

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

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AT COLORADO SPRINGS

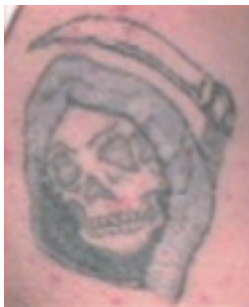


**This work was supported by Army SBIR  
(Award Number W15P7T-12-C-A210).**

# 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

# The Challenge



## Constrained Imagery

- Controlled pose
- Controlled position
- Controlled lighting



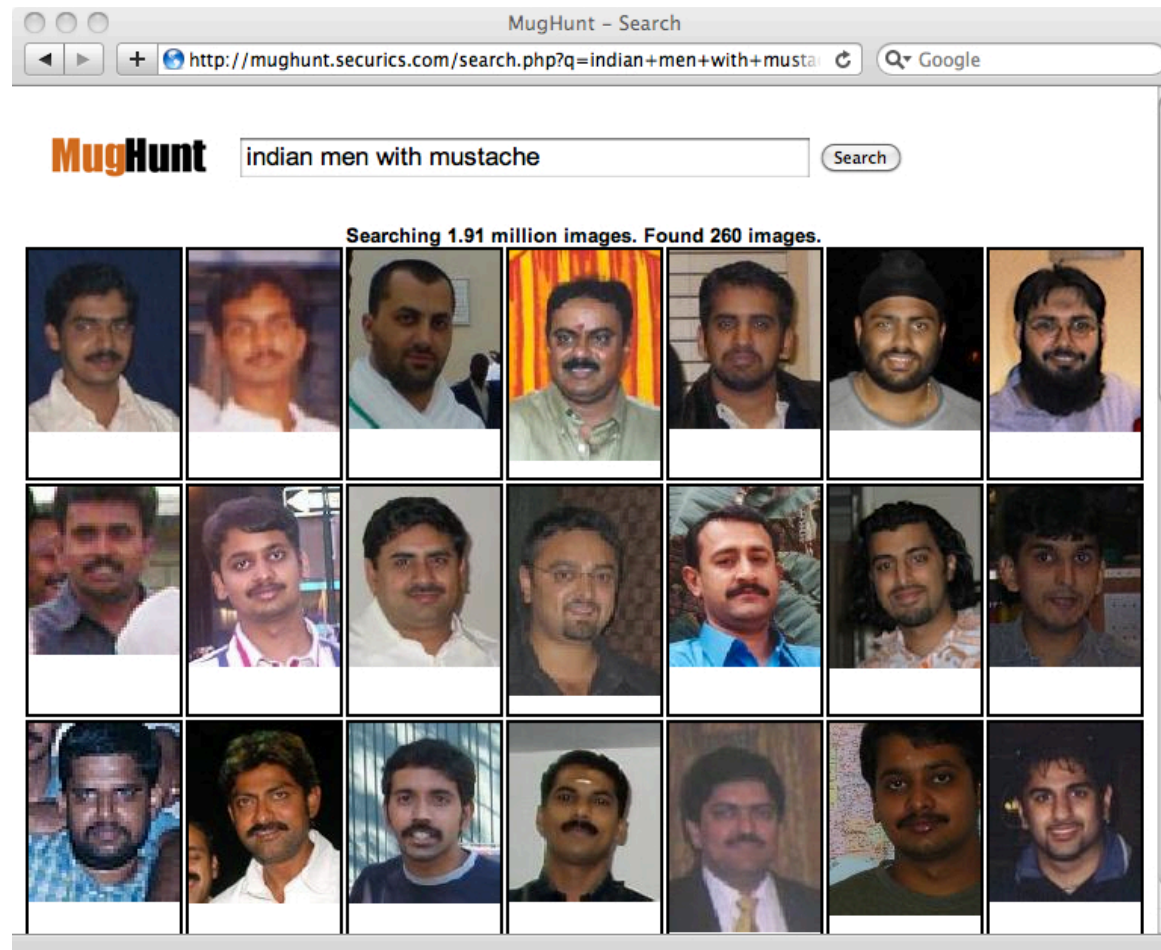
## Unconstrained Imagery

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

# Operational Constraints and Environment

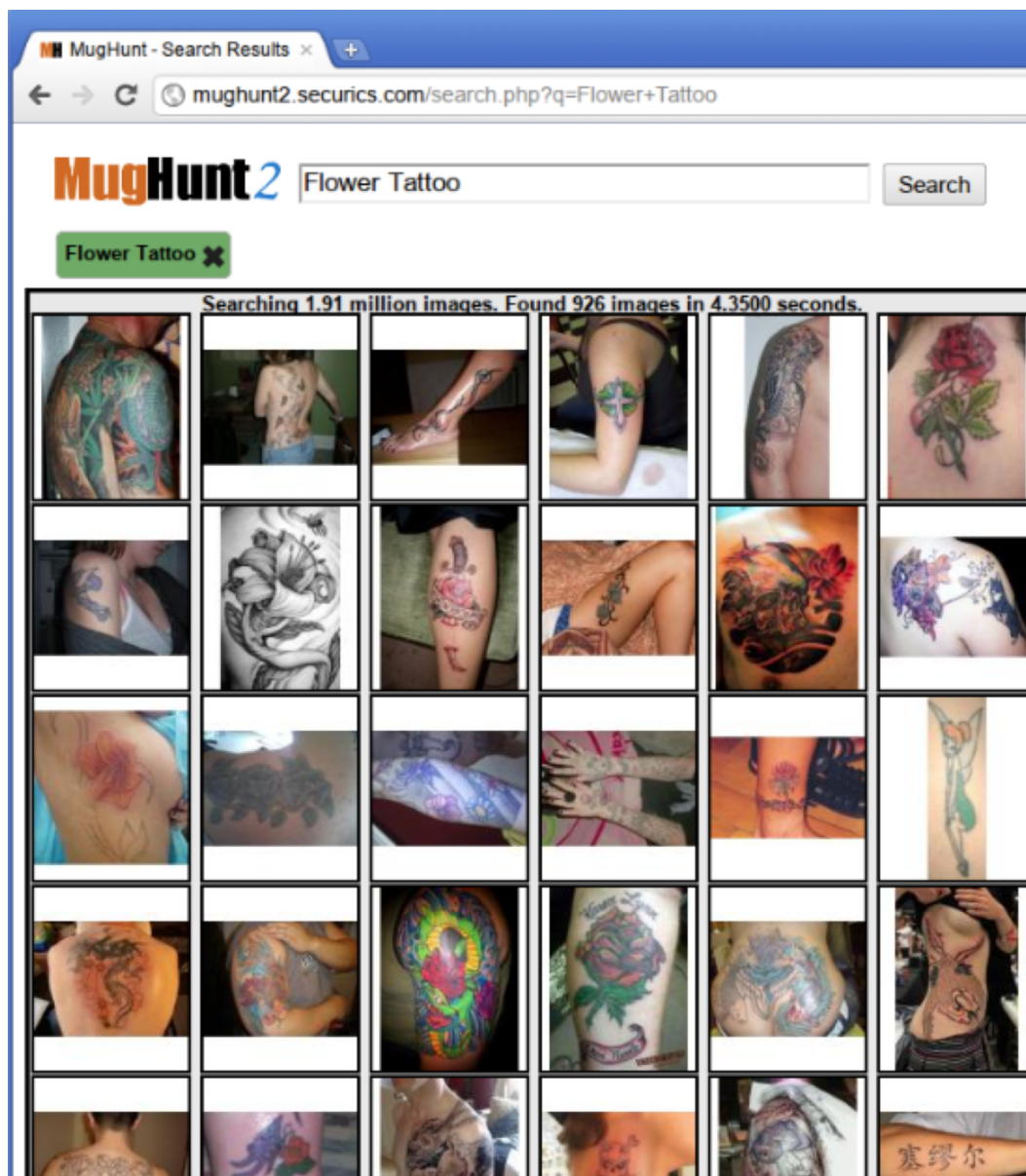
- New Component of the MugHunt Attribute Search Engine (65 Search Attributes)
- Presented at CVPR 2012

