Large-Scale Segmentation and Matching of Unique Image Features of Human Trafficking Victims

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Overview

Goal: *Segmentation* and *Matching* of unique features on online prostitution ads to help law enforcement in human trafficking investigations

Motivation:

Tattoo Clustering

Identifying Brands of Traffickers

Identifying Individuals

Identifying a person that shows up in multiple ads

Overview

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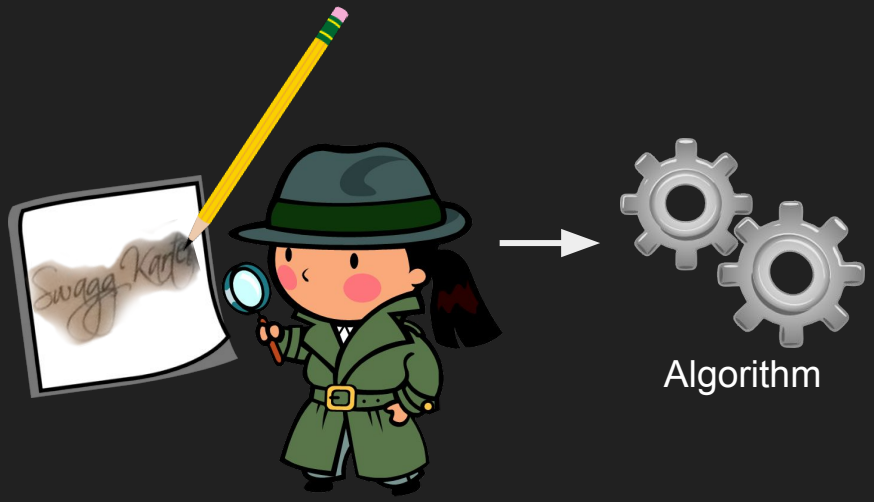
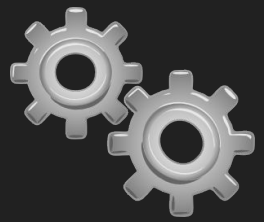


Algorithm

Overview



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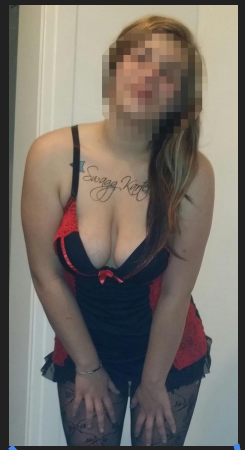

