Scars, Marks and Tattoos (SMT): Automatic Matching & Retrieval

Anil K. Jain
Michigan State University
http://biometrics.cse.msu.edu

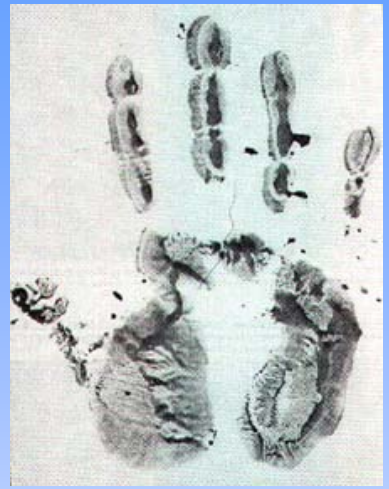
Challenges in Forensic Science

- Increased expectations from forensic science
  - CSI effect: Jurors want to see physical evidence (fingerprints, DNA, etc.) to convict suspects
  - Detectives used to gather 4-5 pieces of evidence at crime scenes; now look at 50-400
  - sources
- Crime rate is falling but backlog is still increasing
- Throughput needs to be increased
- Need for better equipment, efficient techniques & strong theoretical & empirical proofs of effectiveness

Houck, “CSI: The Reality”, Scientific American, June 2006

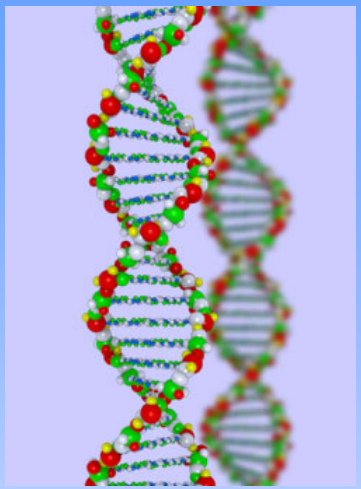
Forensic Evidence

Fingerprint



Palmprint

Face



DNA

Footprint

Bite Mark

Tattoo

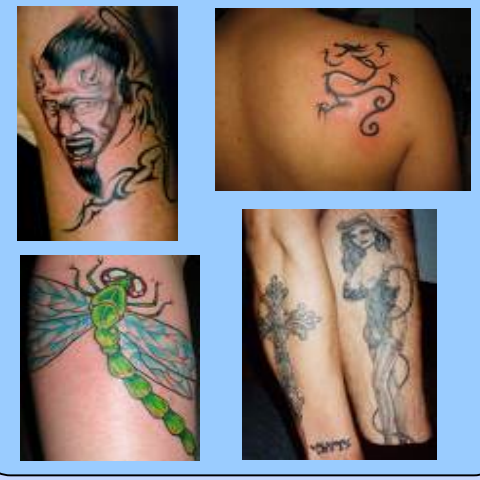
Tyreprint

Scars, Marks and Tattoos

Scars

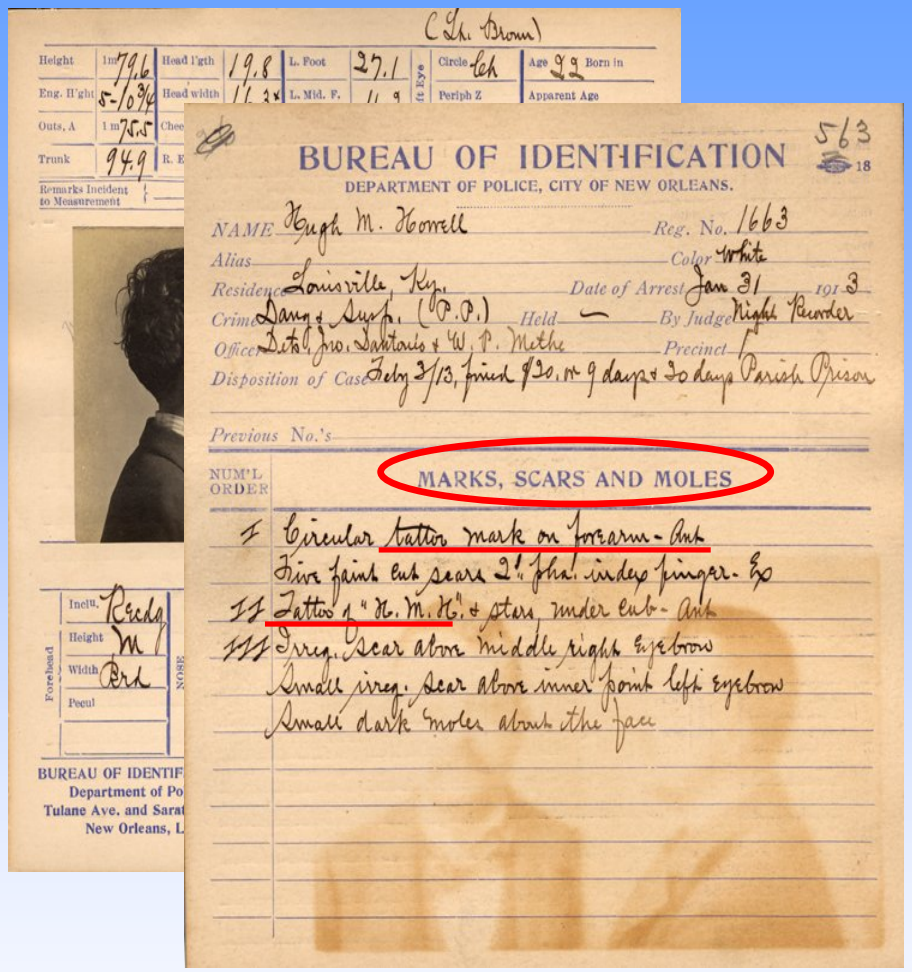
Marks

Tattoos



- Skin imprints:
  - can be used to identify suspects/victims
- 2003 online Harris poll:
  - 16% of adults have at least one tattoo

Criminal History Records



BUREAU OF IDENTIFICATION
DEPARTMENT OF POLICE, CITY OF NEW ORLEANS.

NAME Hugh M. Howell — Reg. No. 1663
Alias — Color White
Residence Louisville, Ky. — Date of Arrest Jan. 31 1913
Crime Dang. & Susp. (P.P.) — Held — By Judge Night Recorder
Officer Det. Jno. Santoro & W. P. Methe — Precinct
Disposition of Case Feby 3/13, fined $20. or 9 days & 30 days Parish Prison

Previous No.'s

NUM'L ORDER — MARKS, SCARS AND MOLES

I Circular tattoo mark on forearm - Ant
Five faint cut scars 2" that index finger - Ep
II Tattoo of "H. M. H." & stars under cub - Ant
III Irreg. scar above middle right eyebrow
Small irreg. scar above inner point left eyebrow
Small dark moles about the face

Bertillon system

MURDER; INTERSTATE FLIGHT - ATTEMPTED MURDER; NATIONAL FIREARMS ACT

WANTED BY FBI

LEONARD PELTIER

FBI No. 631,091 D

ALIASES: Leonard Littleshell, Luis Martinez, John Yellow Robe, Leonard Williams

