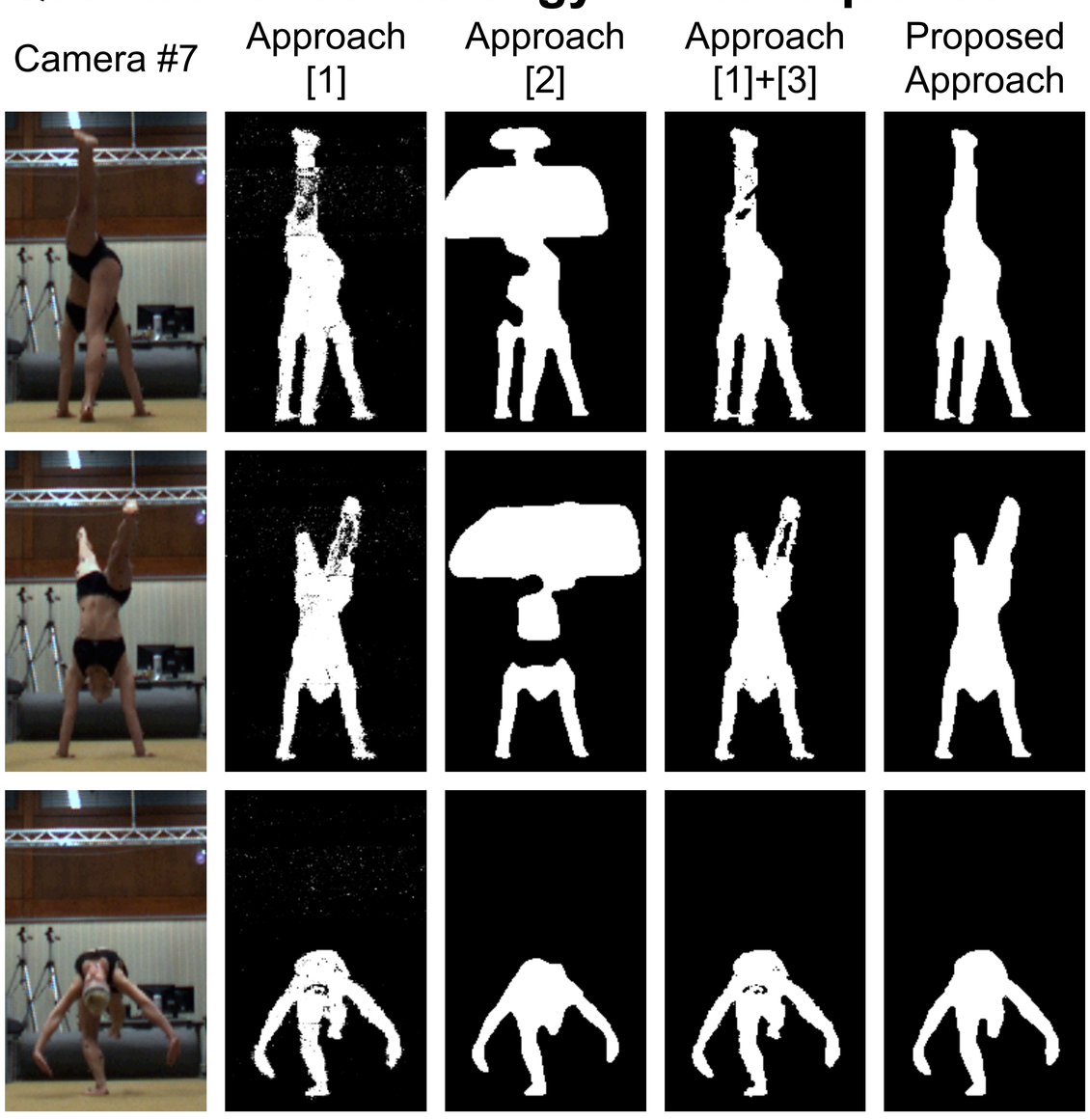
Part II b): Variational segmentation:

- Minimizing the adapted energy function to obtain final segmentation:

$$\mathrm{E}(\varphi) = \underbrace{-\int_\Omega \mathrm{H}(\varphi) \log \mathrm{m_{new}}(\Omega_1)\,\mathrm{d}\Omega - \int_\Omega (1-\mathrm{H}(\varphi)) \log \mathrm{m_{new}}(\Omega_2)\,\mathrm{d}\Omega}_{\text{fusion of image features and probabilistic foreground detection}} + \nu_1 \int_\Omega |\nabla \mathrm{H}(\varphi)|\,\mathrm{d}\Omega\,.$$

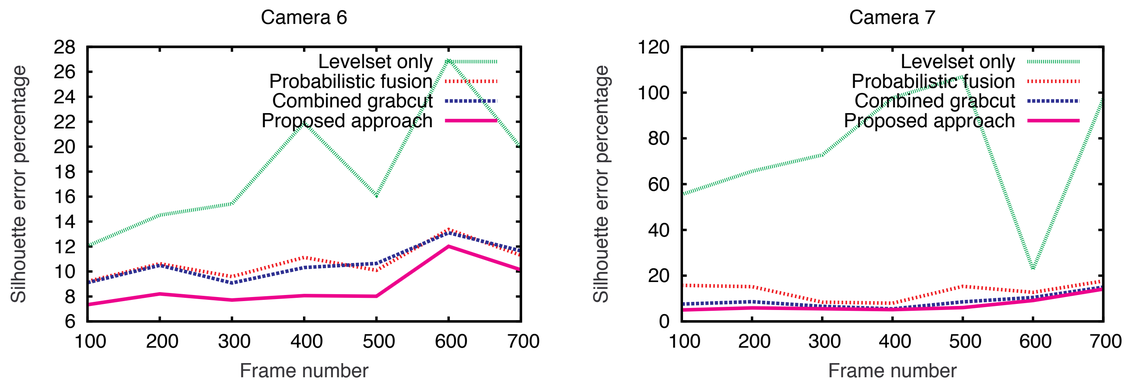


Qualitative results of gymnast sequence:



- Segmentation by probabilistic fusion [1] and Levelsets [2] do not gain satisfying results individually.
- Fusion of [1] and Grabcut [3] are outperformed by the proposed method.

Quantitative results of gymnast sequence:



- Relative silhouette error percentage of the single approaches and the combined approach in two exemplary cameras.
- Proposed approach outperforms segmentation via probabilistic 3d fusion, variational segmentation and combined grabcut.

References:

[1] Feldmann, T., Dießelberg, L., Wörner, A.: *Adaptive foreground/background segmentation using multiview silhouette fusion*. In: DAGM 2009. LNCS, vol. 5748, pp. 522–531. Springer, Heidelberg (2009)

[2] Scheuermann, B., Rosenhahn, B.: *Analysis of numerical methods for level-set based image segmentation*. In: ISVC 2009, Part II. LNCS, vol. 5876, pp. 196–207. Springer, Heidelberg (2009)

[3] Rother, C., Kolmogorov, V., Blake, A.: *"grabcut": interactive foreground extraction using iterated graph cuts.* ACM Trans. Graph. 23(3), 309–314 (2004)

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