Automatic Skin Labeling of Egocentric Images for Virtual Reality Applications

Heiko Raible
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Structure

Structure

- Introduction

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- Introduction
- Research

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- Implementation

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- Evaluation

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- Conclusion

Introduction

Previous Work

My Contribution

Research

GrabCut

GrabCut

- rough foreground and background mask

GrabCut

- rough foreground and background mask
- iteratively optimizes masks
  - Gaussian Mixture Models
  - spatial information
  - graph cuts

Color Spaces

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- RGB (red, green, blue)

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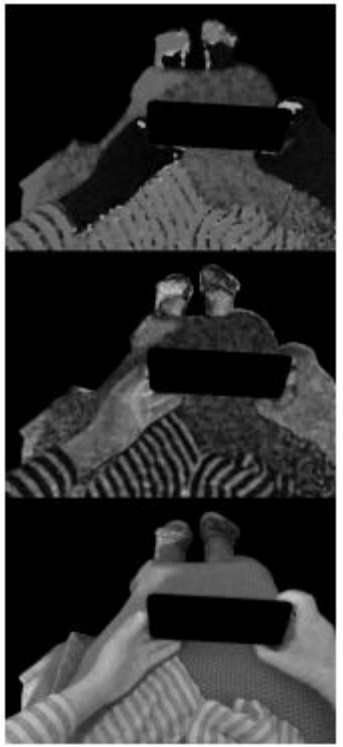
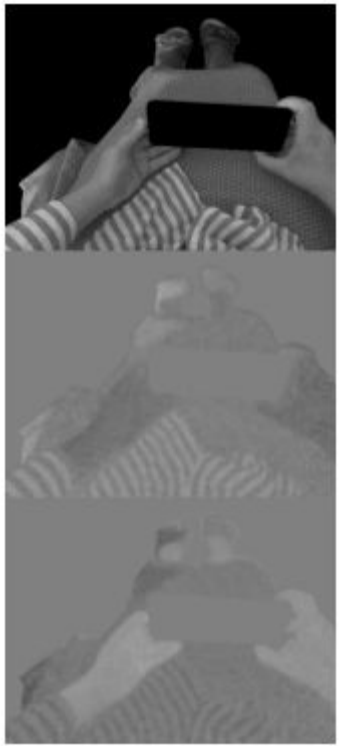
- RGB (red, green, blue)
- HSV (hue, saturation, value)



Color Spaces

- RGB (red, green, blue)
- HSV (hue, saturation, value)
- YCrCb (luma, red-difference chroma, blue-difference chroma)



Color Spaces

- RGB (red, green, blue)
- HSV (hue, saturation, value)
- YCrCb (luma, red-difference chroma, blue-difference chroma)
- LAB (lightness, green-red, blue-yellow)

Otsu’s Method

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- operates on greyscale

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- calculates variance of intensity per threshold

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- operates on greyscale
- calculates variance of intensity per threshold
- maximizes between-class variance

MediaPipe Hands

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- lightweight Convolutional Neural Network (CNN)

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- lightweight Convolutional Neural Network (CNN)
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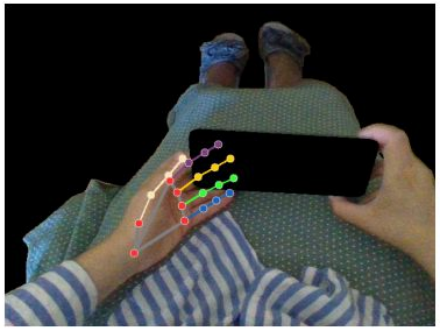
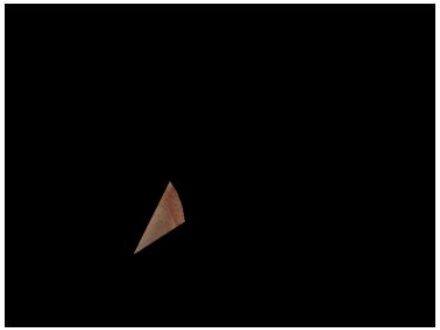
- detects hands
  ⇒ skin patch Region of Interest (ROI)





Mask R-CNN

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- ResNet (Residual Network)
  - addresses vanishing gradient problem (skip connections)

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  - region proposal network for object detection
  - region of interest pooling layer for classification and refinement

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- ResNet (Residual Network)
  - addresses vanishing gradient problem (skip connections)
- Faster R-CNN
  - region proposal network for object detection
  - region of interest pooling layer for classification and refinement
- Mask R-CNN
  - mask prediction branch to generate segmentation mask per object

Implementation

Filtering Methods

Filtering Methods

- color range inside ROI
  - RGB
  - HSV (no value)
  - YCrCb (no luminance)