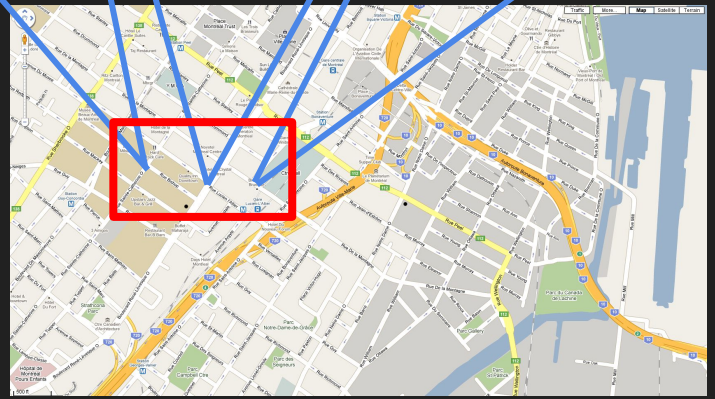

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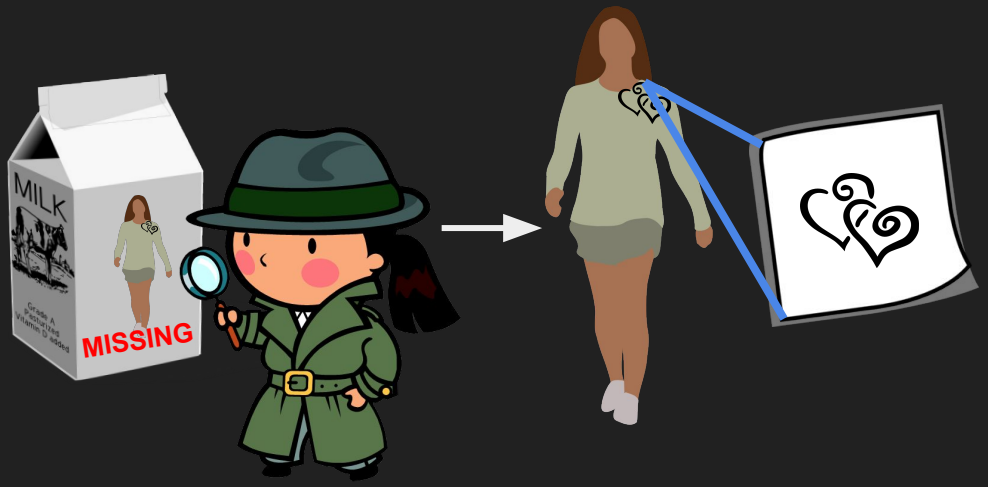

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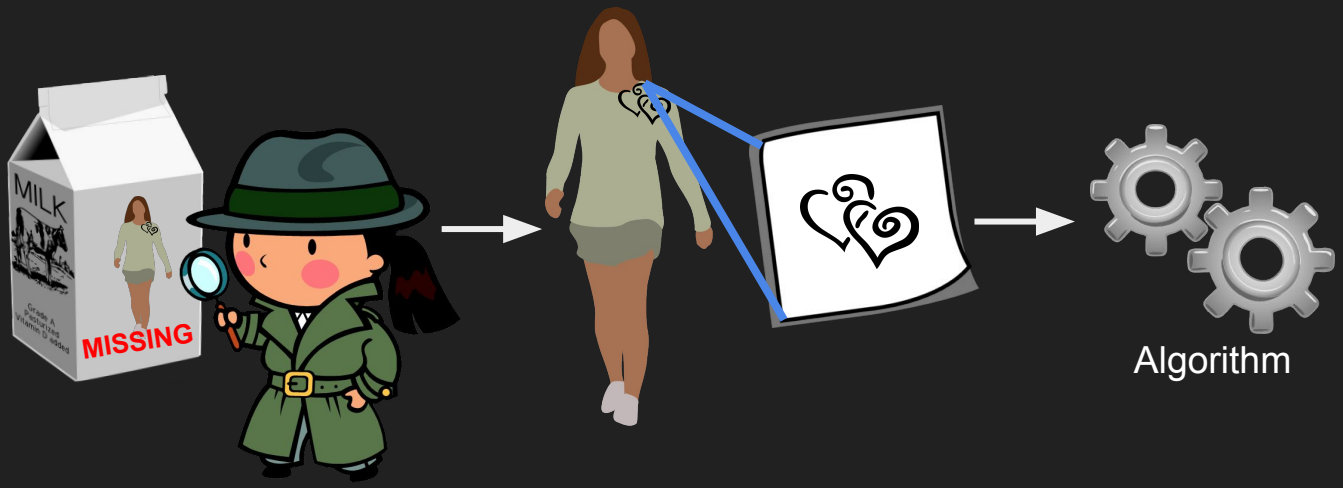

