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Detecting and Classifying Scars, Marks, and Tattoos Found in the Wild

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Outline

- The Challenge
- Operational Constraints and Environment
- Prior Work
- Specific Contributions
- Facial SMT Detection and Refinement
- Generic Tattoo Segmentation
- Classification Approach
- Experiments and Results
- Questions

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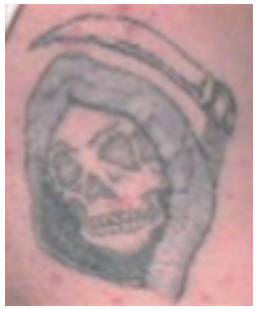
The Challenge



Constrained Imagery

- Controlled pose
- Controlled position
- Controlled lighting

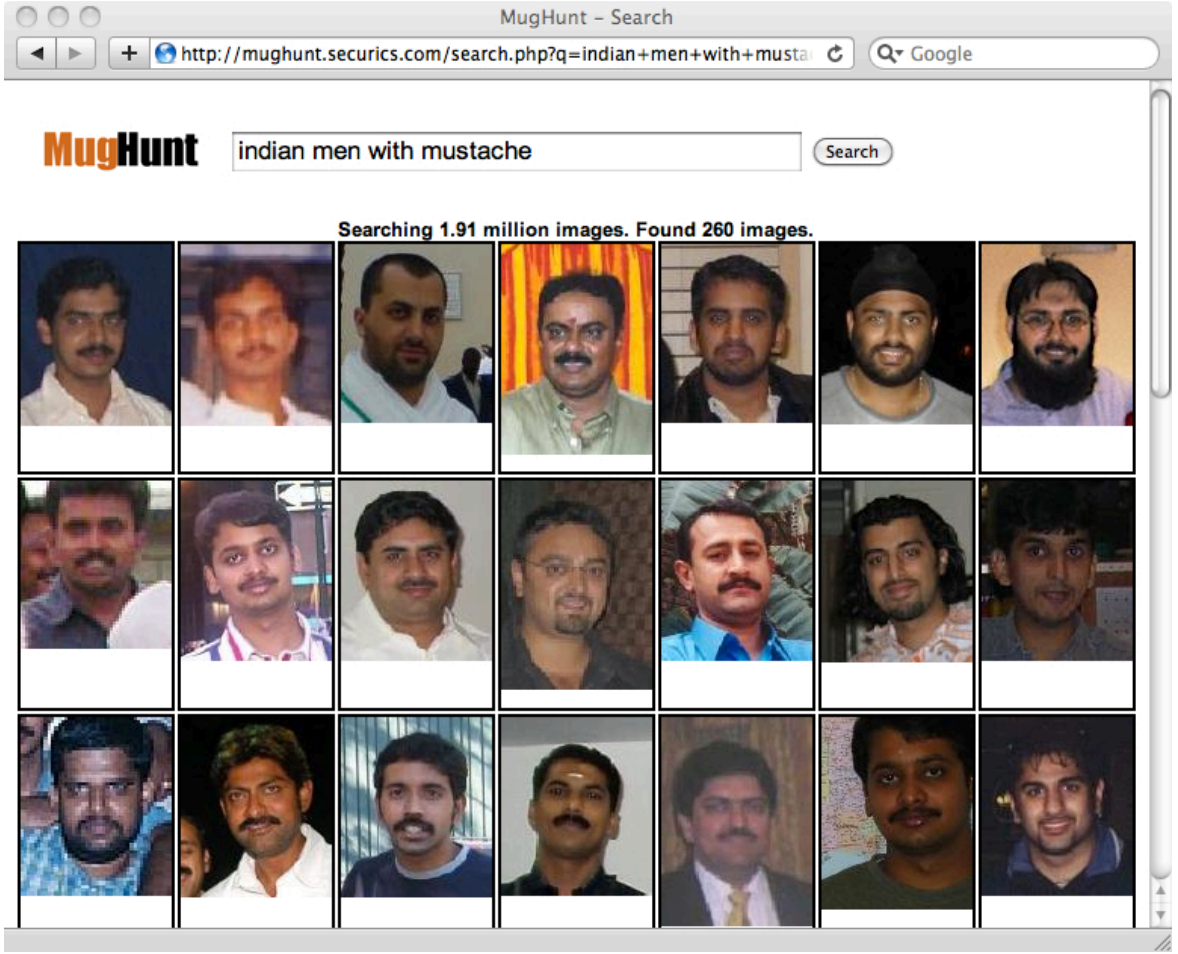
Unconstrained Imagery

- No control over subject
- Outdoors?
- Contains object of interest?

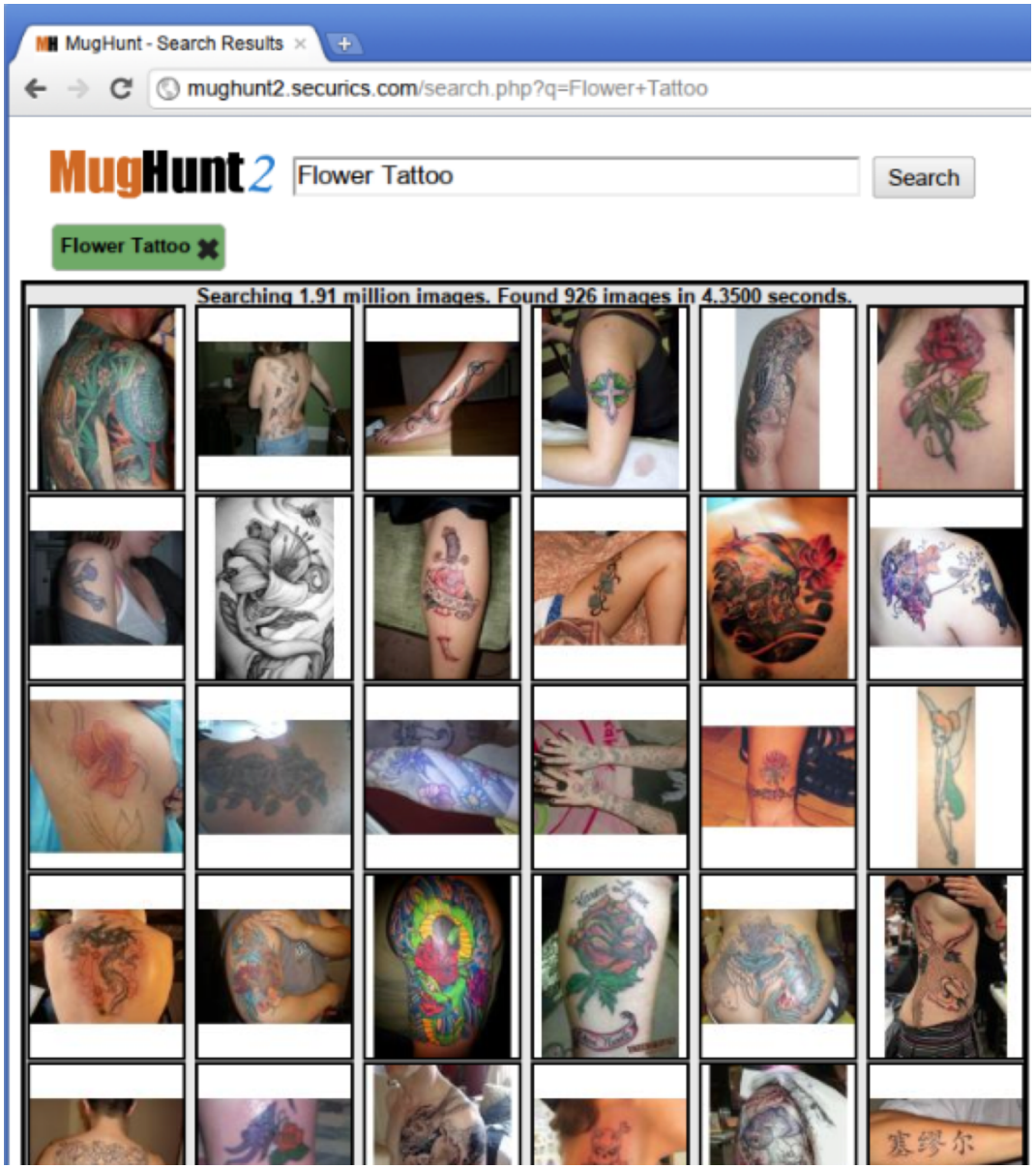
Operational Constraints and Environment

- New Component of the MugHunt Attribute Search Engine (65 Search Attributes)
- Presented at CVPR 2012

http://mughunt.securics.com



Operational Constraints and Environment



Prior Work Marks

- **Face Matching and Retrieval in Forensics Applications:** A. Jain, B. Klare, and U. Park. IEEE Multimedia, 19(1):20–28,January 2012.
- **Template Based Mole Detection for Face Recognition:** K. Ramesha, K. Raja, K. Venugopal, and L. Patnaik. International Journal of Computer Theory and Engineering, 2(5):1793–8201, October 2010.
- **Scars, Marks and Tattoos (SMT):** Soft Biometric for Suspect and Victim Identification. J.-E. Lee, A. Jain, and R. Jin. In Biometrics Symposium, September 2008.
- **A Reliable Skin Mole Localization Scheme:** T. Cho, W. Freeman, and H. Tsao. In IEEE MMBIA, October 2007.
- **Skin Detail Analysis for Face Recognition:** J.-S. Pierrard and T. Vetter. In IEEE CVPR, pages 1–8, 2007.