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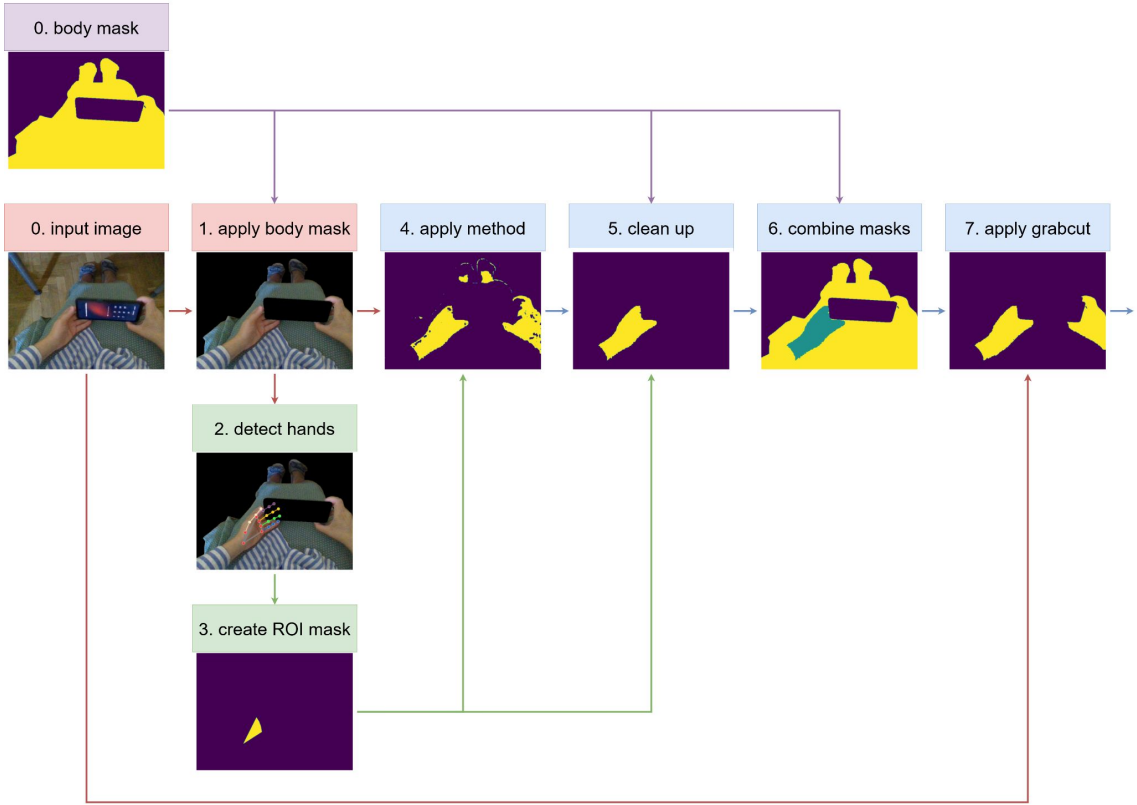
- Otsu’s method
- histogram based inside ROI
  - HSV
  - LAB
  - YCrCb
  - HCrCb