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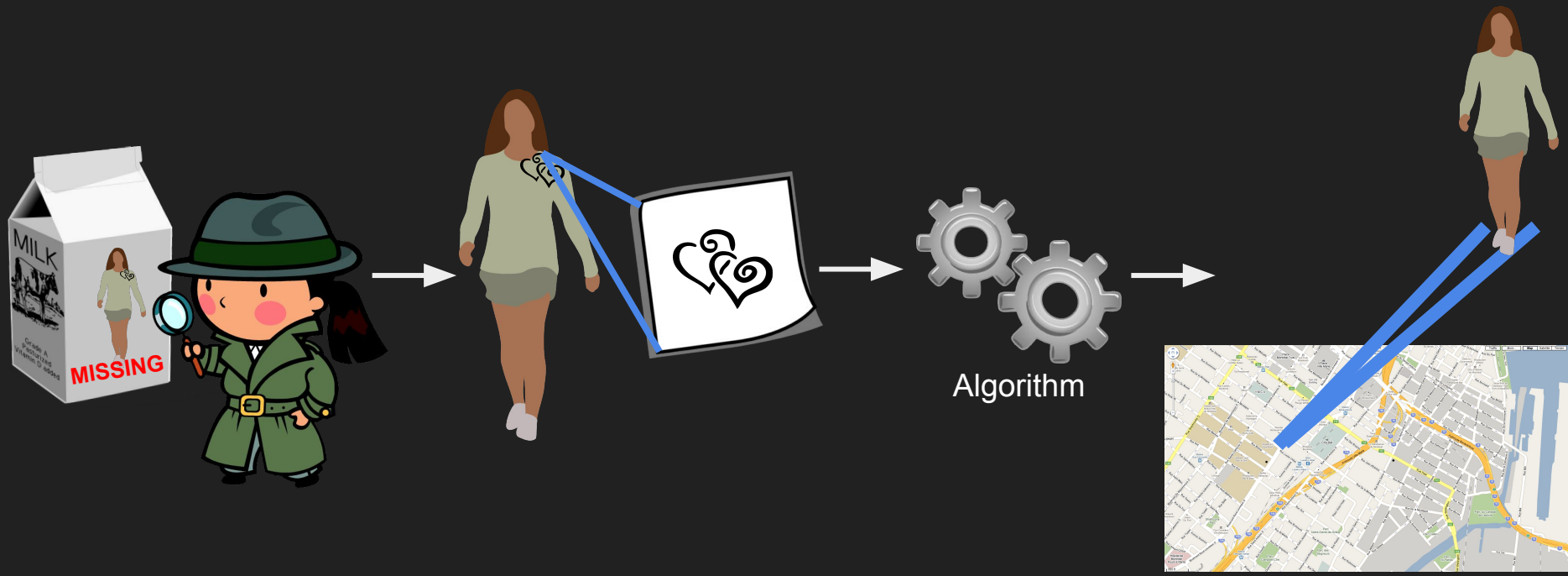

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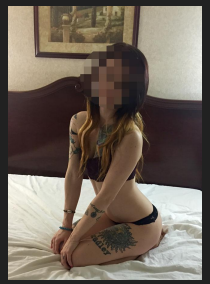
Goal: *Segmentation* and *Matching* of unique features on online prostitution ads to help law enforcement in human trafficking investigations

Pipeline:

Image



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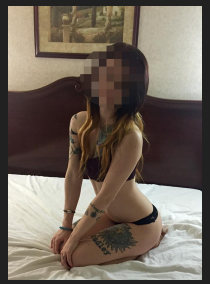
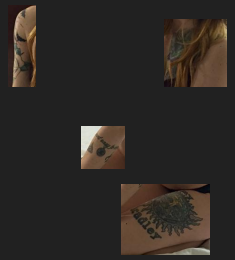