Prior Work Tattoos

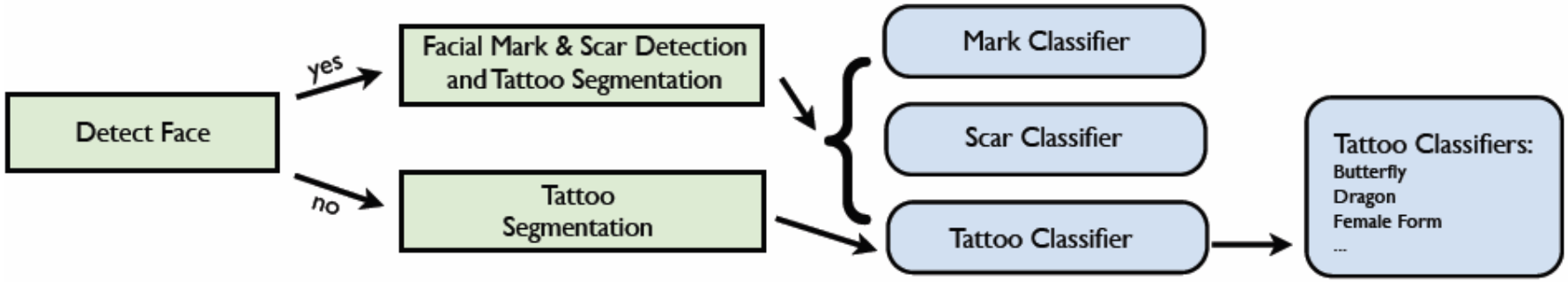
- **Image Retrieval in Forensics: Tattoo Image Database Application:** J.-E. Lee, R. Jin, A. Jain, and W. Tong. IEEE Multimedia, 19(1):2–11, January 2012.
- **Face Matching and Retrieval in Forensics Applications:** A. Jain, B. Klare, and U. Park. IEEE Multimedia, 19(1):20–28,January 2012.
- **Content-based Image Retrieval: an Application to Tattoo Images:** A. Jain, J.-E. Lee, R. Jin, and N. Gregg. In IEEE ICIP, November 2009.
- **Scars, Marks and Tattoos (SMT):** Soft Biometric for Suspect and Victim Identification. J.-E. Lee, A. Jain, and R. Jin. In Biometrics Symposium, September 2008.
- **Matching and Retrieval of Tattoo Images: Active Contour CBIR and Global Image Features:** S. Acton and A. Rossi. In IEEE SSIAI, March 2008.
- **Tattoo-ID: Automatic Tattoo Image Retrieval for Suspect and Victim Identification:** A. Jain, J.-E. Lee, and R. Jin. In PCM, December 2007.

Specific Contributions

1. Detection and Segmentation for Unconstrained Imagery

2. Open Set Classification

3. A Pipeline Methodology Integrating Scars, Marks, and Tattoos



Facial SMT Detection and Refinement

- Generate LoG Based Facial Mark Image
- Face Detection using Viola-Jones Face Detector
- Lighting Normalization using Self-Quotient Image (SQI) Algorithm
- Laplacian of Gaussian (LoG) Filter used at 2 scales
- Image Threshold using 6-Bin Histogram

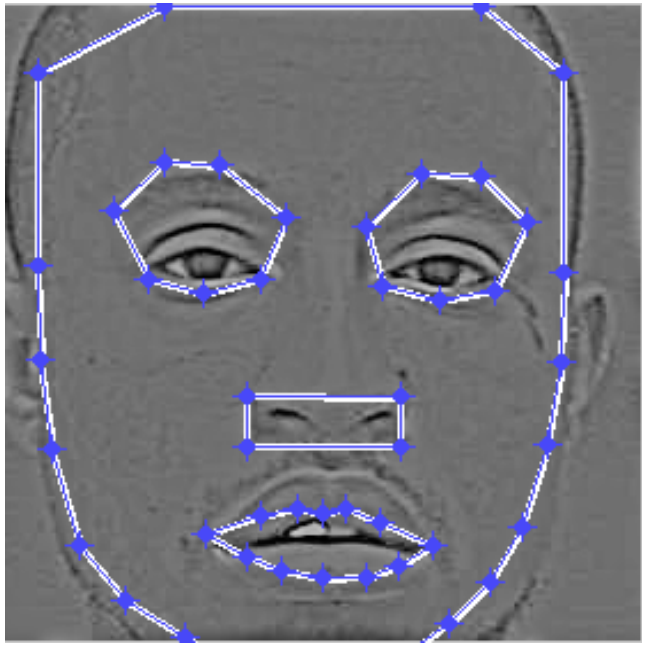
Original Image

Thresholded LoG Image

Facial Mark Detection and Refinement

- User Specific Mask Construction using Active Shape Model program (STASM)
- Delineate Primary Facial Structures: Eyes, Eyebrows, Nose, Mouth, Outline of Face, Hair

Original Image



Primary Facial Features Annotated Using ASM

Facial Mark Detection and Refinement

- Skin based User Specific Mask and Candidate Facial Mark Image
- Color SQI Lighting/Color Normalization
- Skin Map Thresholded using previously presented technique. Small structures are added back into facial mark candidate map. Large structures become part of user specific mask.

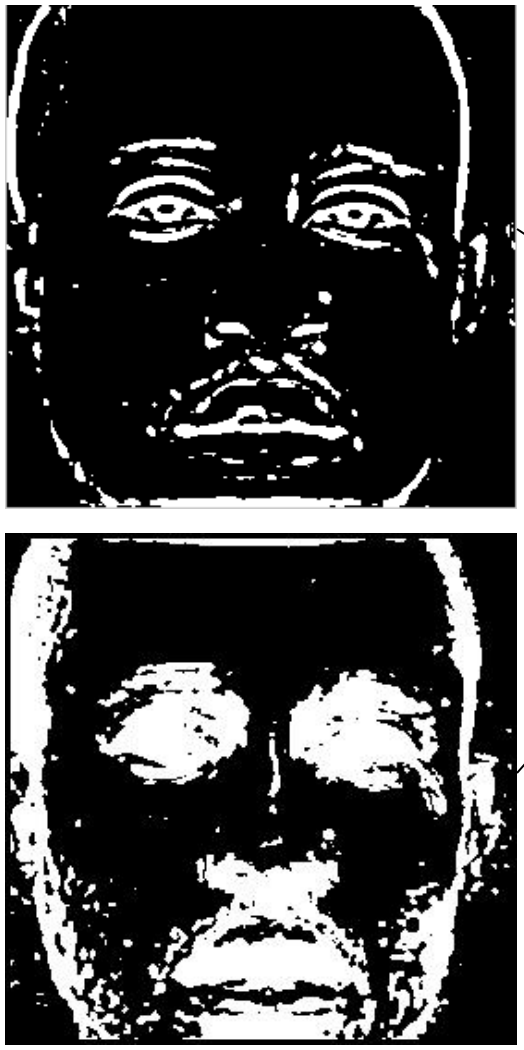
Lighting/Color Normalize Image

Skin Map

Skin Detection Mask

Facial Mark Detection and Refinement

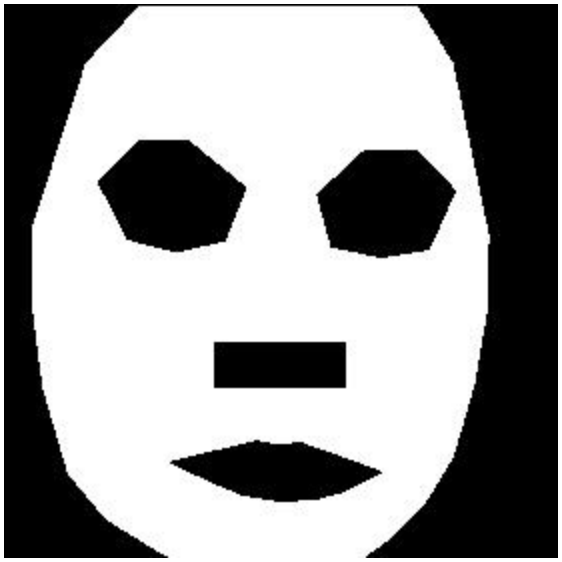
•Generate Final Candidate Facial Mark Image using LoG and Skin based Facial Mark Images