End-to-end System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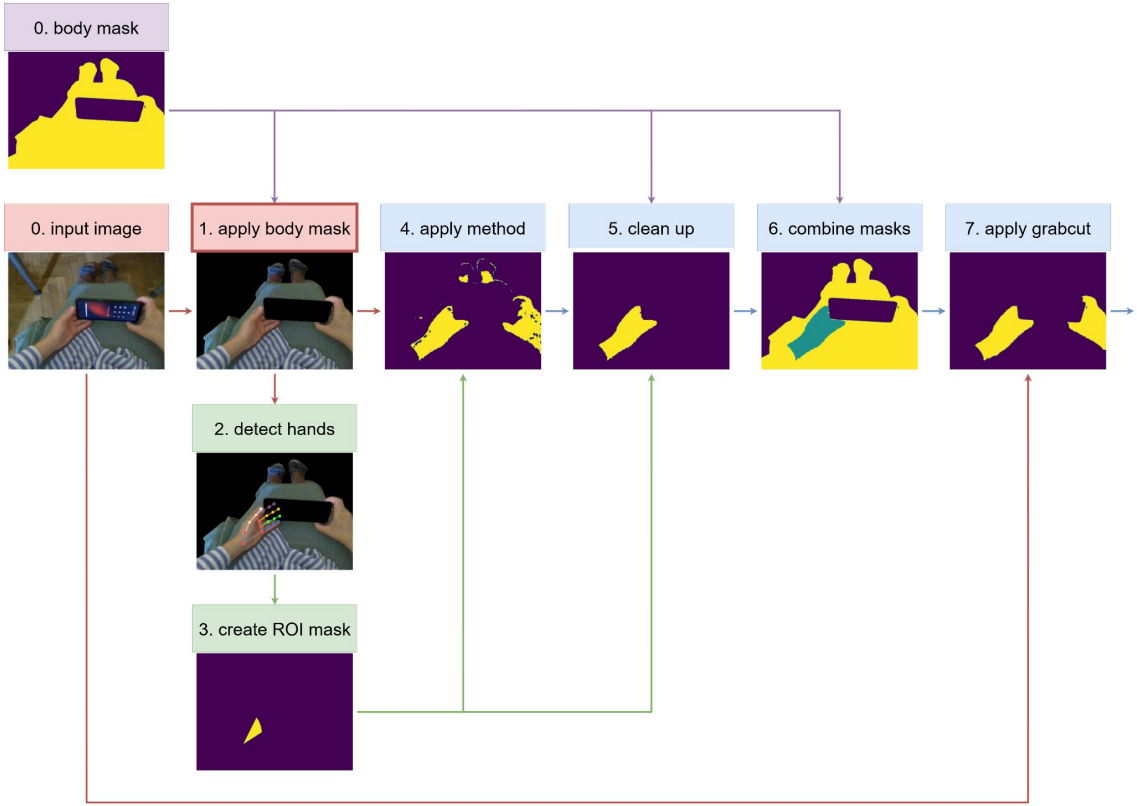
4. apply method
5. clean up
6. combine masks
7. apply grabcut
2. detect hands
3. create ROI mask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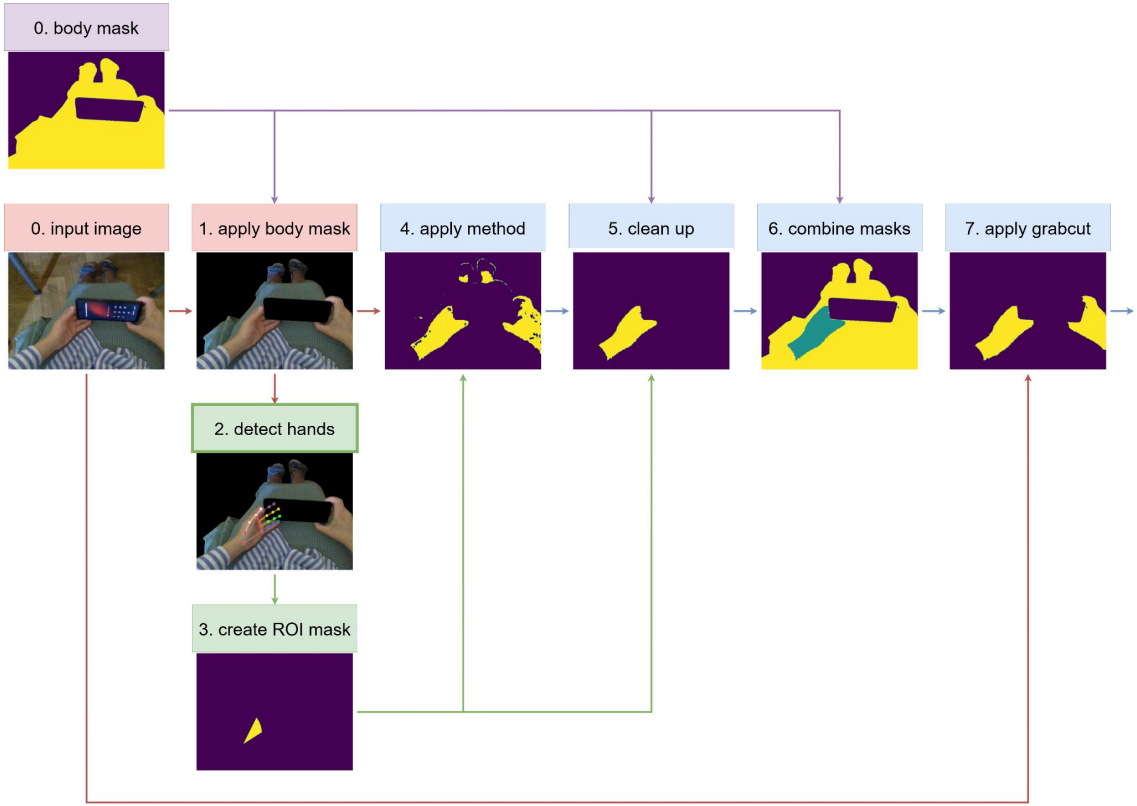