Segmentation



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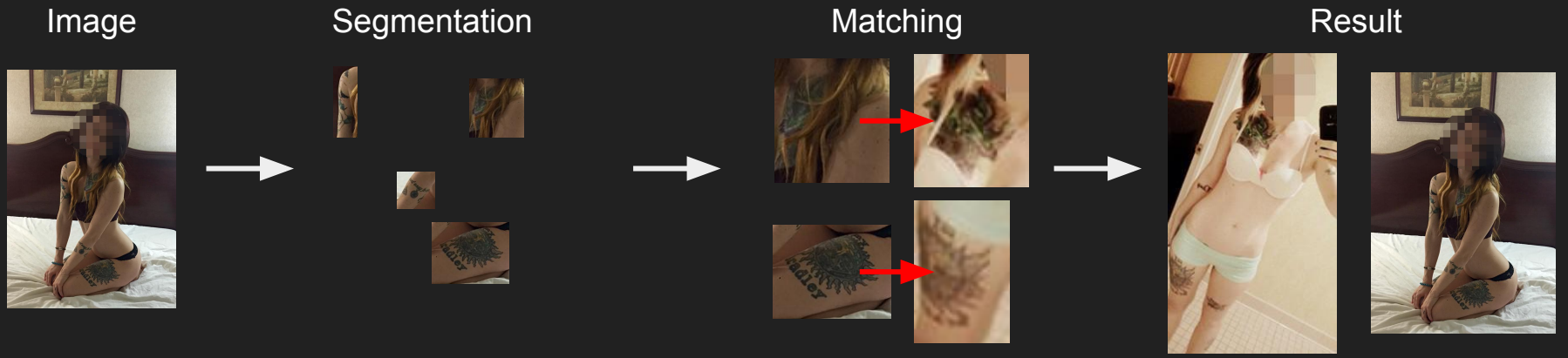
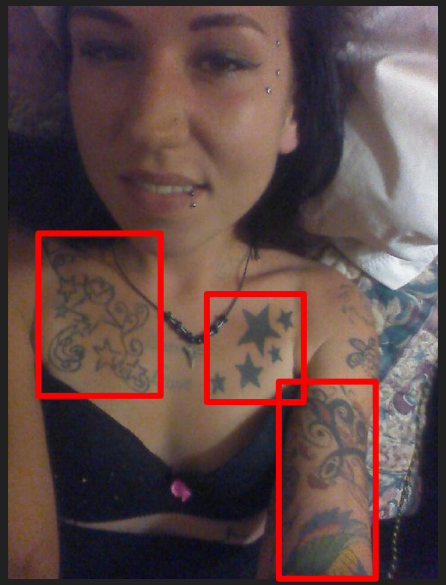
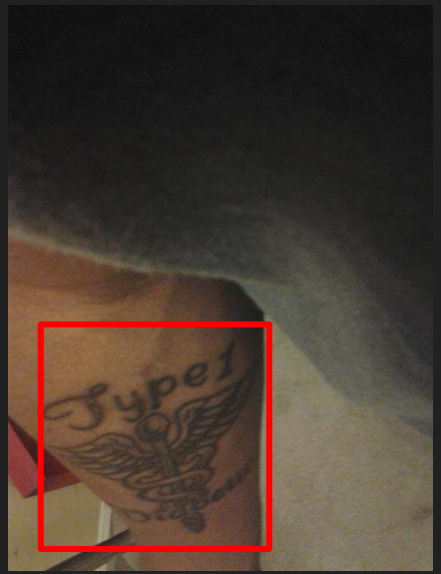


Segmentation: Dataset

Dataset: Subset of MEMEX DeepDive Data Set (which contains 214K+ images total) - 100 Images, 85 with tattoos



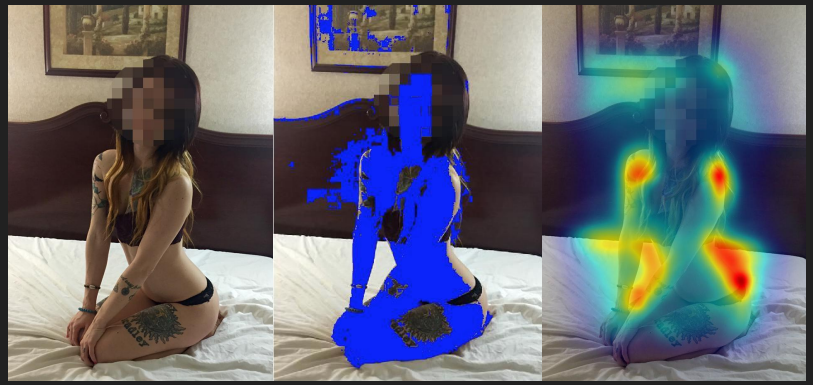


Human Annotated Bounding Boxes

Segmentation: First Approaches

GBVS (Graph-Based Visual Saliency) + Grabcut, YCbCr Skin Color Space

Successful Pipeline



Original Image YCbCr GBVS + Grabcut

Failed Pipeline

Original Image YCbCr

Segmentation: Structured, Dense Edges Represent Tattoos

Insight: A tattoo is a structured, dense set of edges regardless of the factors such as pose, skin color, or lighting