<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

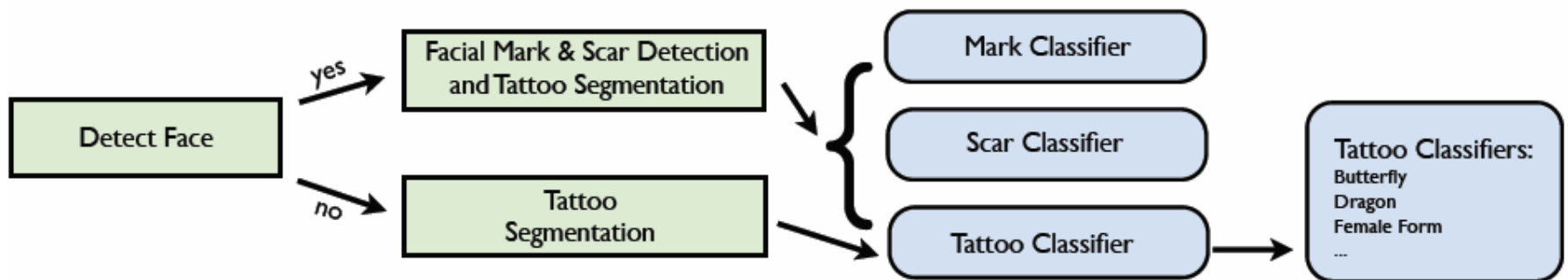
- **Image Retrieval in Forensics: Tattoo Image Database Application:** J.-E. Lee, R. Jin, A. Jain, and W. Tong. IEEE Multimedia, 19(1):2–11, January 2012.
- **Face Matching and Retrieval in Forensics Applications:** A. Jain, B. Klare, and U. Park. IEEE Multimedia, 19(1):20–28, January 2012.
- **Content-based 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

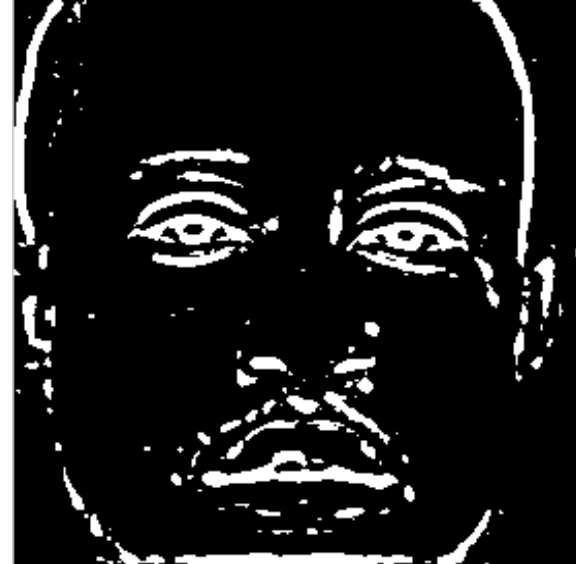


# Facial SMT Detection and Refinement

- 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

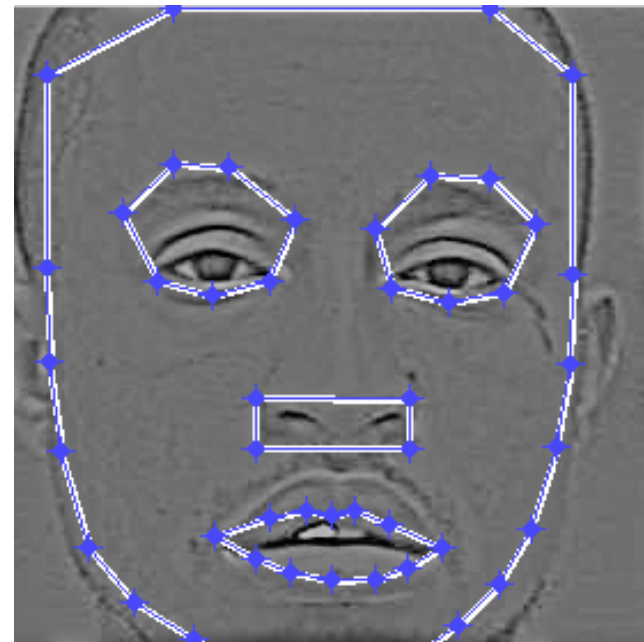


# Facial Mark Detection and Refinement

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



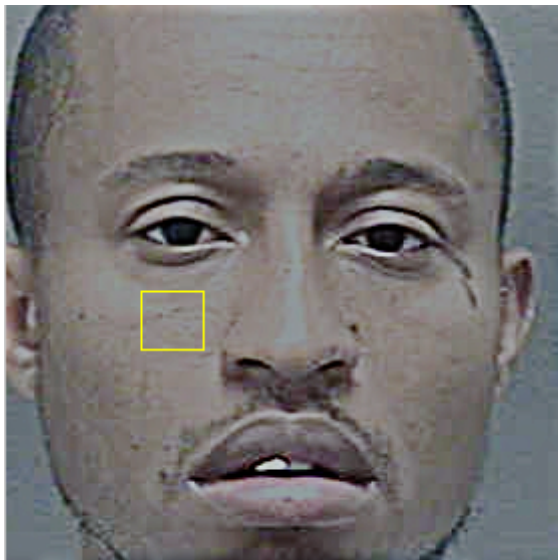
Original Image



Primary Facial  
Features Annotated  
Using ASM

# Facial Mark Detection and Refinement

- Skin based User Specific Mask and Candidate Facial Mark Image
- Color SQL 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

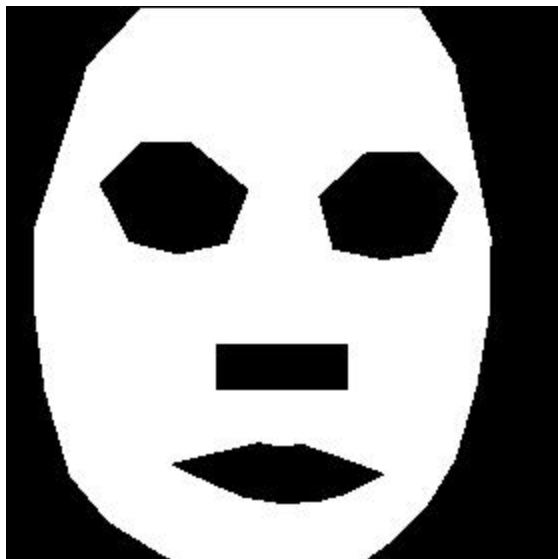
- Generate Final Candidate Facial Mark Image using LoG and Skin based Facial Mark Images



Final Candidate Facial Mark Image

# Facial Mark Detection and Refinement

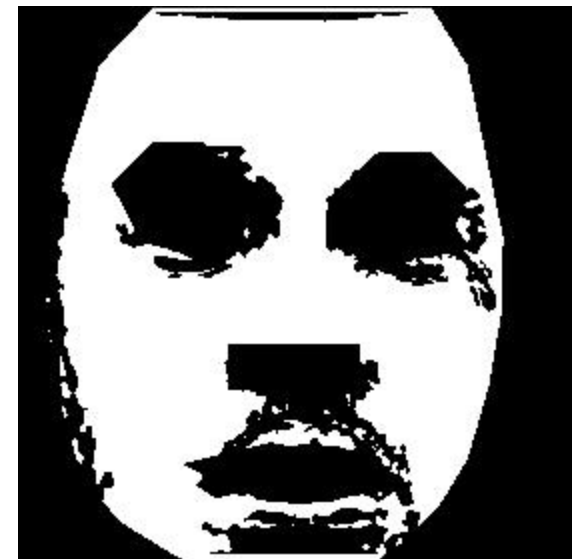
- Generate User Specific Mask from ASM Mask and Skin Detection Mask