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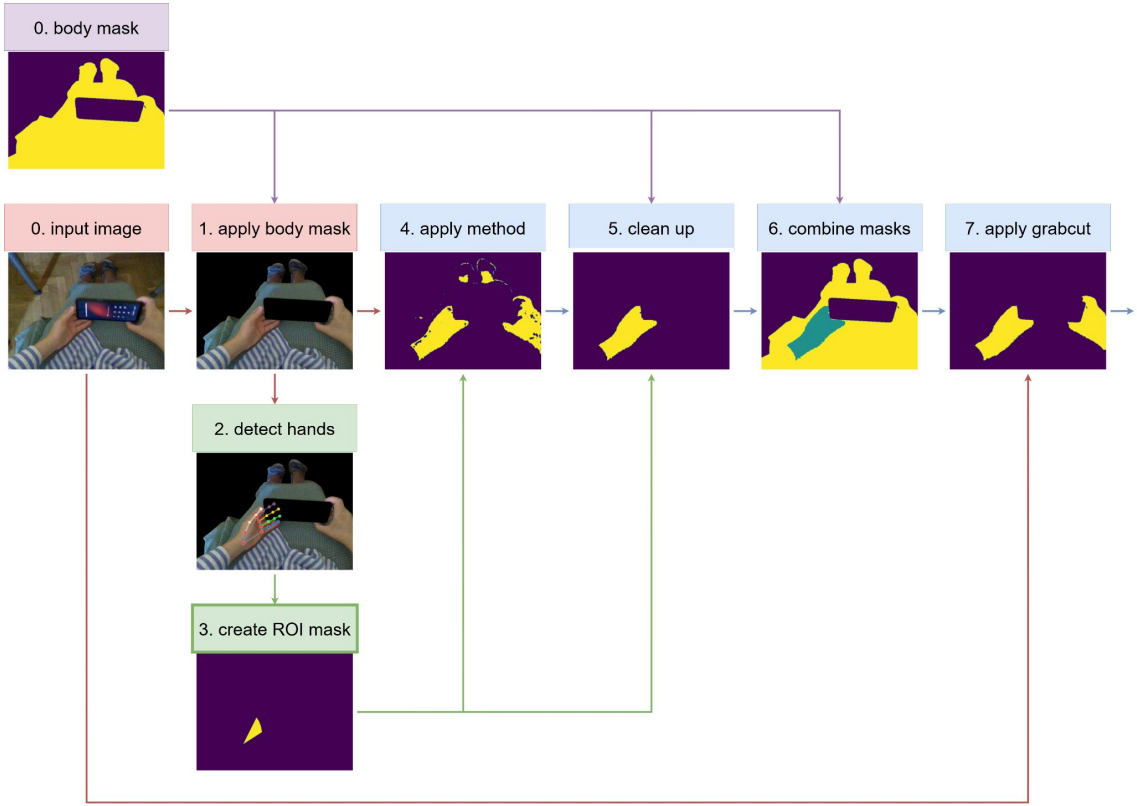
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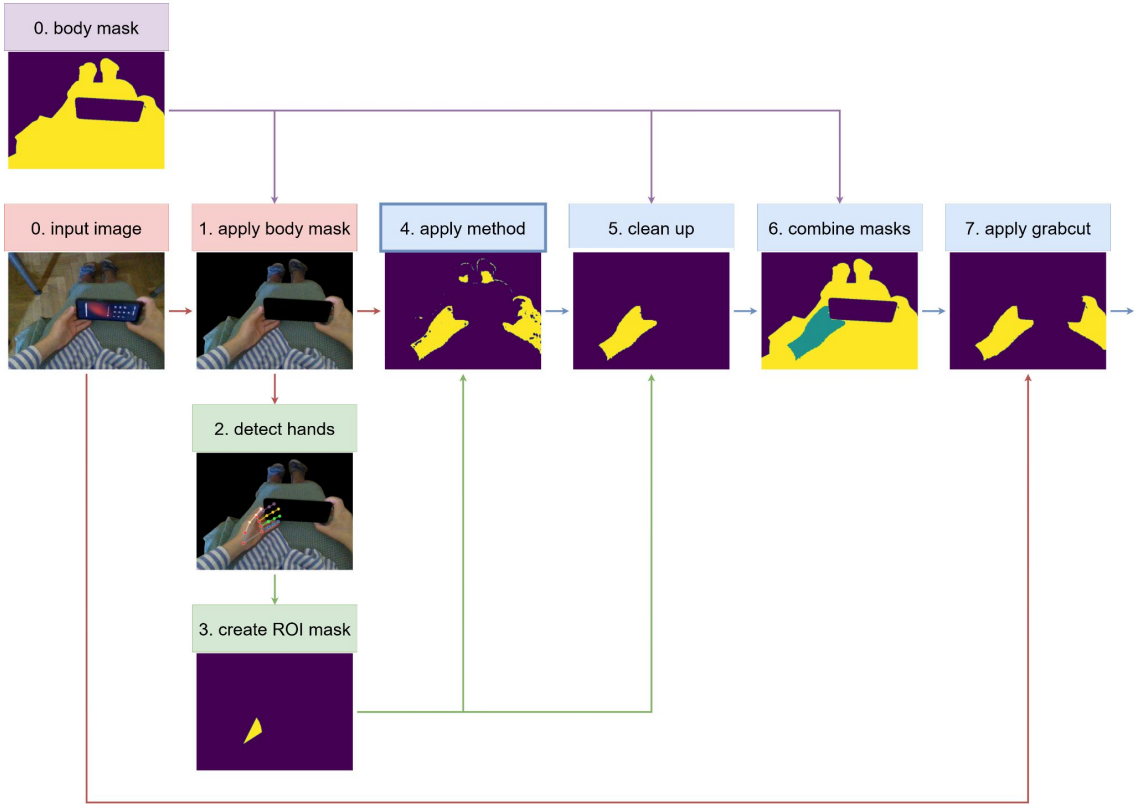
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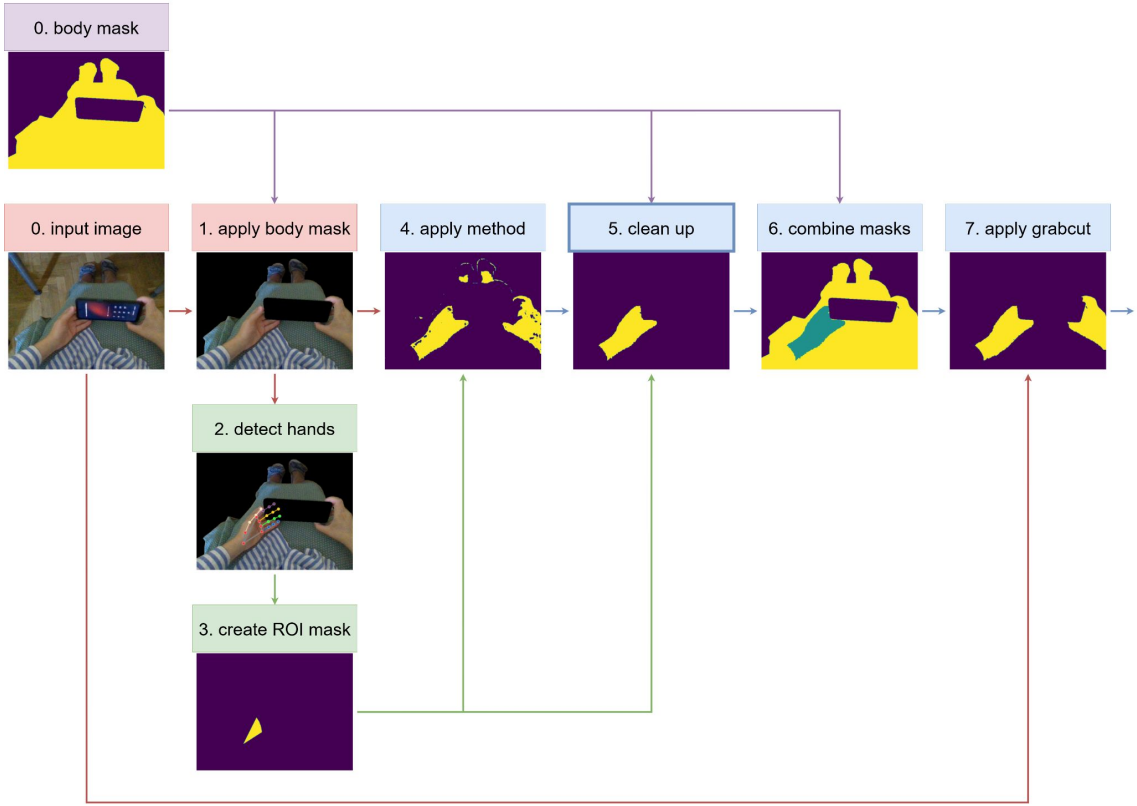