Original Image

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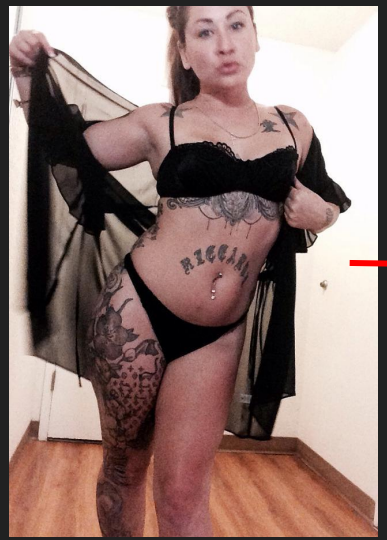

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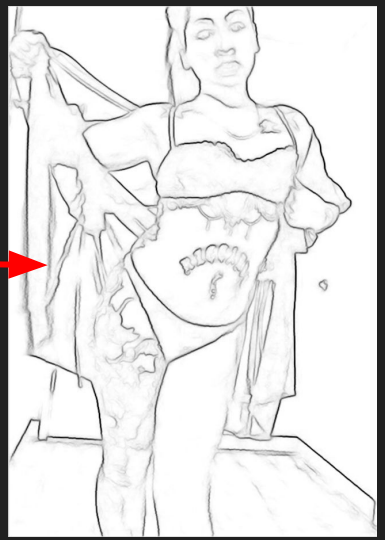
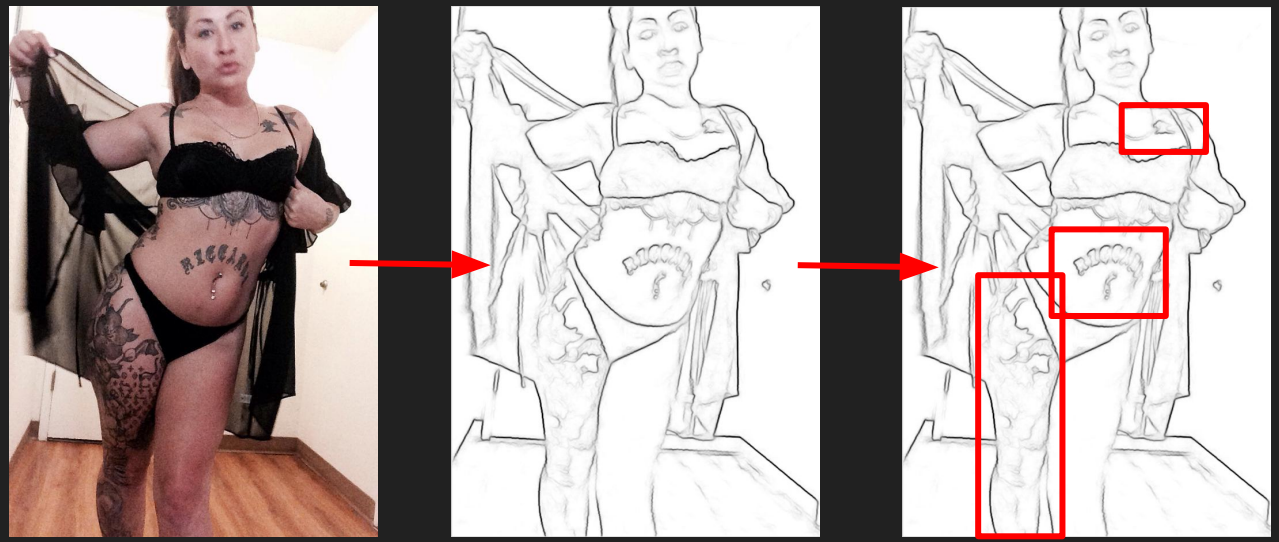


Fast Edge Detection
Using Random Forests
Trained on BSDS500

Segmentation: Structured, Dense Edges Represent Tattoos

Insight: A tattoo is a structured, dense set of edges regardless of the factors such as pose, skin color, or lighting