Final Candidate Facial Mark Image

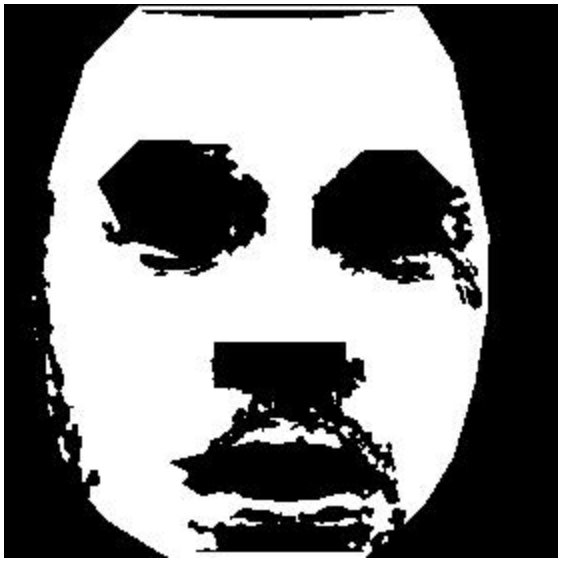
Facial Mark Detection and Refinement

- Generate User Specific Mask from ASM Mask and Skin Detection Mask



ASM Mask

Skin Detection Mask



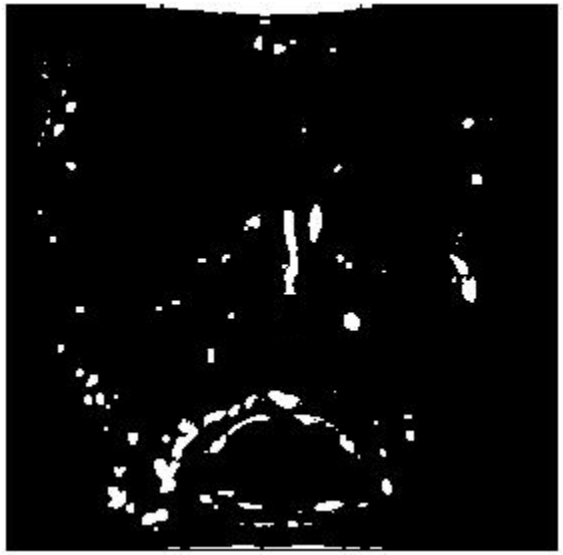
Combination Mask

Facial Mark Detection and Refinement

- Filter User Specific Mask from Final Candidate Facial Mark Image

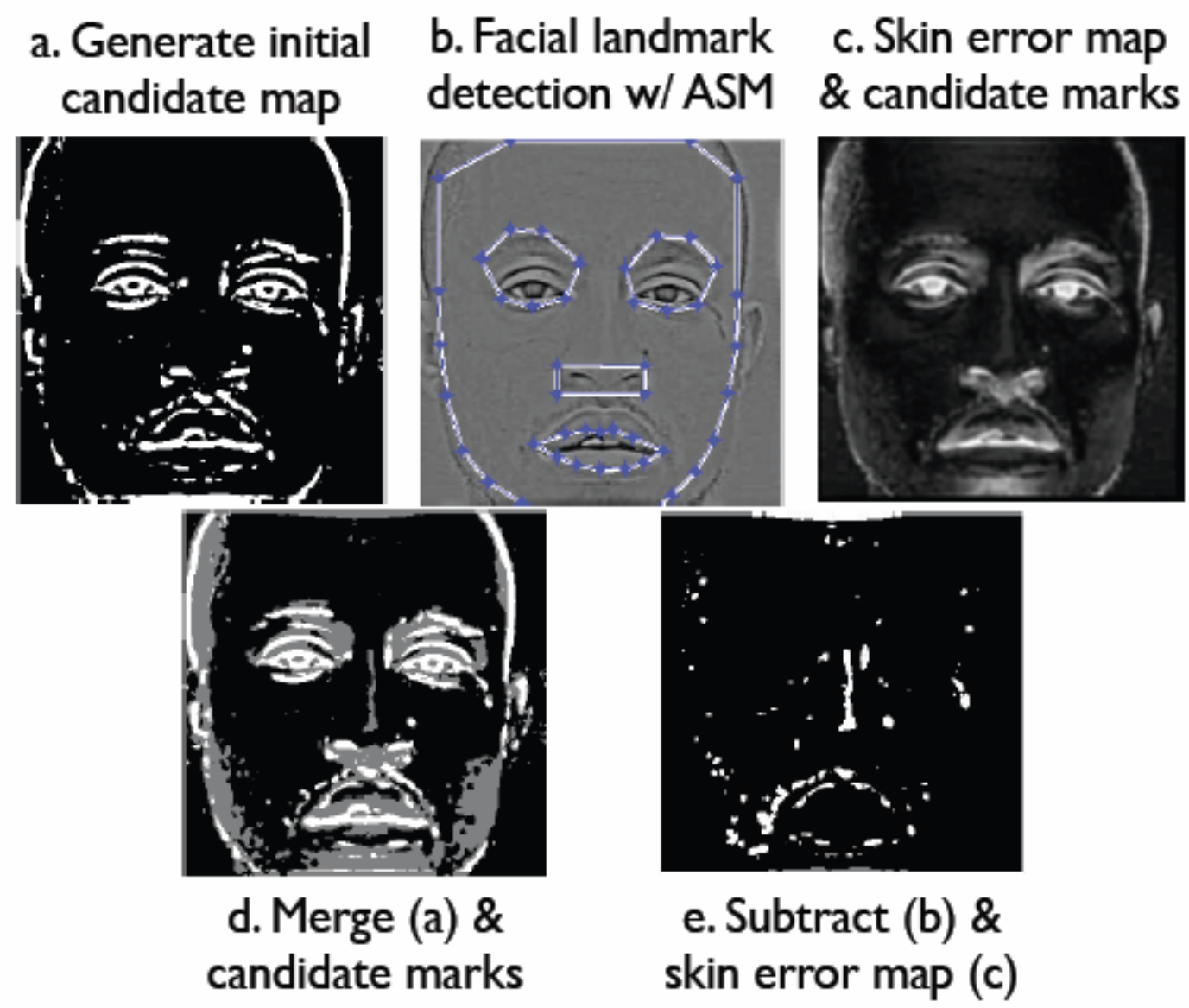
- Remaining Facial Marks Sent to SVM based Object Classifier

Final Candidate Facial Mark Image



Final Candidate Facial Mark Image After Filtering

Facial Mark Detection and Refinement Summary



General Tattoo Segmentation: Automatic GrabCut + Quasi Connected Components

Tattoo Segmentation: Graph Based Visual Saliency (GBVS)

J. Harel, C. Koch, P. Perona, “Graph-Based Visual Saliency”, Proceedings of Neural Informational Processing Systems (NIPS) 2006

Tattoo Segmentation: Graph Based Visual Saliency (GBVS)

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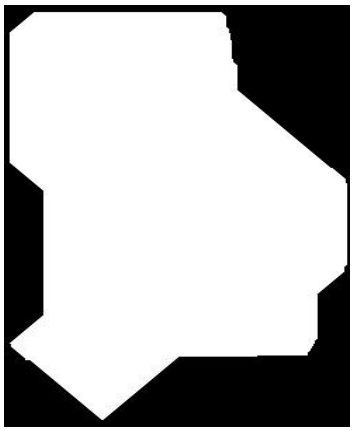
Tattoo Segmentation: GBVS Saliency

1. Segment Image using GBVS and GrabCut Algorithm

Segmentation Image



Segmentation Mask

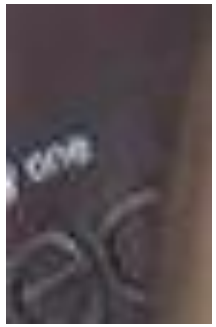
Tattoo Segmentation: Quasi-Connected Components (QCC)