**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

a. Generate initial candidate map



b. Facial landmark detection w/ ASM



c. Skin error map & candidate marks



d. Merge (a) & candidate marks



e. Subtract (b) & skin error map (c)

# 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)

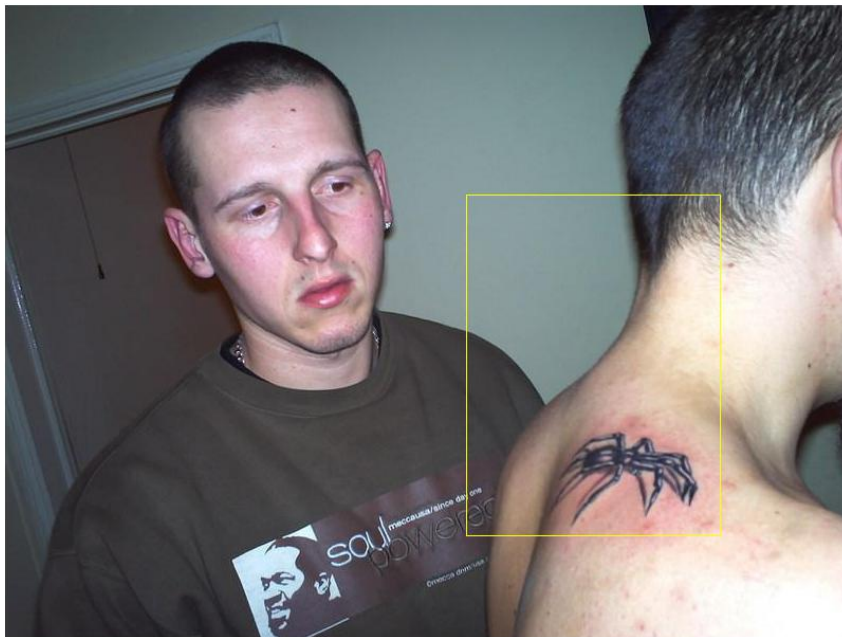


J. Harel, C. Koch, P. Perona, "Graph-Based Visual Saliency", Proceedings of Neural Informational Processing Systems (NIPS) 2006