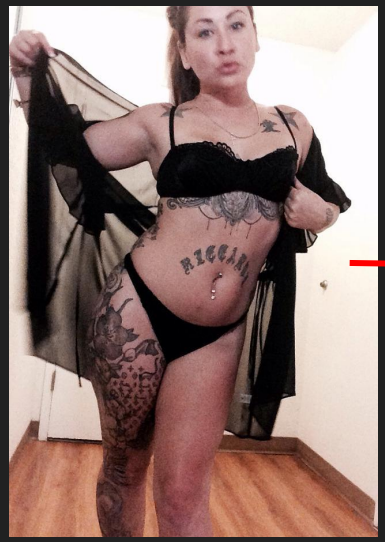
Original Image

Fast Edge Detection Using Random Forests Trained on BSDS500

Detection of Structured, Dense Edges

Segmentation: Structured, Dense Edges Represent Tattoos

Insight: A tattoo is a structured, dense set of edges regardless of the factors such as pose, skin color, or lighting



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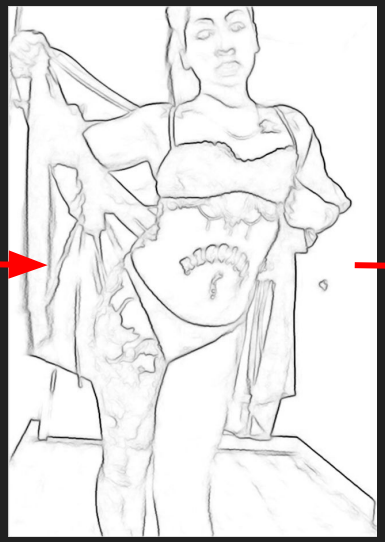
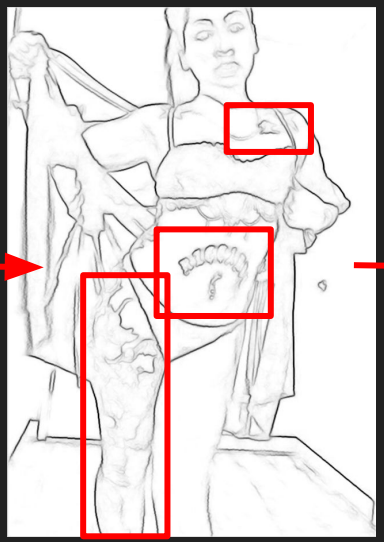


Fast Edge Detection Using Random Forests Trained on BSDS500



Detection of Structured, Dense Edges

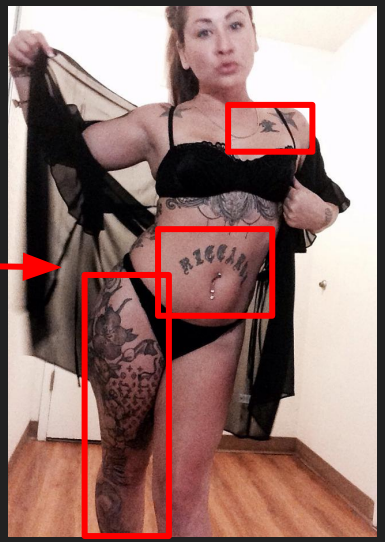


Image with Segmented Tattoos

Segmentation: Structured, Dense Edges Represent Tattoos

Algorithm Details:

- Input Image *i*
- Run Random Forest Fast Edge Detector on *i*
- Generate *n* bounding boxes using a sliding window
- Score each bounding box:

Score = contours within the box - contours touching the box boundary

- The top *k* scoring boxes are used for tattoo matching

Why do we need to crop out tattoos?

- Tattoos we're matching to may be cropped
- Want image matching to focus on the tattoo
- Later: how well do the tattoos need to be cropped?