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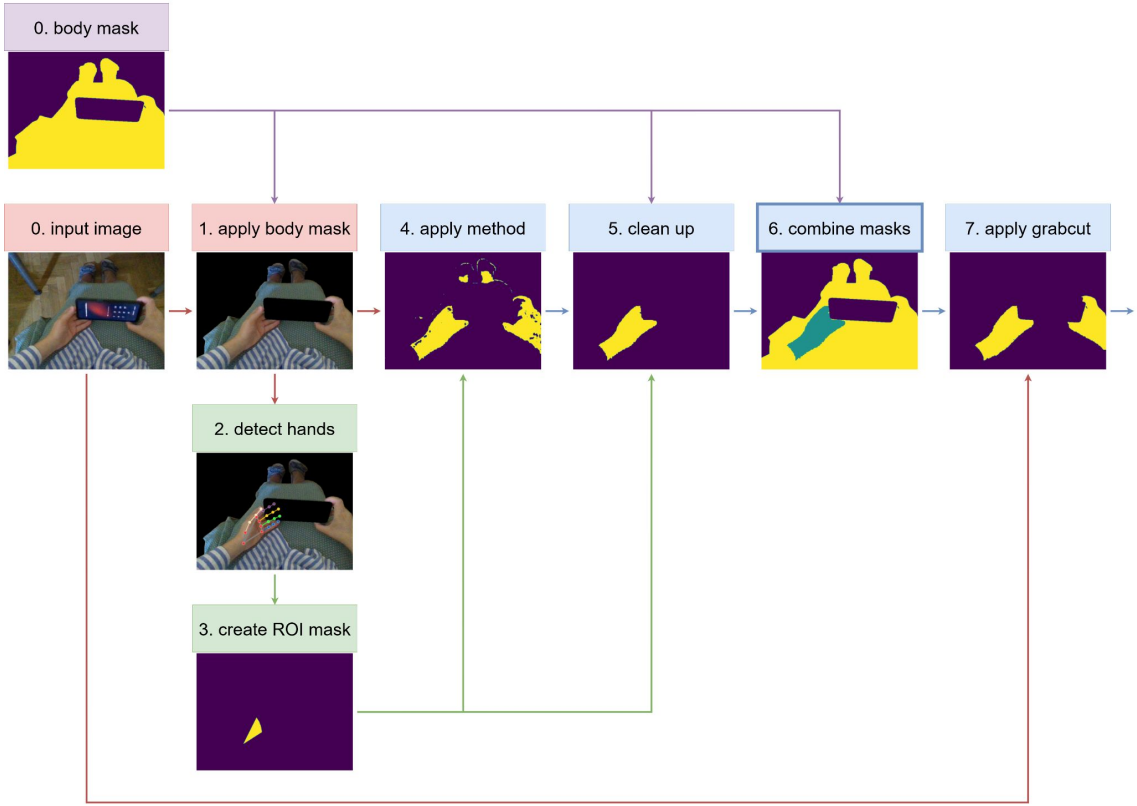
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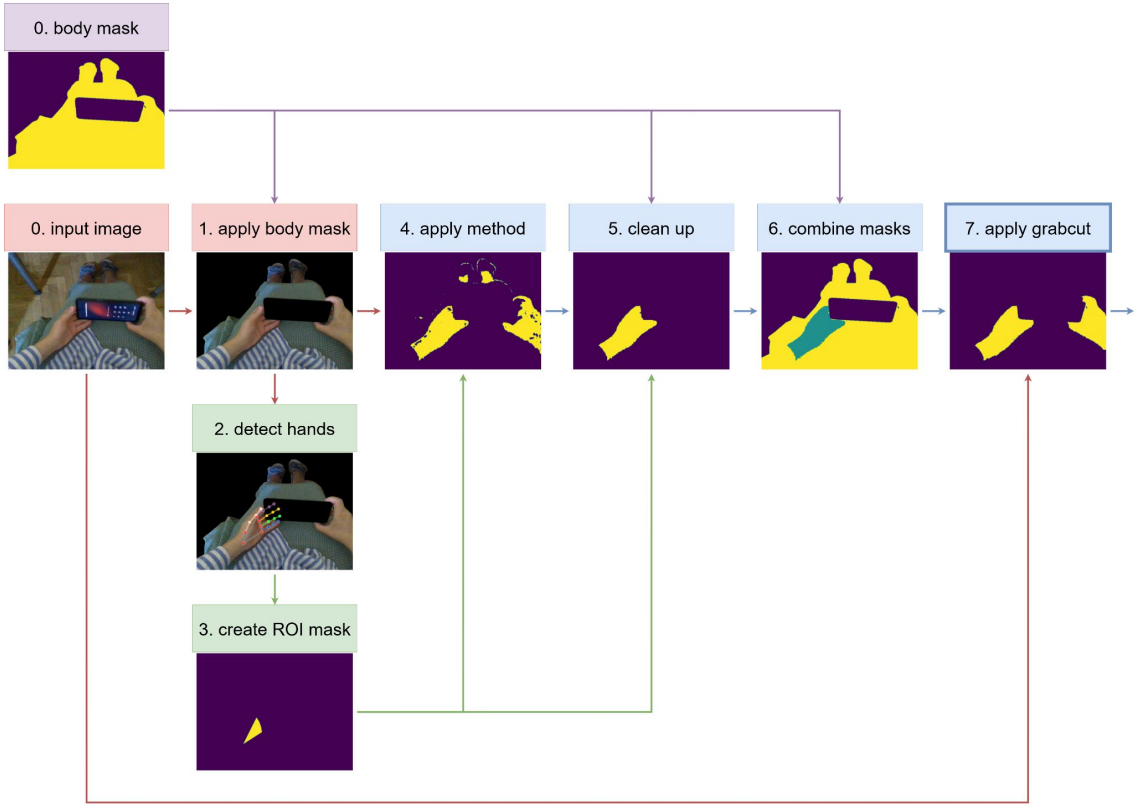
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Mask R-CNN