2. Perform QCC on combined high/low threshold images

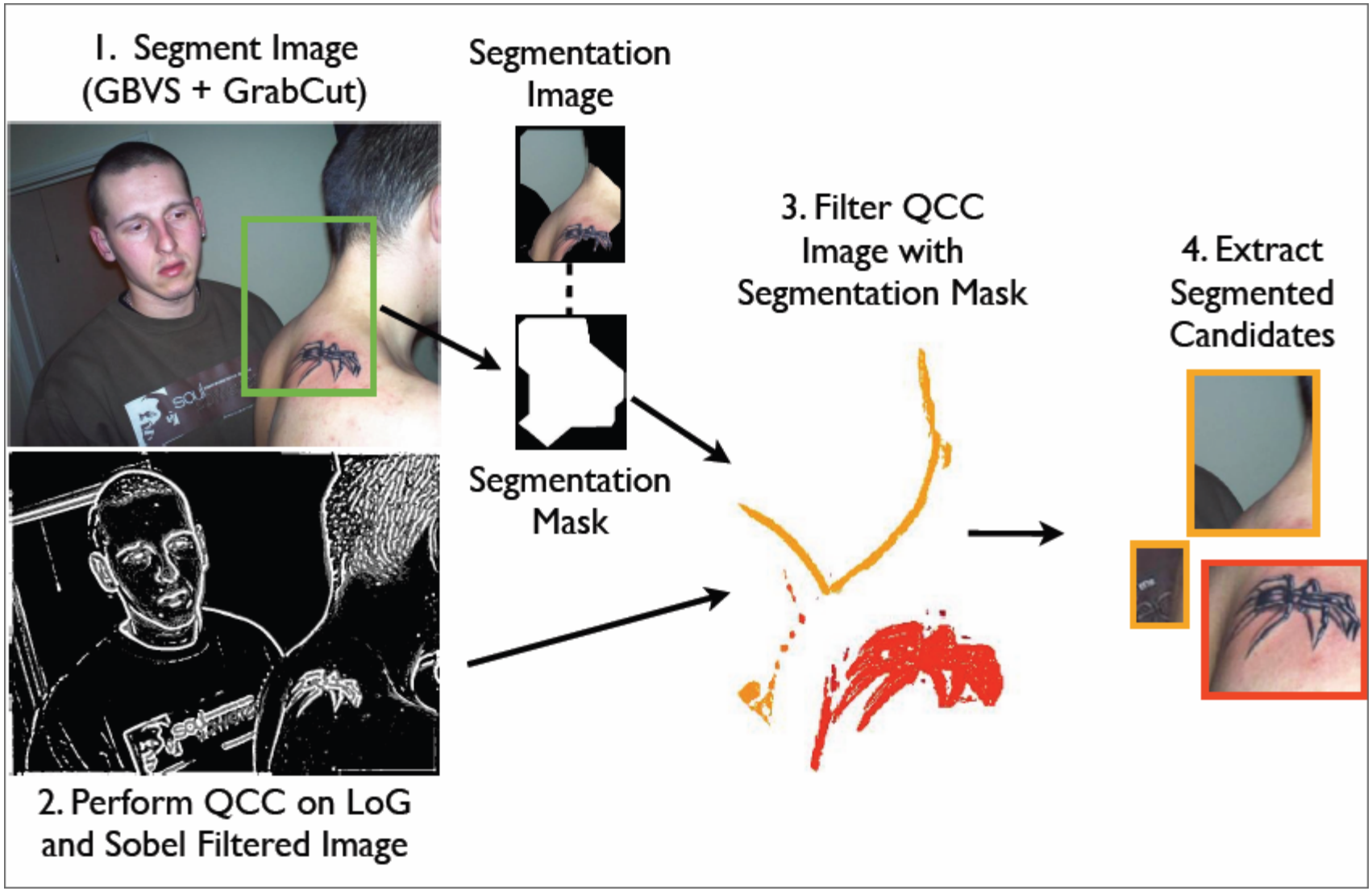
3. Filter QCC grouping image with Segmentation Mask and perform connected components

Tattoo Segmentation: Quasi-Connected Components (QCC)

4. Extract Segmented Tattoo Candidates



Tattoo Segmentation: Summary

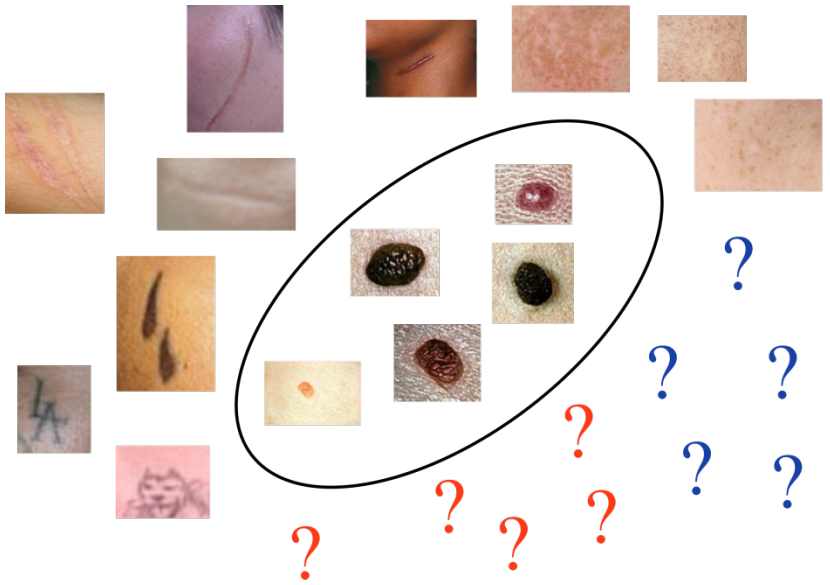


Open Set vs. Closed Set Recognition

- In traditional problems, we often consider a closed set, where all possible classes are known to the classification system.
- For the problem we consider here, we must assume that our candidates for recognition can be anything.

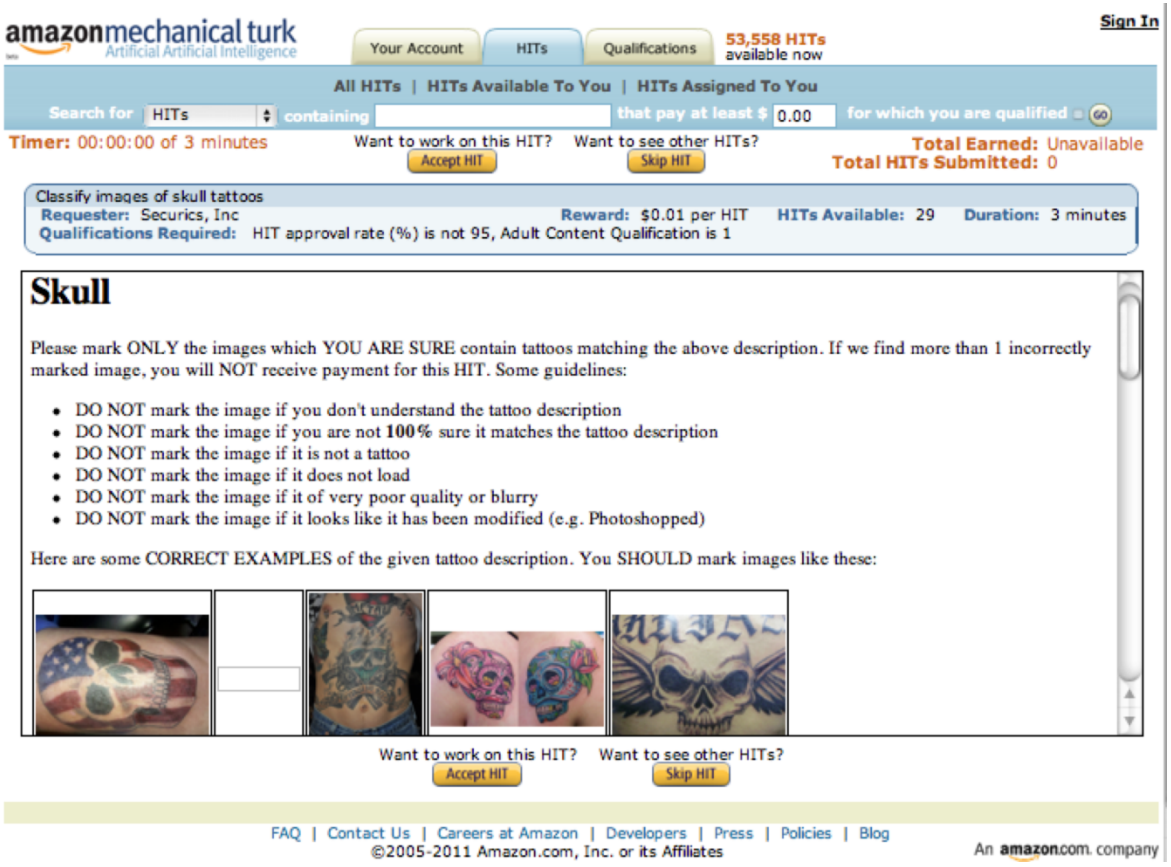
1-Class SVM Approach for Open Set Recognition

- Use a 1-Class SVM to build classifiers only for the objects of interest, i.e. moles, scars, tattoos and make a positive or negative determination with respect to them
- This approach can be thought of as outlier detection with respect to the objects that represent each class.



Ground Truth for Experimental Evaluation

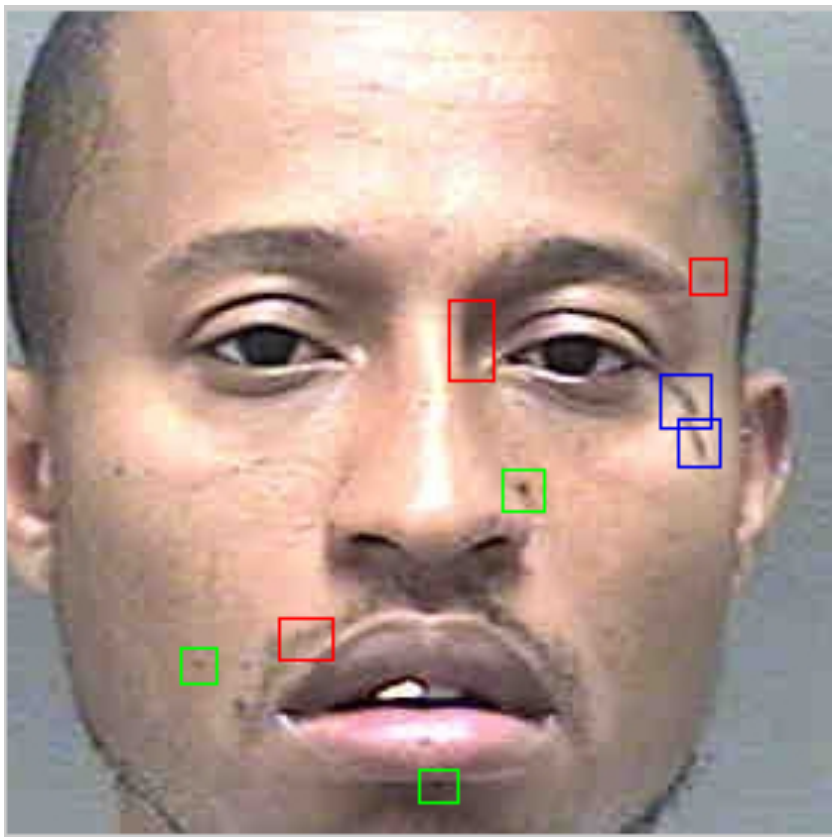
- Amazon's Mechanical Turk Service Used to generate ground truth labels for training and evaluation.
- 19,000 Images Evaluated by Mechanical Turk Workers