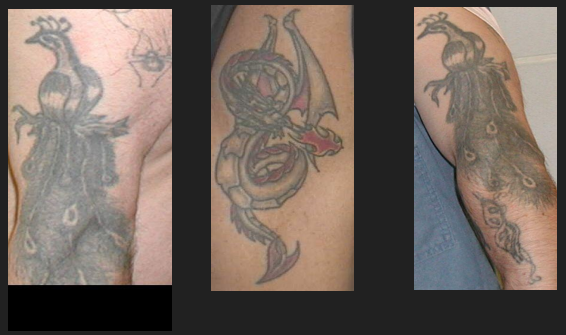
Matching: First Approaches

Dataset: 157 probes, 215 gallery images; mostly 1-to-1 matches

Nearest Neighbor

- 60% average recall at rank 20

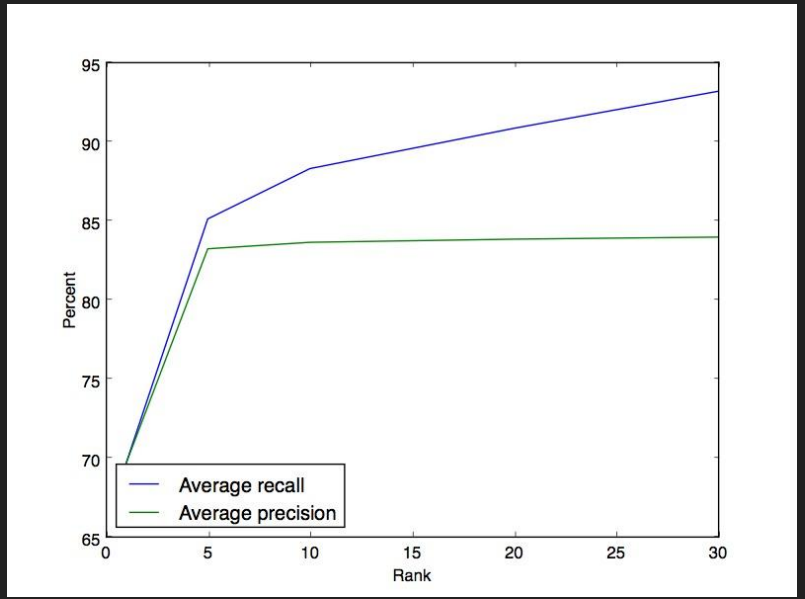
SIFT + Bag of Words



- 50% average recall at rank 20
- Could be good approach for similarity matching

Matching: SURF Nearest Neighbor

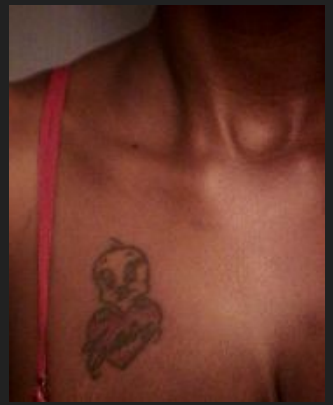
- Main difference from SIFT is speed
- Many more points of interest can be found and compared
- Rank 20
  - 91% average recall
  - 84% average precision
- Biggest problem: faded tattoos



Matching: SURF - how robust is it?

- Junk images: doubled gallery size with backgrounds, uncropped tattoo images, and faces
- No change in average precision or recall

Matching: SURF - how robust is it?



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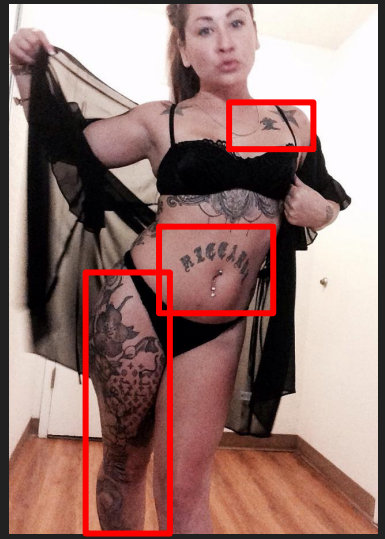