Mask R-CNN

- Training
  - pretrained on COCO
  - fine-tuned for 20 epochs

Evaluation

Datasets

Datasets

- THU-READ
  - 158 images
  - multiple of same scene
  - many where skin = body
    ⇒ 35 body images

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- THU-READ
  - 158 images
  - multiple of same scene
  - many where skin = body
    ⇒ 35 body images
- Egocentric Bodies
  - 103 images
  - fewer of same scene
  - skin ≠ body

THU_READ_RGBD

joint-ep-of-thu-ego

Datasets

- THU-READ
- Egocentric Bodies
- Amazon Mechanical Turk

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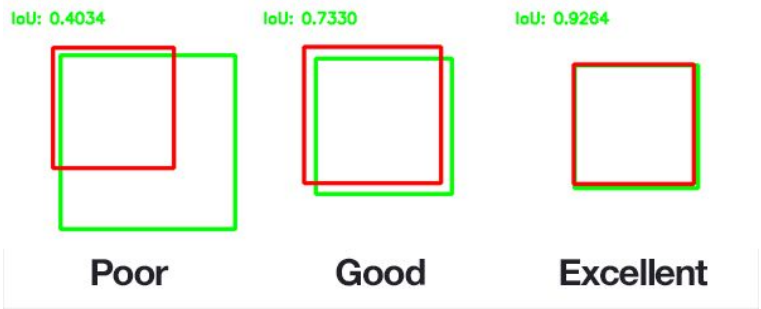
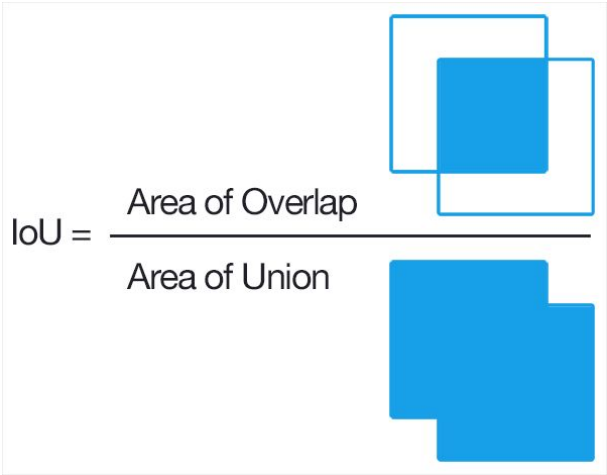
Datasets

- THU-READ
- Egocentric Bodies
- Amazon Mechanical Turk
- end-to-end system
- Mask R-CNN
  - data augmentation
    ⇒ 259 → 519 images
  - 200 random test dataset
    319 remaining training dataset

(mean) Intersection over Union (IoU)





Results

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- end-to-end system

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- end-to-end system
- GrabCut iterations