Experiments and Results

Application of Open Set Recognition model to Facial Marks and Tattoos

Qualitative Results

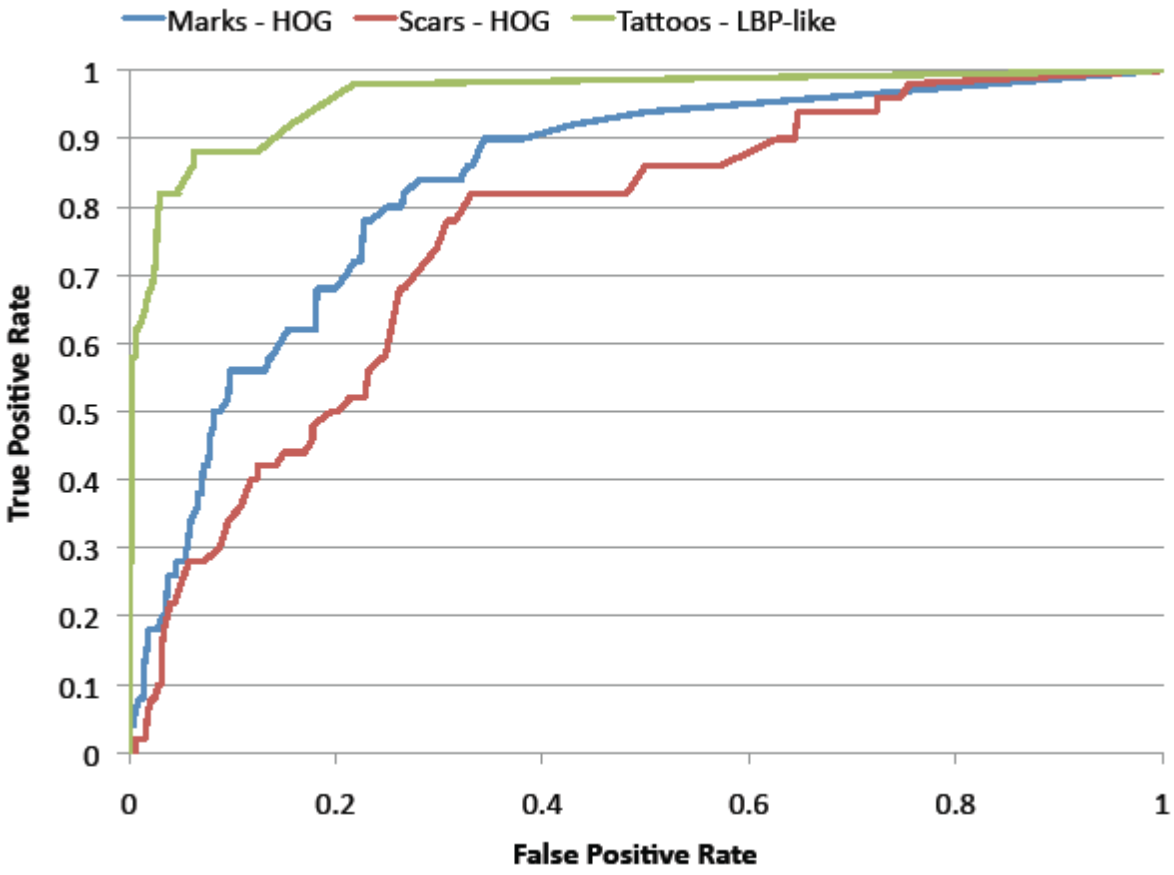


Facial SMT Classification
Green: Positive Moles
Blue: Positive Tattoo
Red: Negatives

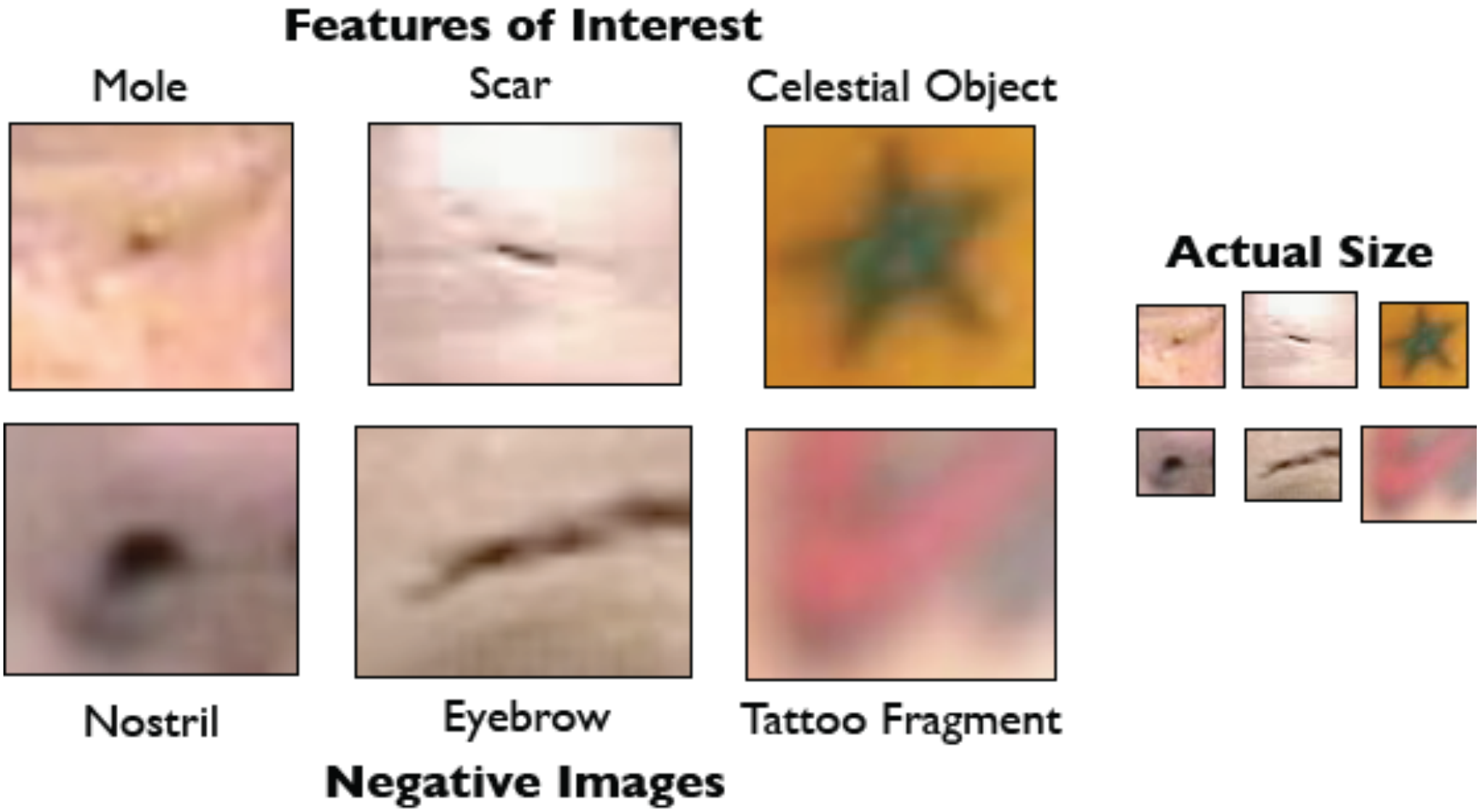
Experimental Evaluation

Facial SMT (Moles and Scars) and Generic Tattoo Classifier

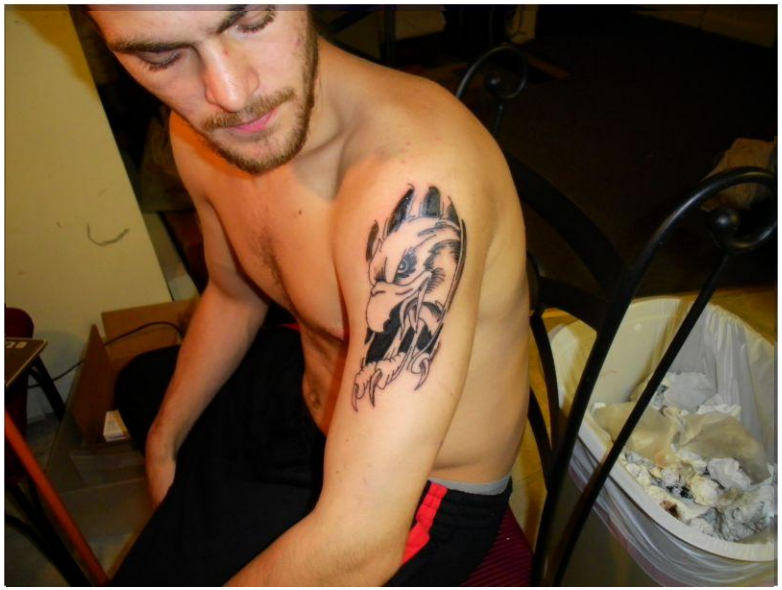
- 150 Images for Training
- 50 Positive Testing Samples
- 500 Negative Testing Samples