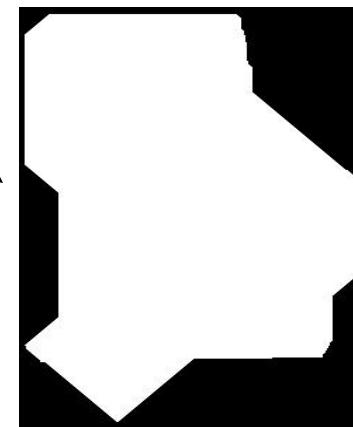


# Tattoo Segmentation: GBVS Saliency

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

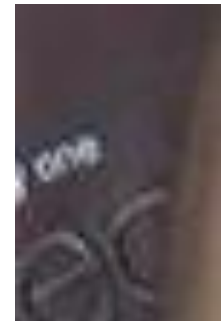


3. Filter QCC grouping image with Segmentation Mask and perform connected components

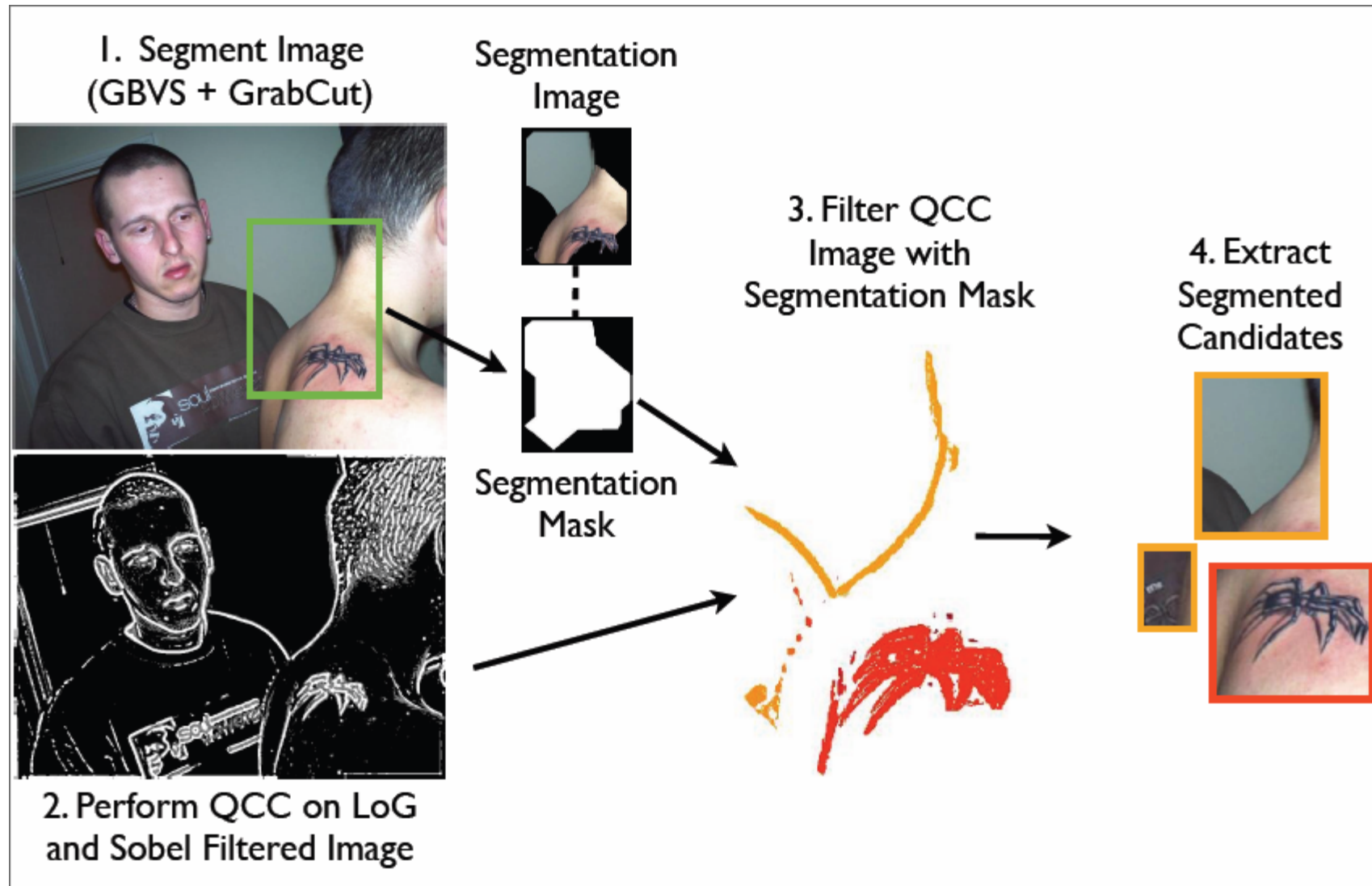


# Tattoo Segmentation: Quasi-Connected Components (QCC)

## 4. Extract Segmented Tattoo Candidates



# Tattoo Segmentation: Summary

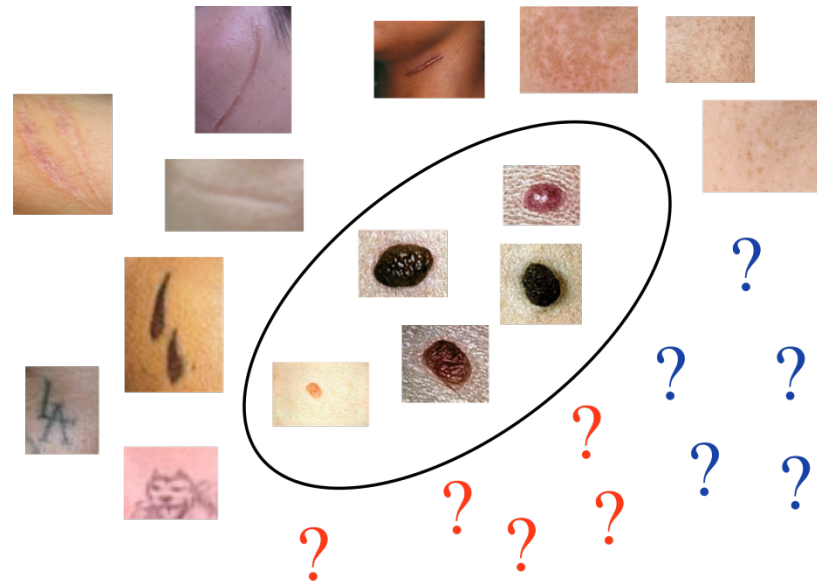


# Open Set vs. Closed Set Recognition

- 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

The screenshot displays the Amazon Mechanical Turk ' HITs ' page. At the top, the Amazon Mechanical Turk logo is visible, along with navigation links for 'Your Account', 'HITs', and 'Qualifications'. A status bar indicates '53,558 HITs available now' and a 'Sign In' link. The main search area shows 'All HITs | HITs Available To You | HITs Assigned To You'. A search filter is set to 'HITs' containing 'that pay at least \$ 0.00 for which you are qualified'. A timer shows '00:00:00 of 3 minutes'. Below the search bar, there are buttons for 'Accept HIT' and 'Skip HIT', and a summary: 'Total Earned: Unavailable' and 'Total HITs Submitted: 0'.

The selected HIT is titled 'Classify images of skull tattoos' by requester 'Securics, Inc'. The reward is '\$0.01 per HIT', with '29 HITs Available' and a 'Duration' of '3 minutes'. The qualifications required are 'HIT approval rate (%) is not 95, Adult Content Qualification is 1'.

The task description is titled 'Skull' and instructs workers to 'Please mark ONLY the images which YOU ARE SURE contain tattoos matching the above description. If we find more than 1 incorrectly marked image, you will NOT receive payment for this HIT. Some guidelines:'. The guidelines listed are:

- DO NOT mark the image if you don't understand the tattoo description
- DO NOT mark the image if you are not **100%** sure it matches the tattoo description
- DO NOT mark the image if it is not a tattoo
- DO NOT mark the image if it does not load
- DO NOT mark the image if it is of very poor quality or blurry
- DO NOT mark the image if it looks like it has been modified (e.g. Photoshopped)

Below the guidelines, it states 'Here are some CORRECT EXAMPLES of the given tattoo description. You SHOULD mark images like these:'. Five example images are shown in a row: a skull tattoo with an American flag pattern, a skull tattoo with a floral design, a skull tattoo with a tribal design, a skull tattoo with a colorful floral design, and a skull tattoo with a tribal design.

At the bottom of the task area, there are buttons for 'Accept HIT' and 'Skip HIT', and a link to 'Want to see other HITs?'.

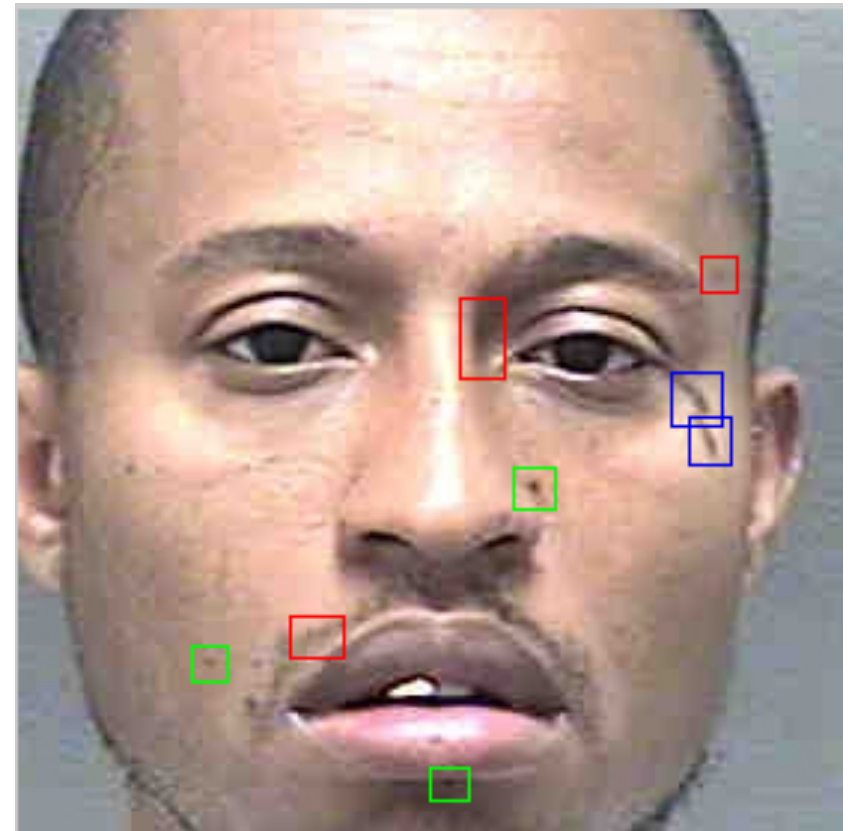
The footer contains links for 'FAQ | Contact Us | Careers at Amazon | Developers | Press | Policies | Blog', the copyright notice '©2005-2011 Amazon.com, Inc. or its Affiliates', and the text 'An amazon.com company'.