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- Mask R-CNN epochs

Results

- end-to-end system
- GrabCut iterations
- Mask R-CNN epochs
- illustrative examples

thresholding method	**THU_READ_RGBD** (158 images)			**THU_READ_RGBD_BODIES** (35 images)			**joint-ep-thu-ego** (103 images)		
	mIoU (%) @ method	mIoU (%) @ clean up	mIoU (%) @ grabcut	mIoU (%) @ method	mIoU (%) @ clean up	mIoU (%) @ grabcut	mIoU (%) @ method	mIoU (%) @ clean up	mIoU (%) @ grabcut
baseline		81.7			49.0			40.3	
ROI mask	07.4	07.4	79.4	06.3	06.3	77.2	09.1	09.1	61.4
RGB	07.4	74.5	75.9	08.3	45.5	45.8	11.0	31.4	32.8
HS	06.7	71.0	76.7	07.0	48.9	49.7	12.7	48.1	46.4
CrCb	32.1	74.8	79.0	37.2	66.9	65.4	29.8	44.5	48.1
Otsu's	71.8	67.8	79.4	71.2	70.3	77.9	47.8	45.0	50.5
RGB · HS	06.5	69.7	76.8	06.9	48.8	50.1	11.8	44.6	46.5
RGB · CrCb	31.2	73.6	79.4	36.8	66.4	65.5	28.0	42.0	48.2
HS · CrCb	28.7	68.8	80.0	32.7	60.1	69.0	28.6	44.3	51.6
RGB · Otsu's	69.8	66.5	79.7	70.6	70.3	79.0	47.9	44.6	53.2
HS · Otsu's	66.7	63.1	79.0	63.9	64.4	77.3	54.5	48.1	60.0
CrCb · Otsu's	67.6	65.4	79.1	67.7	68.3	77.3	53.6	48.5	59.4
RGB · HS · CrCb	27.8	67.5	80.0	32.3	59.5	69.0	26.7	41.4	51.8
RGB · HS · CrCb · Otsu's	61.9	60.0	78.7	61.3	61.9	77.5	49.1	44.5	61.9
hist HSV	12.9	11.6	69.4	11.6	08.6	73.4	23.7	20.2	61.0
hist LAB	43.1	43.7	71.1	38.3	37.5	71.3	47.0	43.3	58.8
hist YCrCb	41.6	41.7	68.3	33.1	32.0	63.2	46.5	42.9	59.7
hist HCrCb	59.6	72.1	80.4	60.7	67.9	73.2	42.5	49.3	53.1
hist HCrCb · RGB	58.0	70.7	80.4	59.8	67.3	73.2	39.6	46.7	53.7
hist HCrCb · HS	54.6	65.9	80.0	53.5	59.9	73.2	39.7	46.8	55.7
hist HCrCb · CrCb	57.4	69.6	79.7	58.9	66.3	73.7	40.7	47.2	55.1
hist HCrCb · Otsu's	65.9	63.1	78.7	65.1	66.1	77.5	58.7	52.1	63.4

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RGB · HS	06.5	69.7	76.8	06.9	48.8	50.1	11.8	44.6	46.5
RGB · CrCb	31.2	73.6	79.4	36.8	66.4	65.5	28.0	42.0	48.2
HS · CrCb	28.7	68.8	80.0	32.7	60.1	69.0	28.6	44.3	51.6
RGB · Otsu's	69.8	66.5	79.7	70.6	70.3	79.0	47.9	44.6	53.2
HS · Otsu's	66.7	63.1	79.0	63.9	64.4	77.3	54.5	48.1	60.0
CrCb · Otsu's	67.6	65.4	79.1	67.7	68.3	77.3	53.6	48.5	59.4
RGB · HS · CrCb	27.8	67.5	80.0	32.3	59.5	69.0	26.7	41.4	51.8
RGB · HS · CrCb · Otsu's	61.9	60.0	78.7	61.3	61.9	77.5	49.1	44.5	61.9
hist HSV	12.9	11.6	69.4	11.6	08.6	73.4	23.7	20.2	61.0
hist LAB	43.1	43.7	71.1	38.3	37.5	71.3	47.0	43.3	58.8
hist YCrCb	41.6	41.7	68.3	33.1	32.0	63.2	46.5	42.9	59.7
hist HCrCb	59.6	72.1	80.4	60.7	67.9	73.2	42.5	49.3	53.1
hist HCrCb · RGB	58.0	70.7	80.4	59.8	67.3	73.2	39.6	46.7	53.7
hist HCrCb · HS	54.6	65.9	80.0	53.5	59.9	73.2	39.7	46.8	55.7
hist HCrCb · CrCb	57.4	69.6	79.7	58.9	66.3	73.7	40.7	47.2	55.1
hist HCrCb · Otsu's	65.9	63.1	78.7	65.1	66.1	77.5	58.7	52.1	63.4