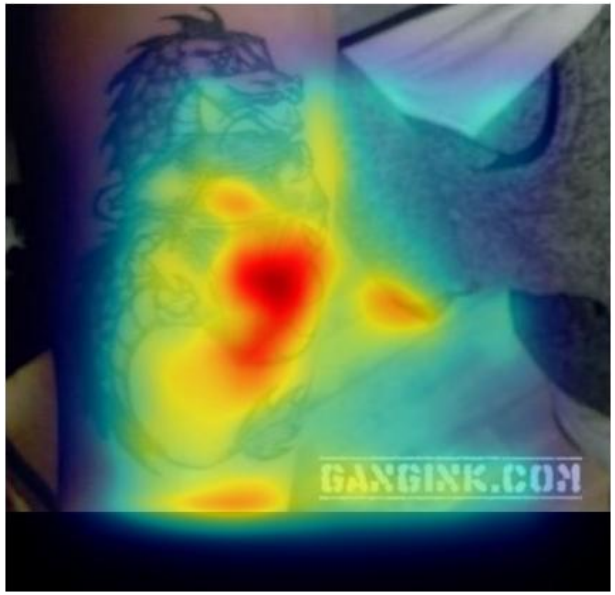
Experimental Evaluation



Qualitative Results: Tattoo Detection



Qualitative Results: Tattoo Detection



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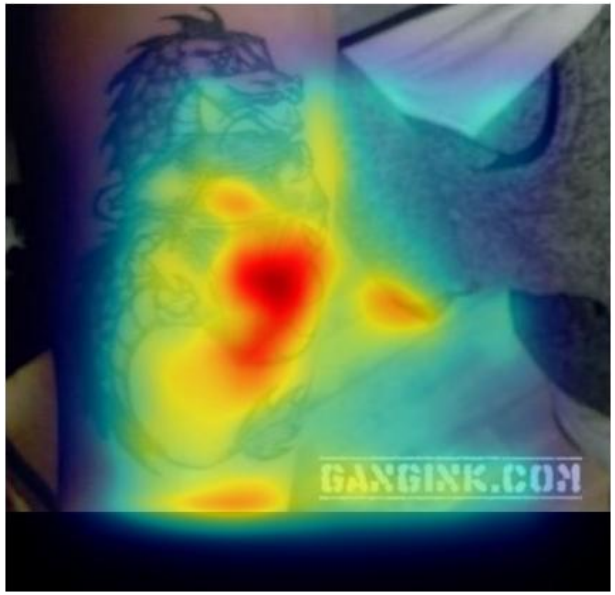
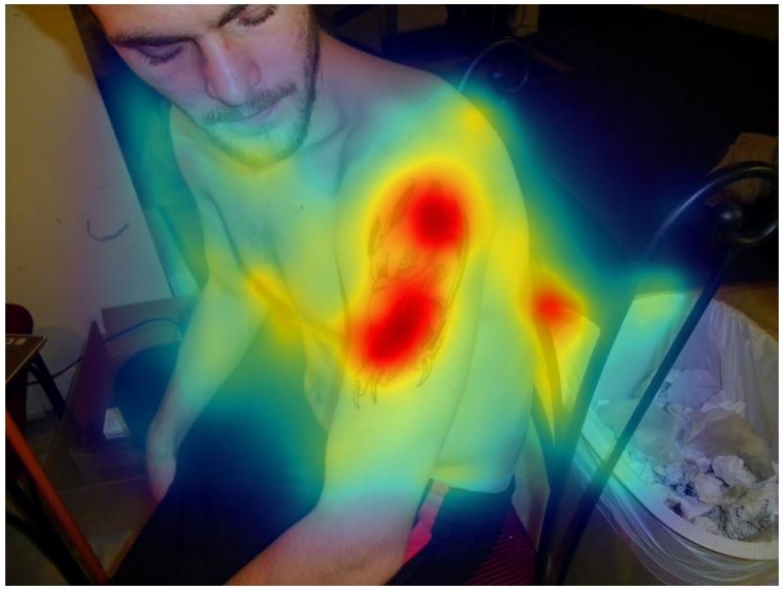
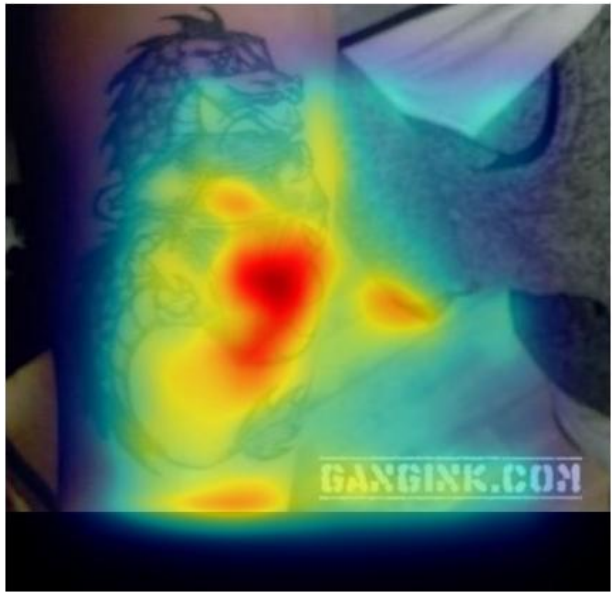
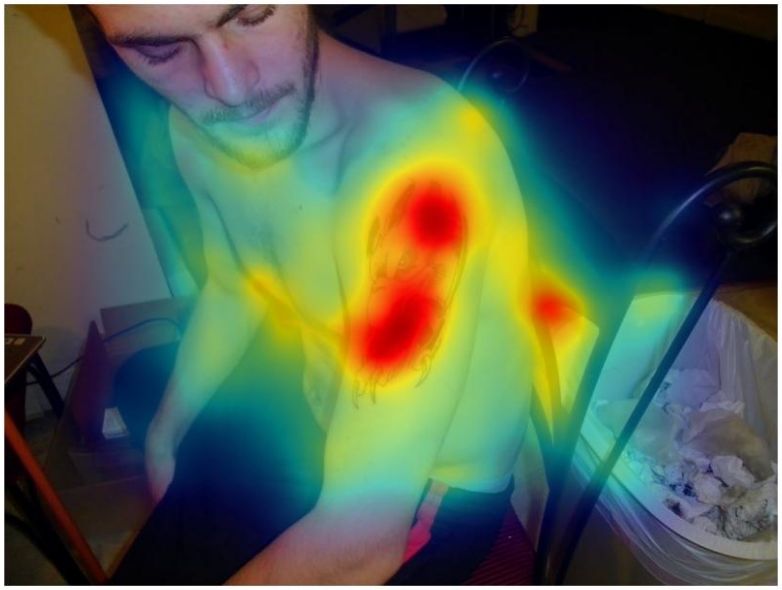
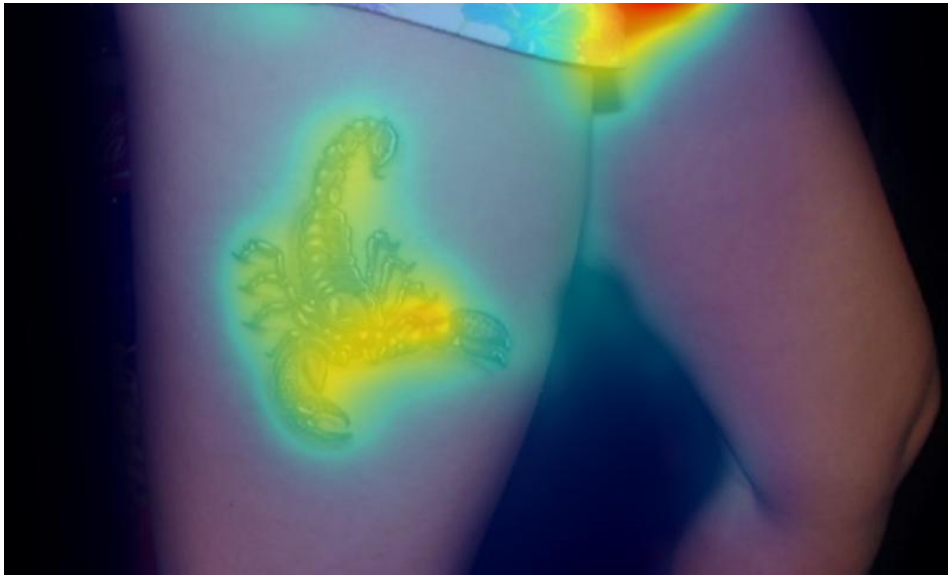