# Experiments and Results



Application of Open Set Recognition model to  
Facial Marks and Tattoos

# Qualitative Results

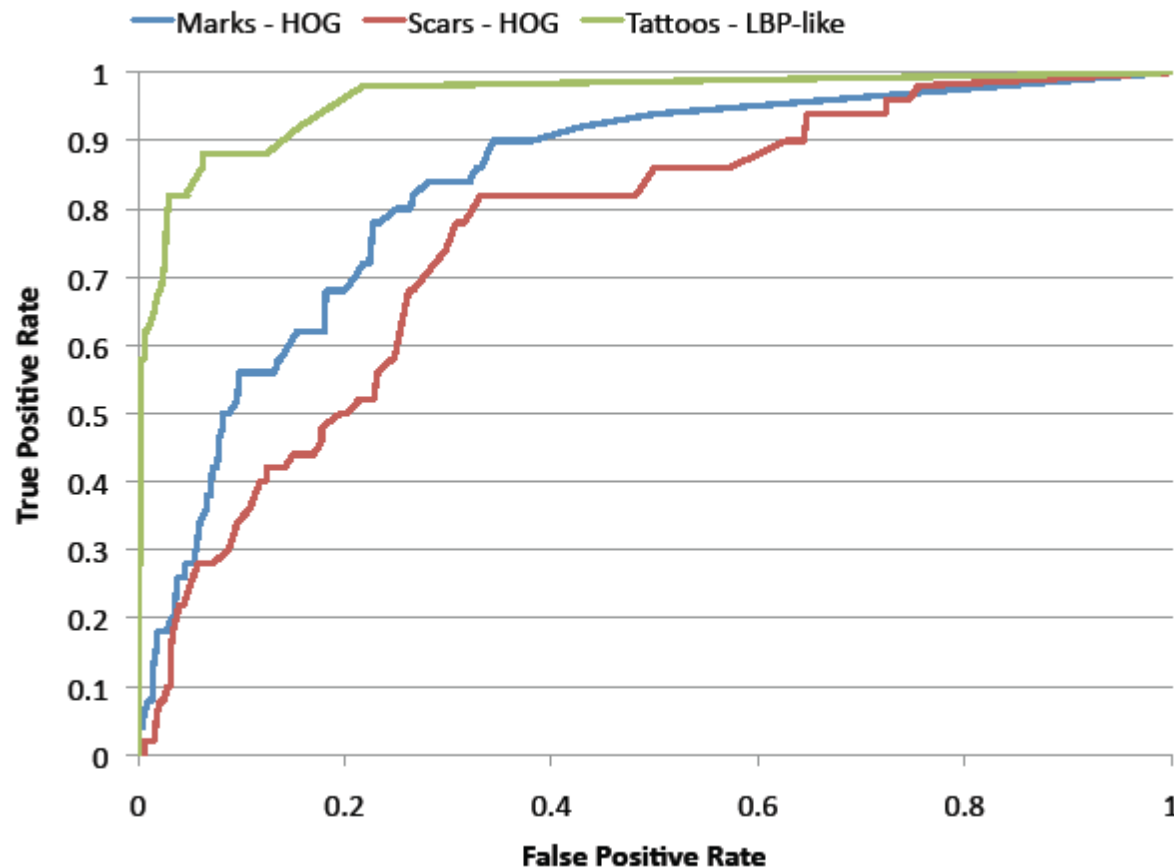


Facial SMT Classification  
Green: Positive Moles  
Blue: Positive Tattoo  
Red: Negatives

# Experimental Evaluation

## Facial SMT (Moles and Scars) and Generic Tattoo Classifier

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

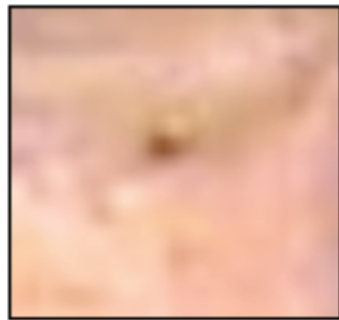




# Experimental Evaluation

## Features of Interest

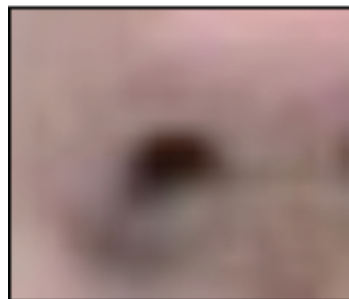
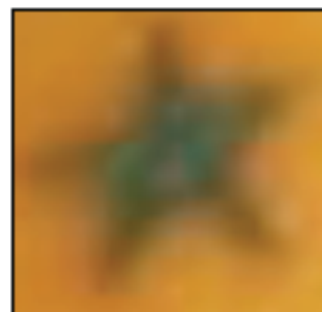
Mole



Scar



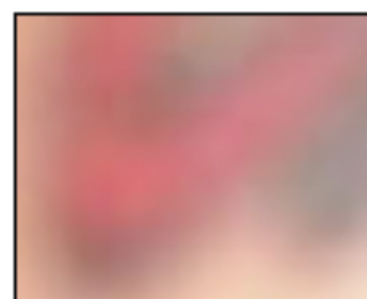
Celestial Object



Nostril



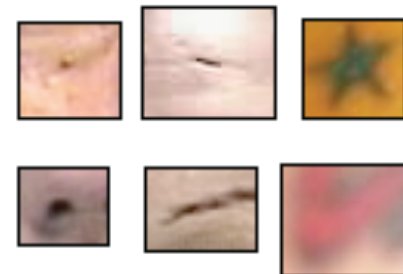
Eyebrow



Tattoo Fragment

## Negative Images

## Actual Size

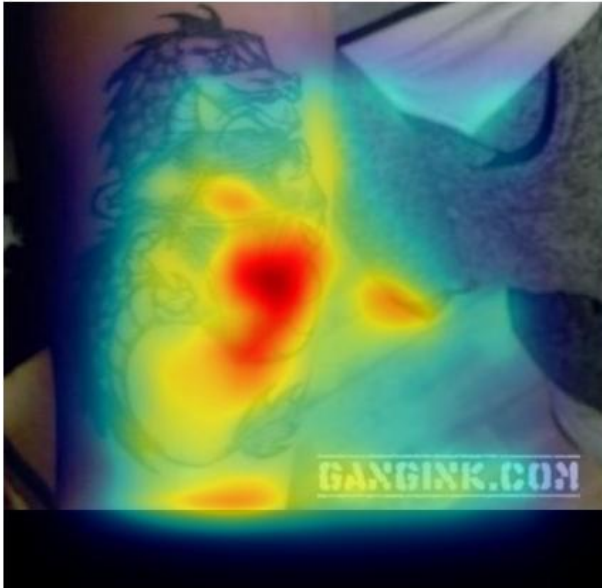




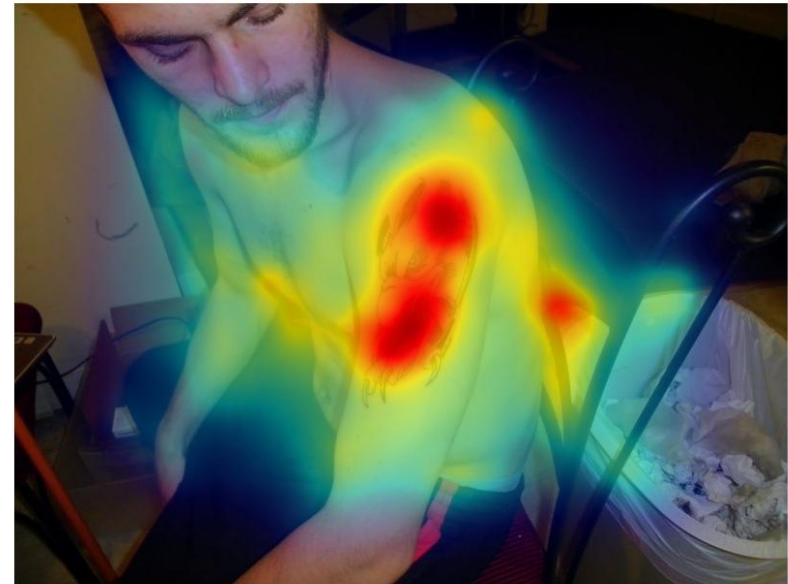
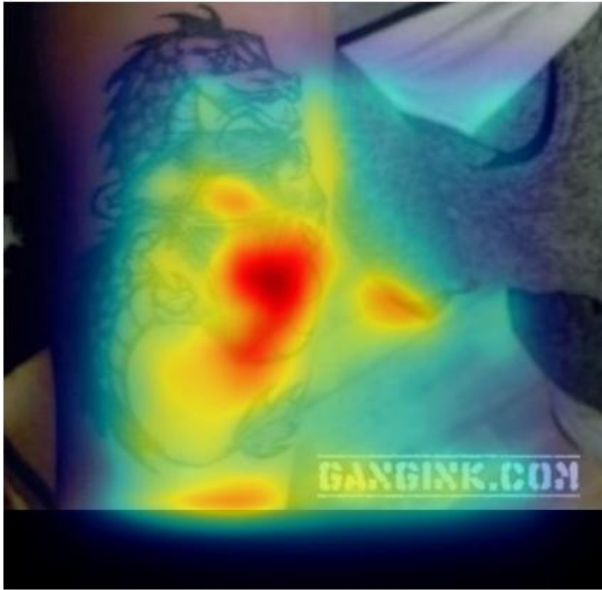
# Qualitative Results: Tattoo Detection