Segmentation

Fast Edge Detection

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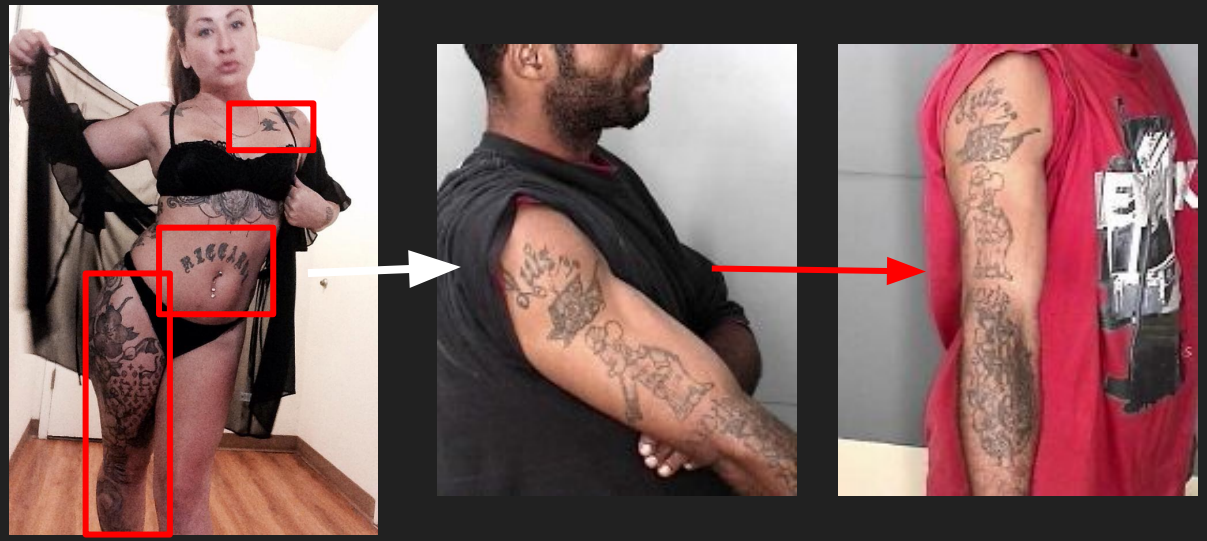

Segmentation
Fast Edge Detection

Matching
SURF, SIFT

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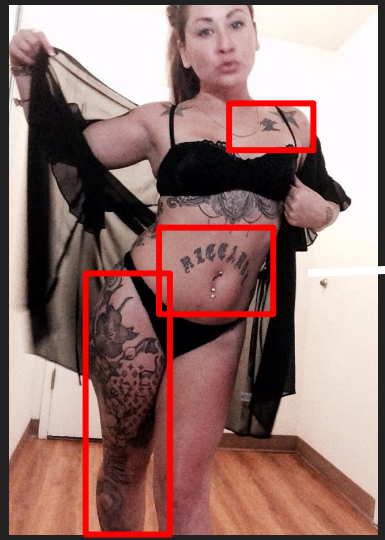

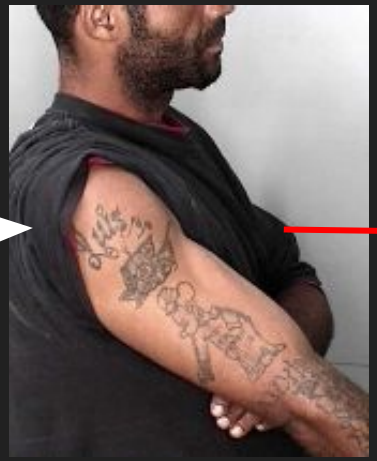

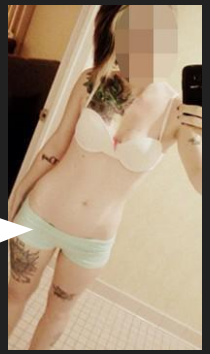

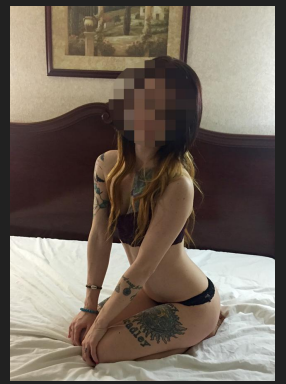

Segmentation
Fast Edge Detection

Matching
SURF, SIFT

Next Steps
Output Results

Next Steps

Question: Given an accurate system for identifying and matching tattoos, how do we rank similarity of individuals?

Future Research Questions:

- Using duplicate images to rank individual similarity
- Using multiple tattoo matches to rank individual similarity
- Using size and other factors to cull false positive tattoo segmentation