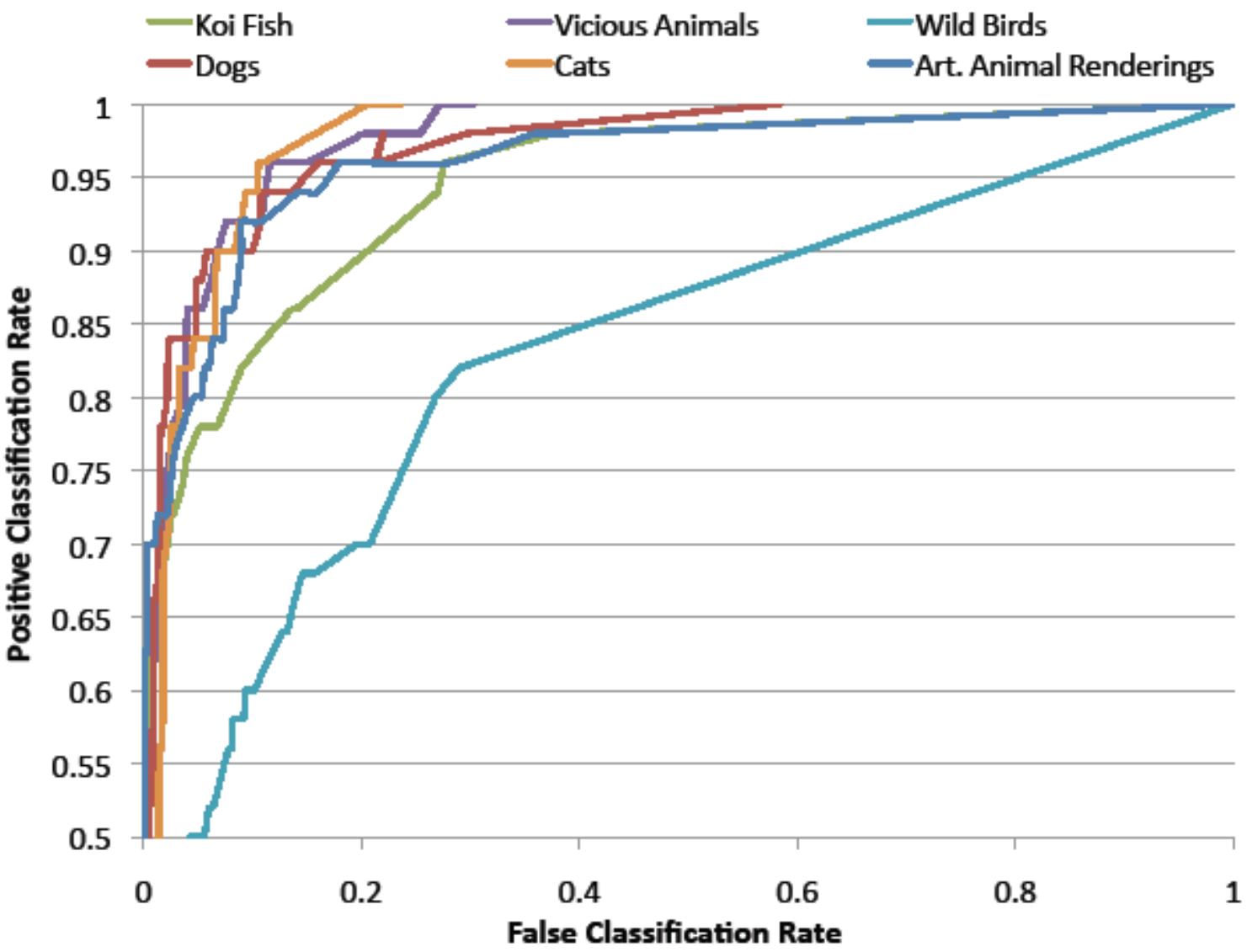
Qualitative Results: Tattoo Detection



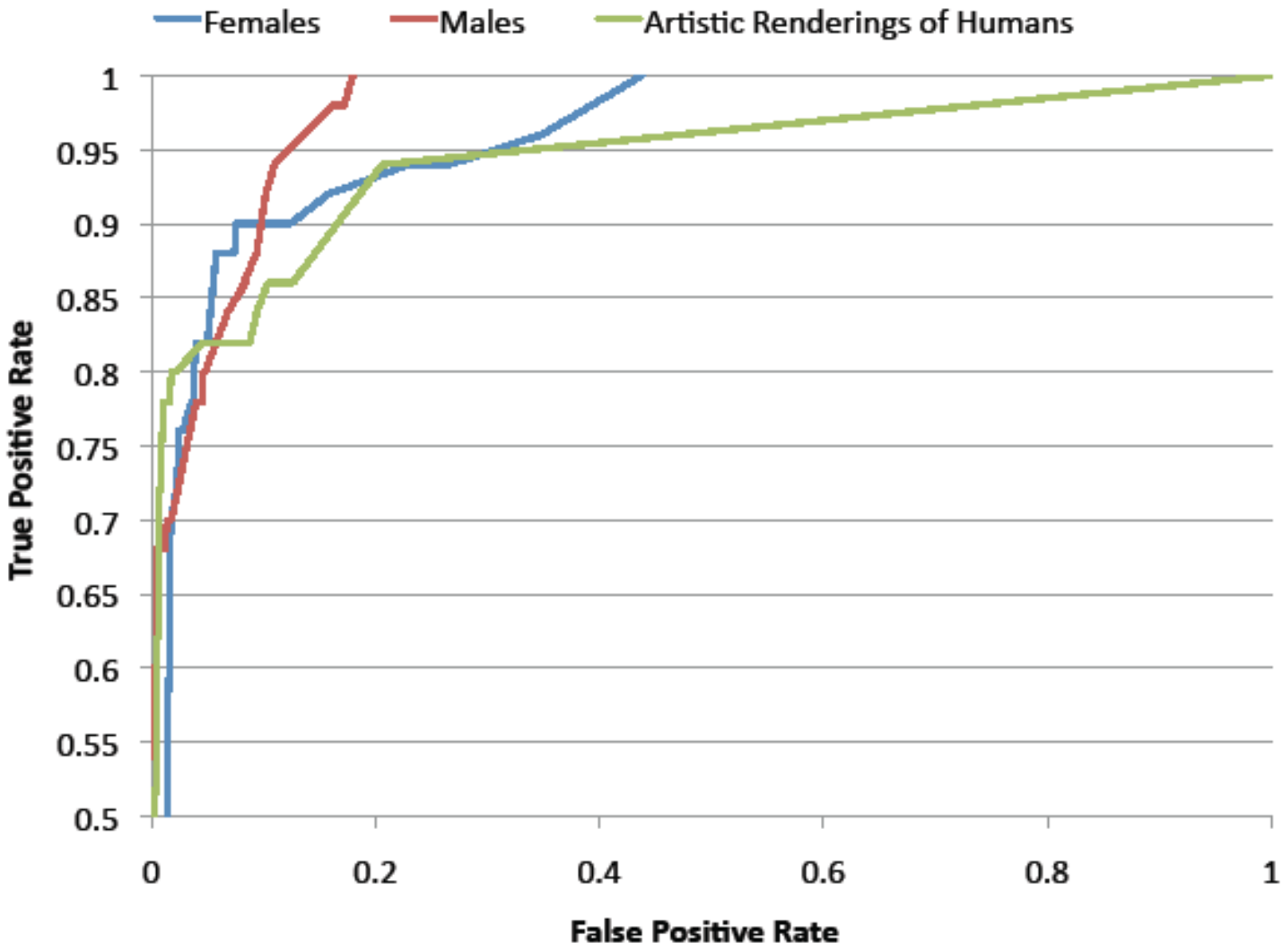




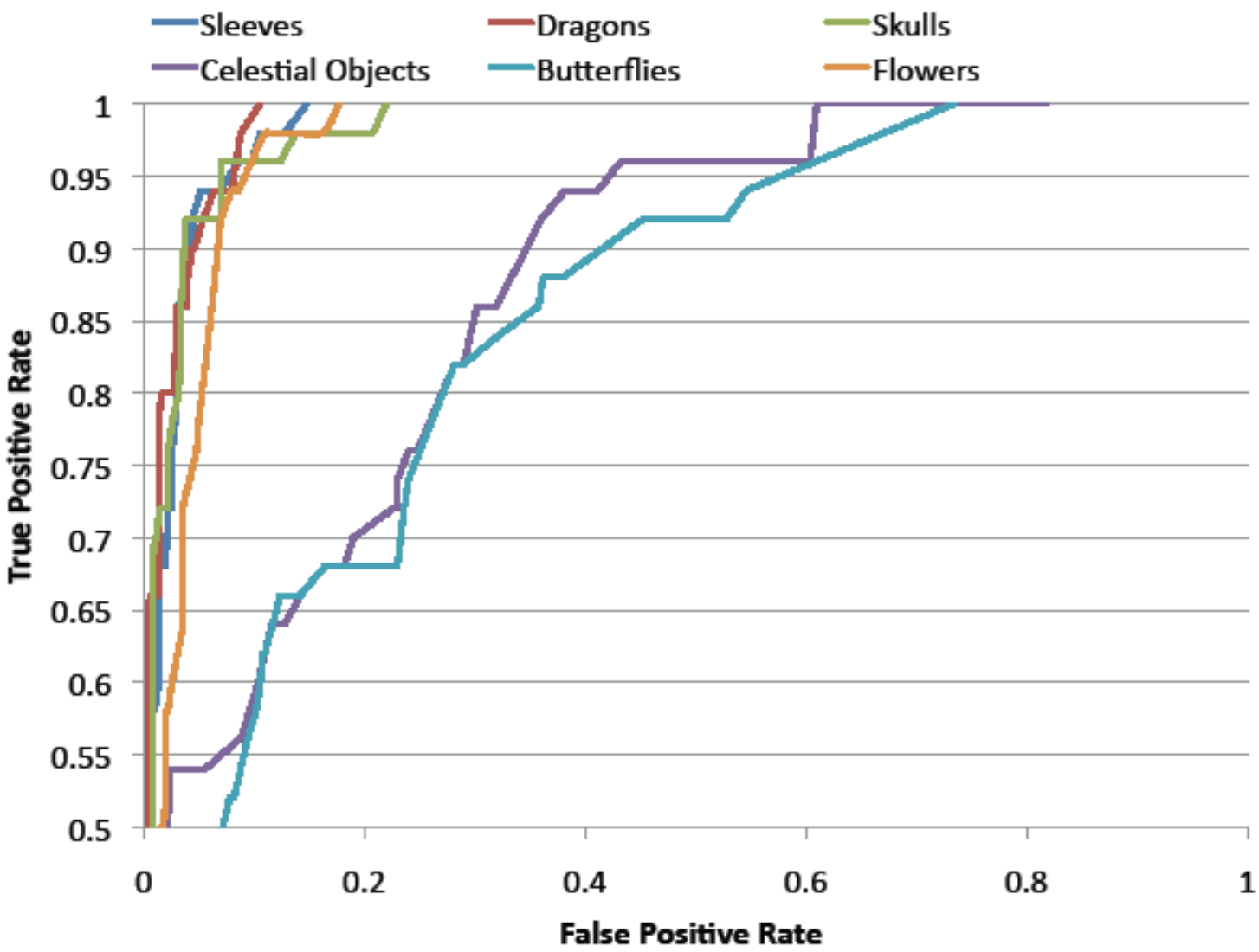
Experimental Evaluation Tattoos



Experimental Evaluation Tattoos



Experimental Evaluation Tattoos



Conclusions

- In this paper, Introduced Algorithm for the for the detection and classification of scars, marks and tattoos: constrained and unconstrained imagery for forensics applications.

- While promising recent work, including our own, has demonstrated that these dermatological features can be detected and classified, there is much work yet to be done to accurately process images found in the wild.