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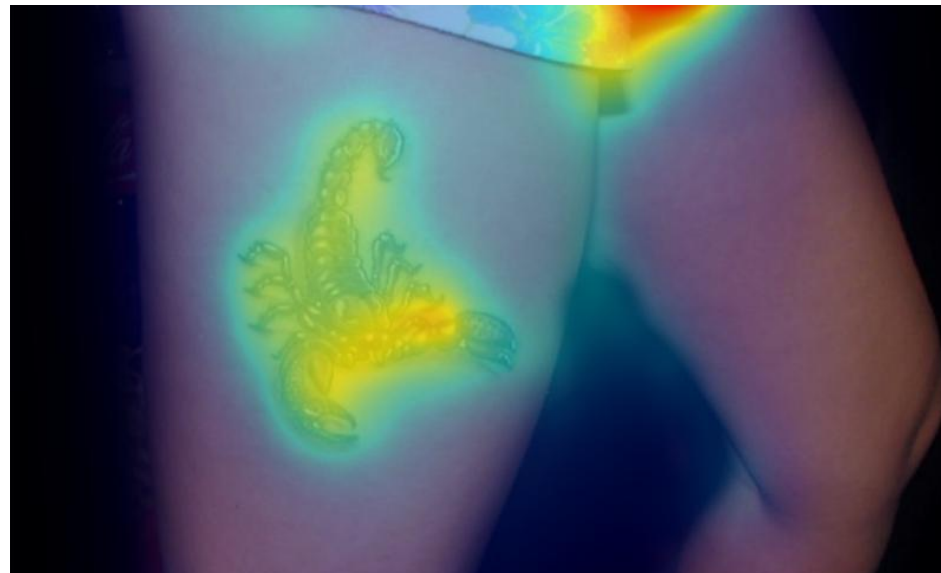
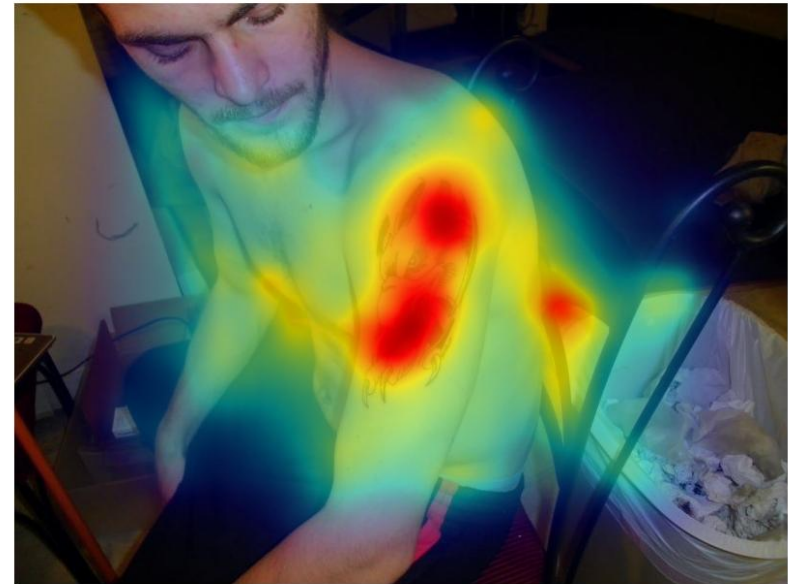
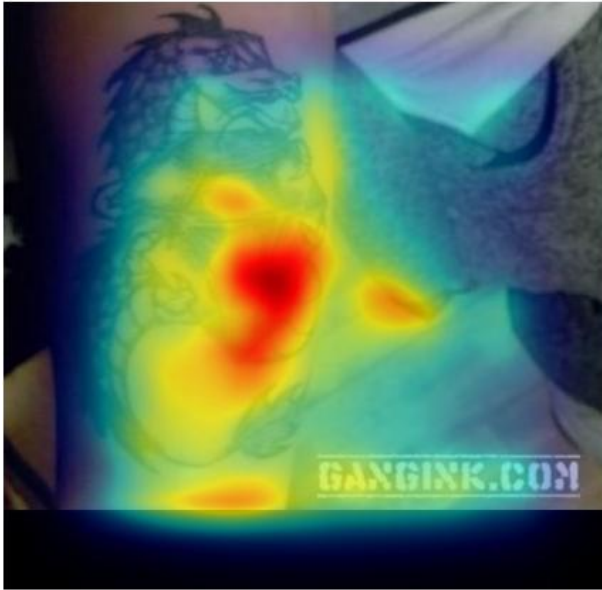