thresholding method	**THU_READ_RGBD** (158 images)			**THU_READ_RGBD_BODIES** (35 images)			**joint-ep-thu-ego** (103 images)		
	mIoU (%) @ method	mIoU (%) @ clean up	mIoU (%) @ grabcut	mIoU (%) @ method	mIoU (%) @ clean up	mIoU (%) @ grabcut	mIoU (%) @ method	mIoU (%) @ clean up	mIoU (%) @ grabcut
baseline		81.7			49.0			40.3	
ROI mask	07.4	07.4	79.4	06.3	06.3	77.2	09.1	09.1	61.4
RGB	07.4	74.5	75.9	08.3	45.5	45.8	11.0	31.4	32.8
HS	06.7	71.0	76.7	07.0	48.9	49.7	12.7	48.1	46.4
CrCb	32.1	74.8	79.0	37.2	66.9	65.4	29.8	44.5	48.1
Otsu's	71.8	67.8	79.4	71.2	70.3	77.9	47.8	45.0	50.5
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HS · Otsu's	66.7	63.1	79.0	63.9	64.4	77.3	54.5	48.1	60.0
CrCb · Otsu's	67.6	65.4	79.1	67.7	68.3	77.3	53.6	48.5	59.4
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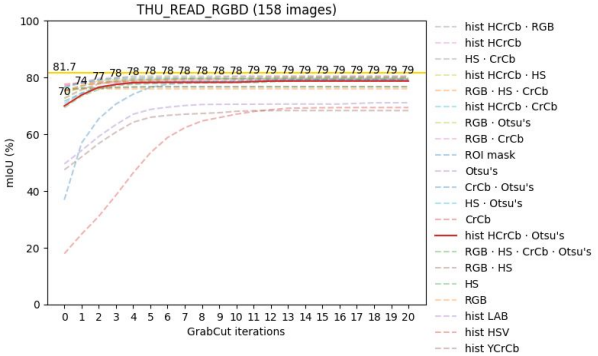
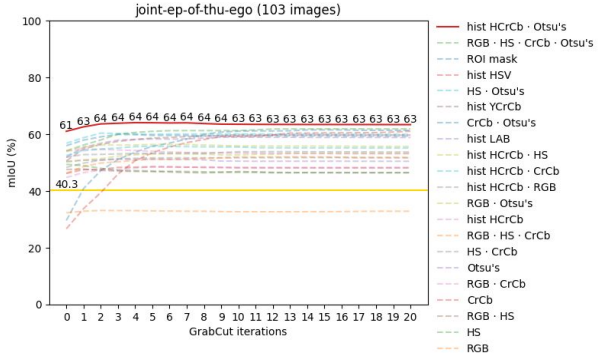
hist HCrCb · Otsu's	65.9	63.1	78.7	65.1	66.1	77.5	58.7	52.1	63.4

GrabCut iterations





Mask R-CNN epochs

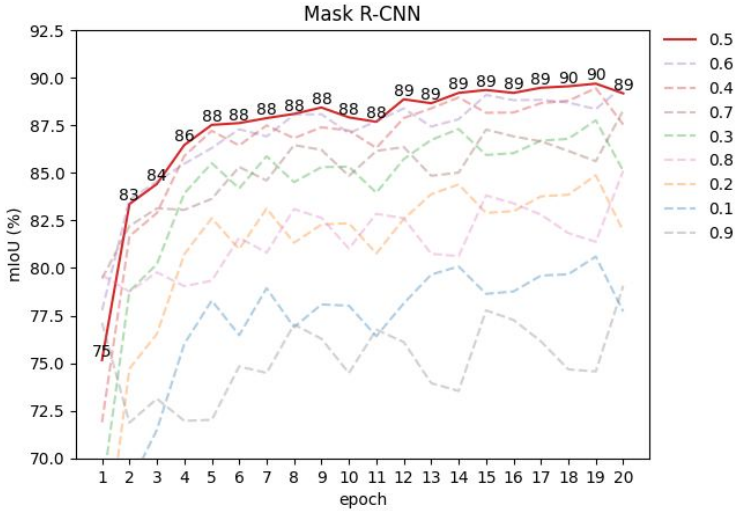
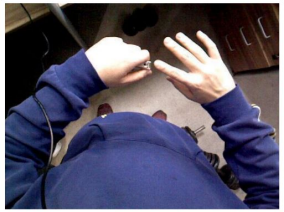
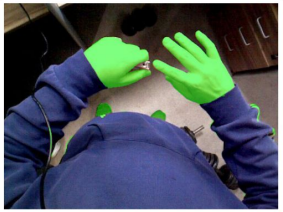
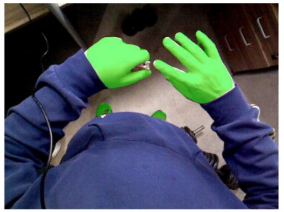
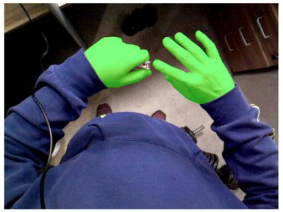
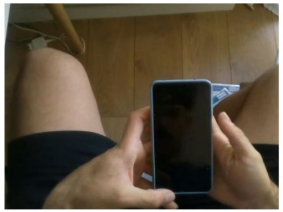
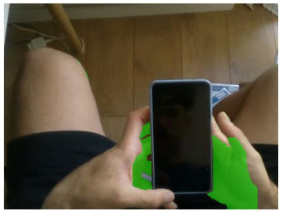
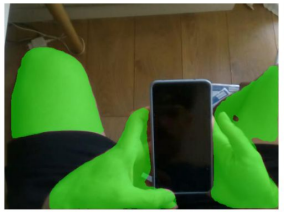
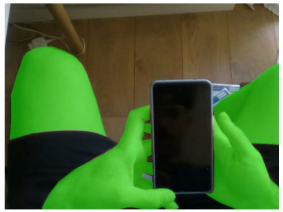


Image	hist HCrCb · Otsu's	Mask R-CNN	Label
			
			
			
			

Conclusion

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  - 80% skin = body

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- Mask R-CNN results put into question

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Future Work

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- less restrictive between mask and border
- if skin doesn’t touch border, k-means (k=2)
- additional, different clean up step after GrabCut
- investigate using semantic segmentation models
- more / higher quality datasets
- generate initial background mask through other means (no labels)

Thank you for listening!