- We also discovered that approaches designed for closed set evaluation do not readily apply to open set problems where we don’t have complete control over the input images.

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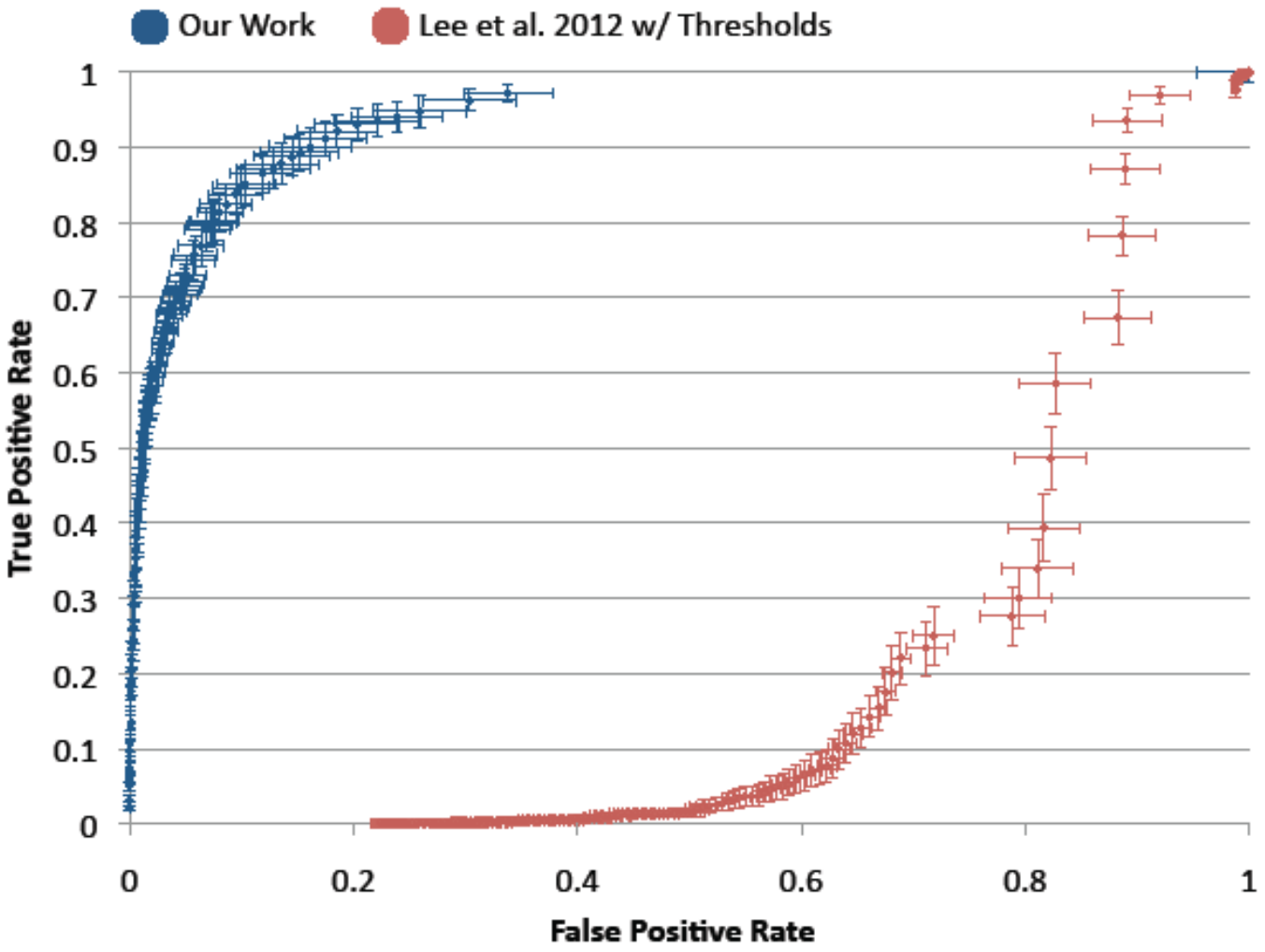
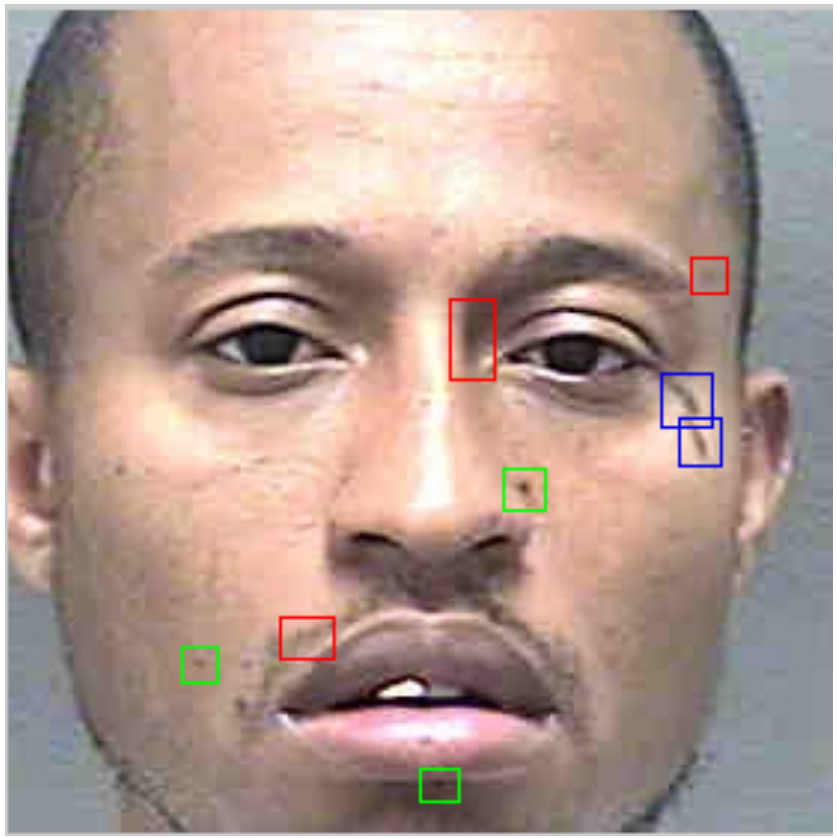
Experimental Evaluation Tattoos



Facial Mark Detection and Refinement



Facial Mark Classification (8 Blobs)
Green: Positive Moles
Blue: Positive Tattoo
Red: Negatives

Facial Mark Detection and Refinement

- Generate Final Candidate Facial Mark Image using LoG and Skin based Facial Mark Images
- Gray Pixels Corresponds to a value of ‘1’, and white pixels correspond to a value of ‘2’

Original Image

Final Candidate Facial Mark Image