# Qualitative Results: Tattoo Detection

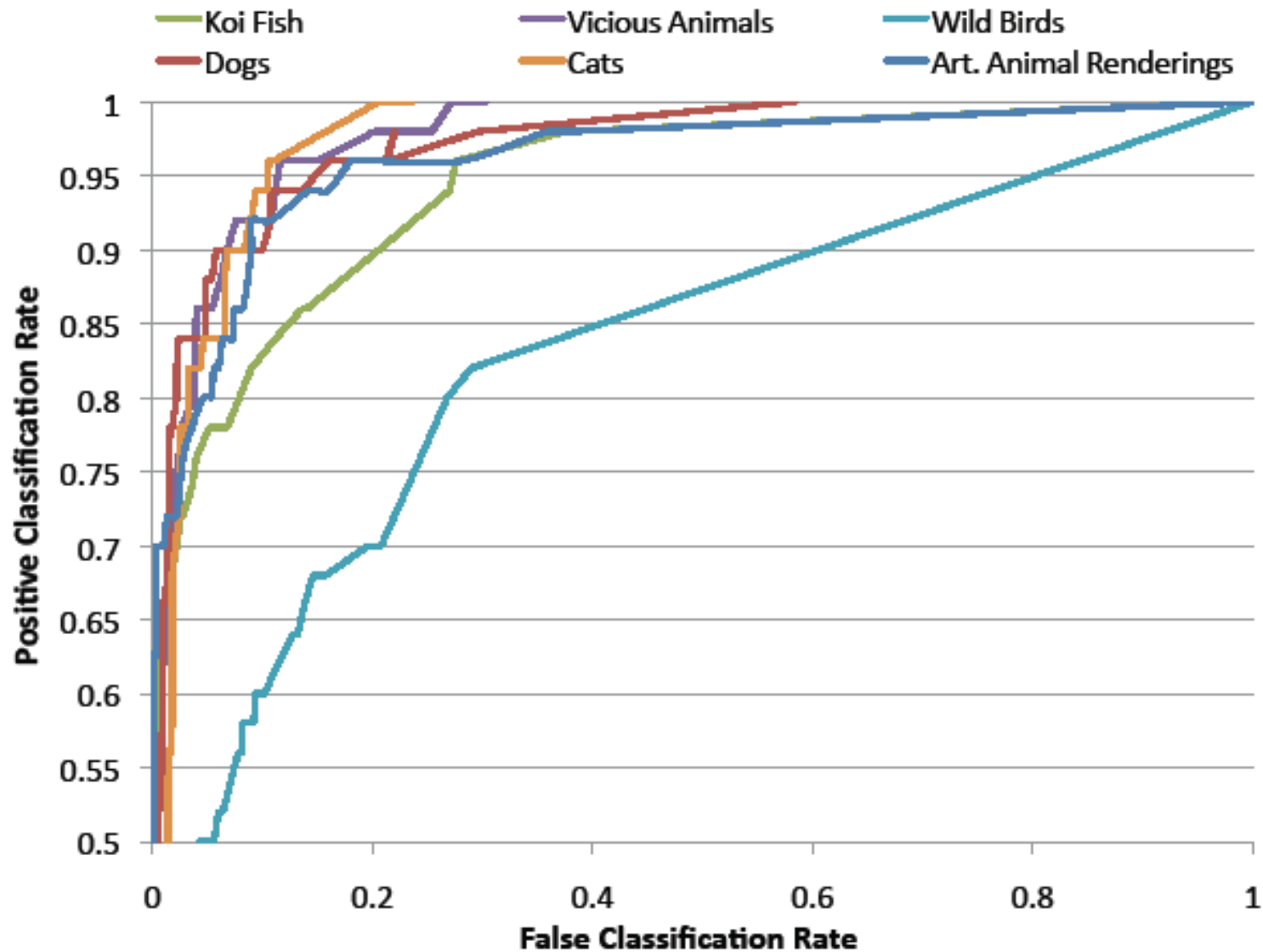




# Qualitative Results: Tattoo Detection

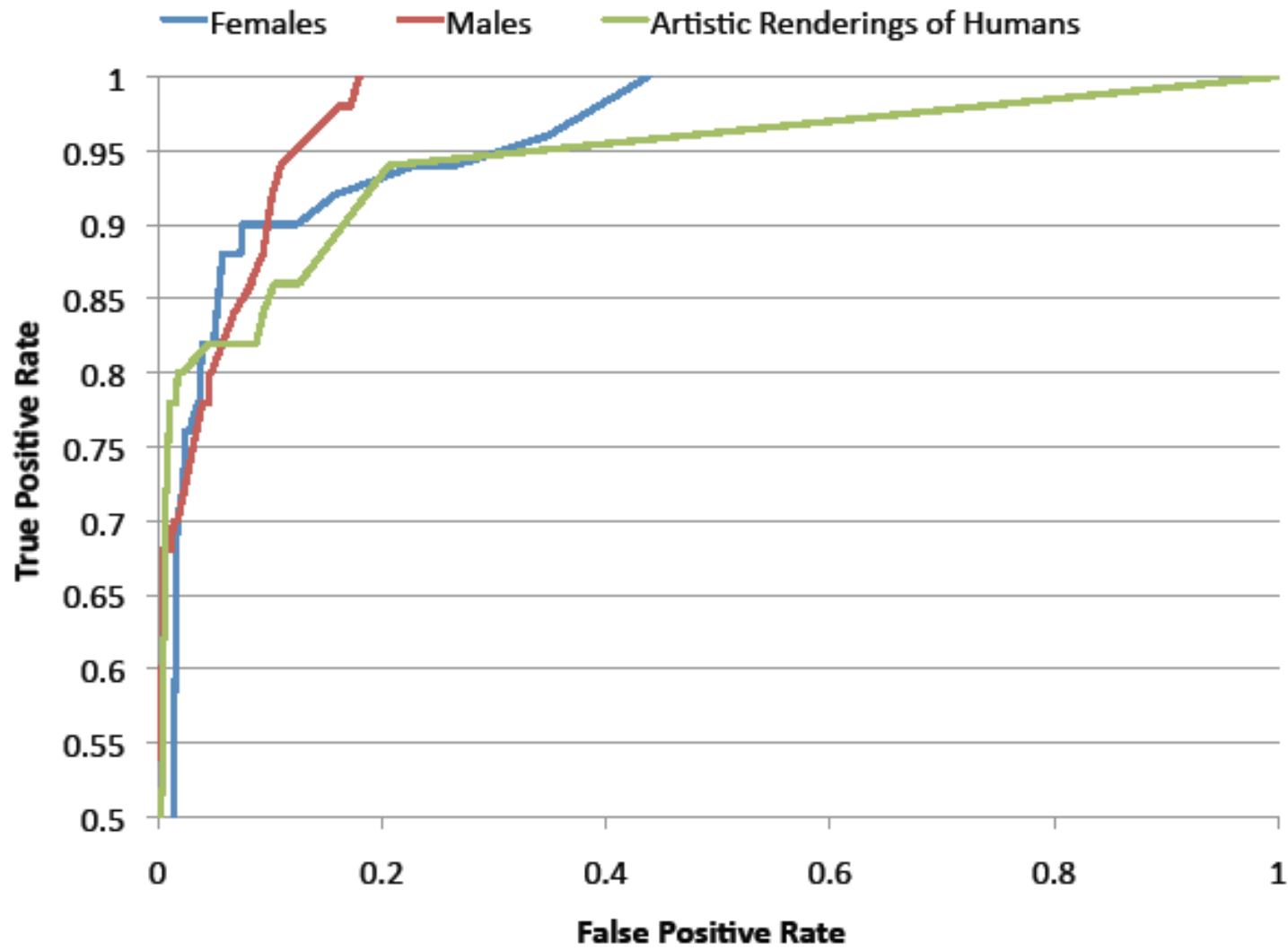


# Experimental Evaluation Tattoos

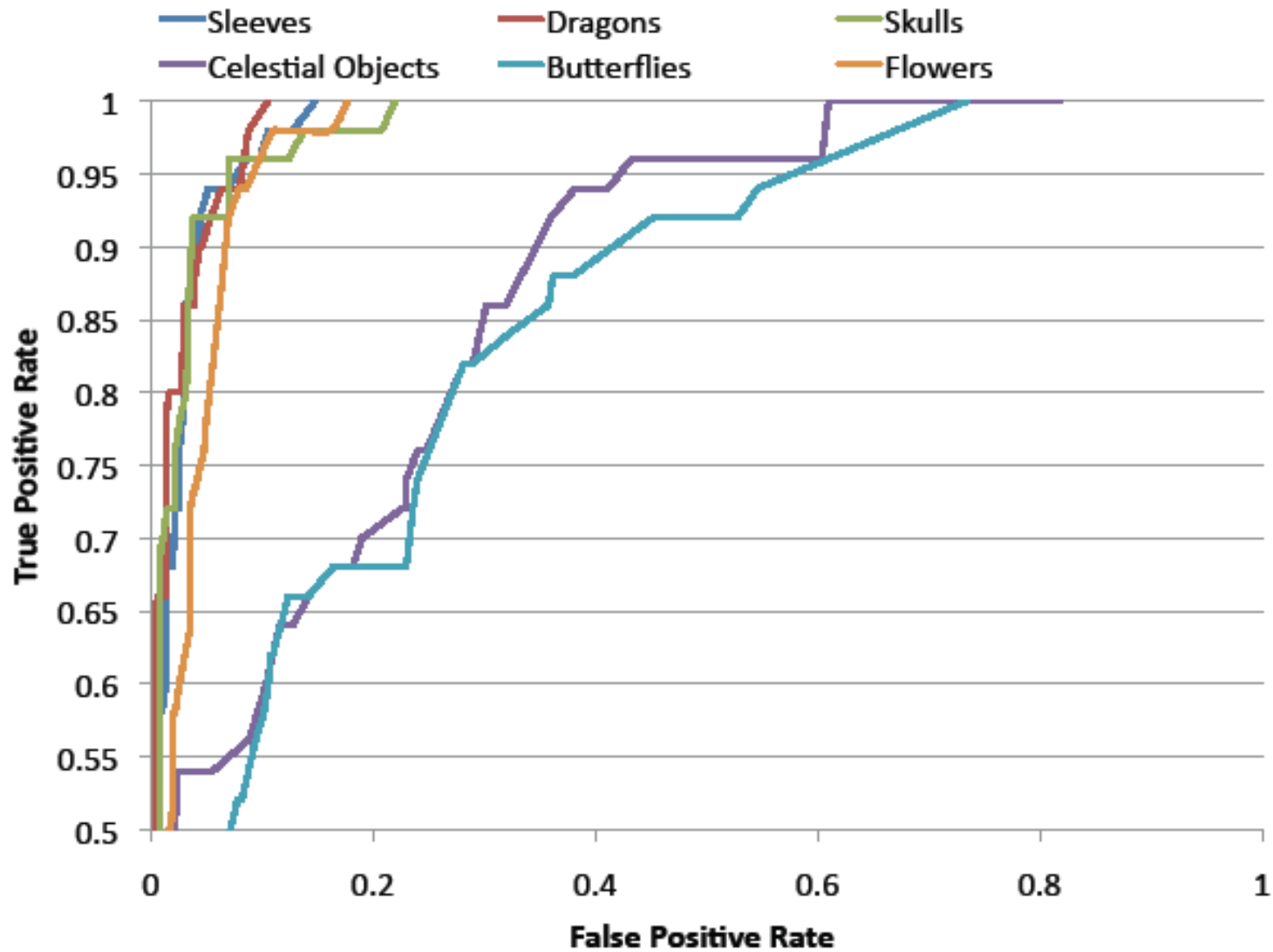




# Experimental Evaluation Tattoos



# Experimental Evaluation Tattoos



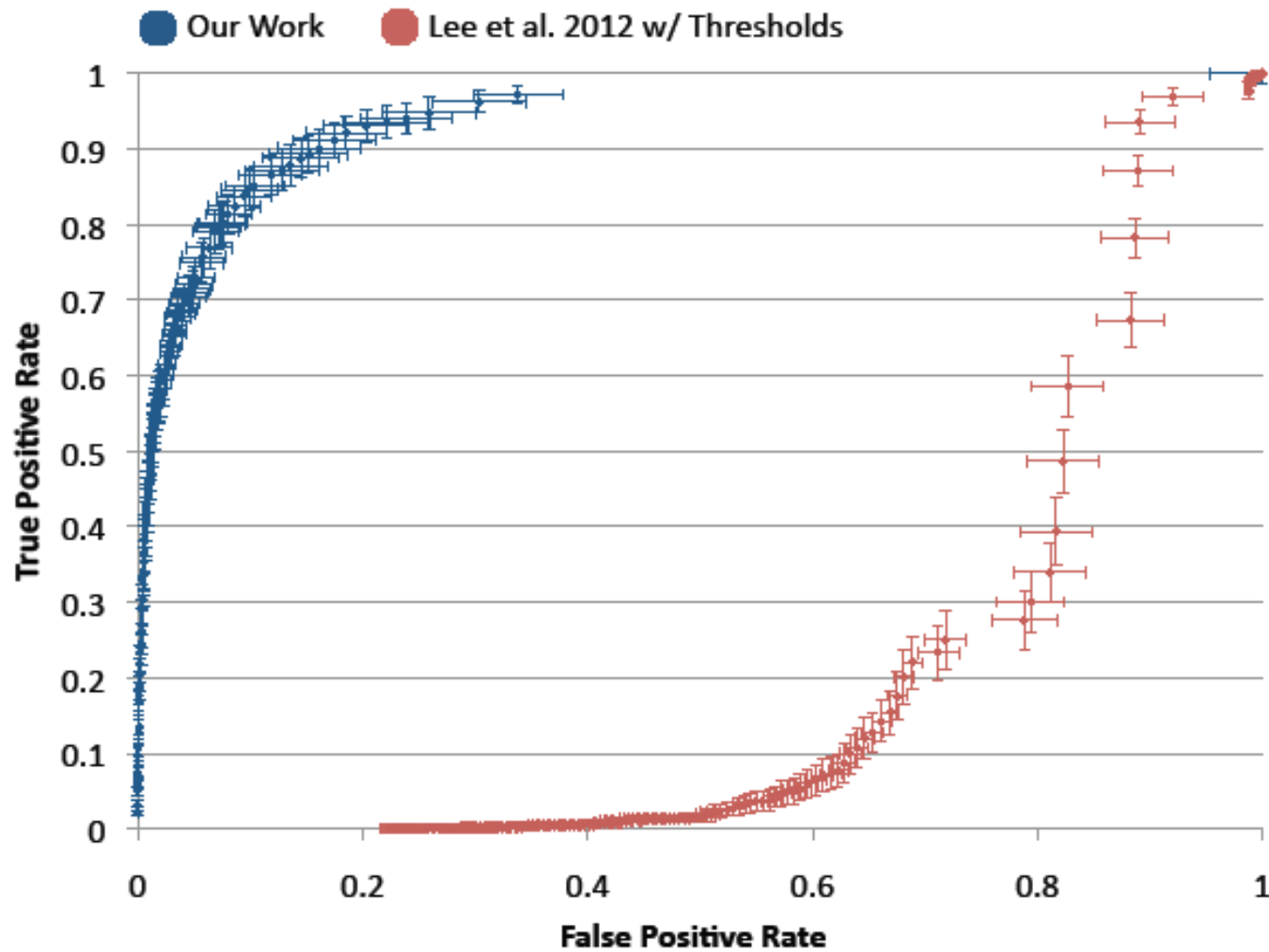
# Conclusions

- 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.



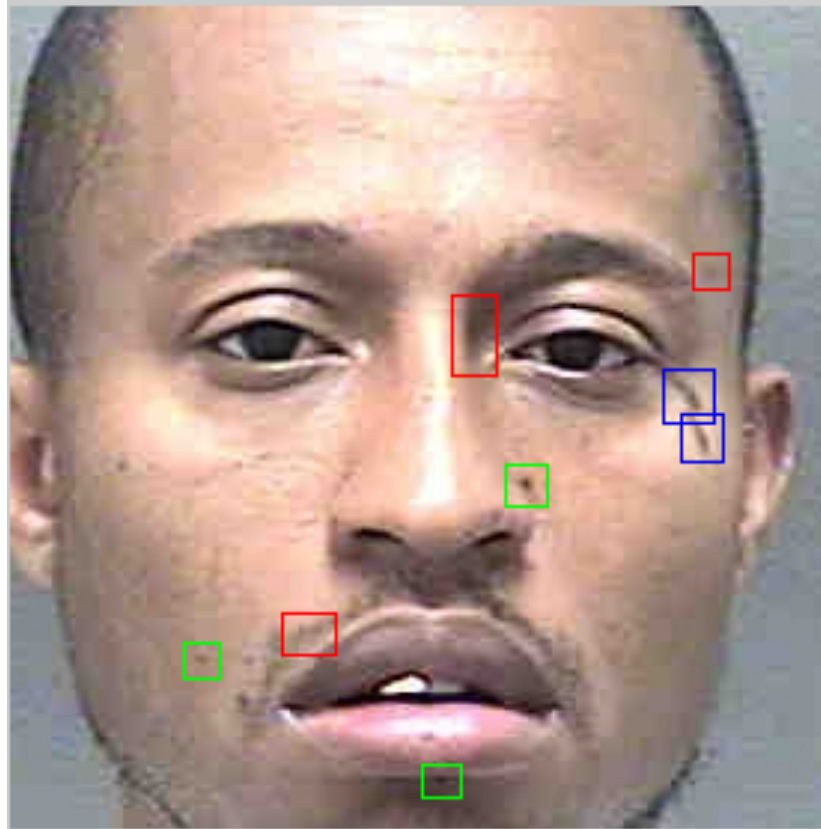
This work was supported by Army SBIR  
(Award Number W15P7T-12-C-A210).

# 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