Photographs taken 1972 — Photograph taken 1974

DESCRIPTION
AGE: 31, born September 12, 1944, Grand Forks, North Dakota
HEIGHT: 5'11" — EYES: brown
WEIGHT: 190 pounds — COMPLEXION: medium
BUILD: muscular — RACE: Indian
HAIR: black — NATIONALITY: American
OCCUPATIONS: body and fender work, carpenter, employment manager, hod carrier
SCARS AND MARKS: birthmark on right cheek, scar on left cheek, scar on left side of neck; Tattoos: a rose on upper outer right arm, "Leonard" on upper outer left arm
It is believed he may be wearing shoulder hair, mustaches and goatee
SOCIAL SECURITY NUMBERS USED: 543-50-5518; 542-50-5417; 542-50-5416

CAUTION
PELTIER HAS POSSESSED NUMEROUS FIREARMS AND DESTRUCTIVE DEVICES AND HAS RESISTED ARREST BY FIRING AT POLICE OFFICERS IN THE PAST. CONSIDER ARMED AND EXTREMELY DANGEROUS.

Federal warrants were issued August 9, 1974, at Milwaukee, Wisconsin, charging Peltier with unlawful interstate flight to avoid prosecution for attempted murder (Title 18, U. S. Code, Section 1073); November 25, 1975, at Rapid City, South Dakota, charging Peltier with murder - first degree, killing two Federal officers while in the performance of their duties and aiding and abetting (Title 18, U. S. Code, Sections 1111, 1114 and 2); and on November 25, 1975, at Portland, Oregon, charging Peltier with possession of a destructive device and possession of firearms in violation of the National Firearms Act (Title 26, U. S. Code, Sections 5861 (d), 5861 (h) and 5871), respectively.

IF YOU HAVE INFORMATION CONCERNING THIS PERSON, PLEASE CONTACT YOUR LOCAL FBI OFFICE. TELEPHONE NUMBERS AND ADDRESSES OF ALL FBI OFFICES LISTED ON BACK.

Identification Order 4681
December 3, 1975

Director
Federal Bureau of Investigation
Washington, D. C. 20535

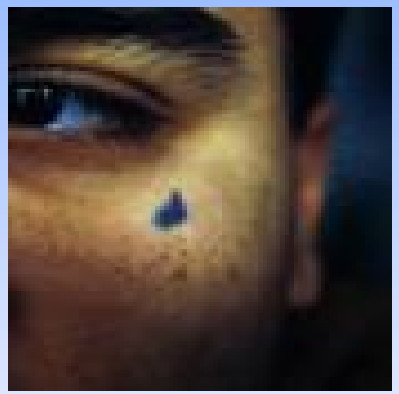
SCARS AND MARKS: birthmark on right cheek, scar on left cheek, scar on left side of neck; Tattoos: a rose on upper outer right arm, "Leonard" on upper outer left arm

Suspect & Victim Identification

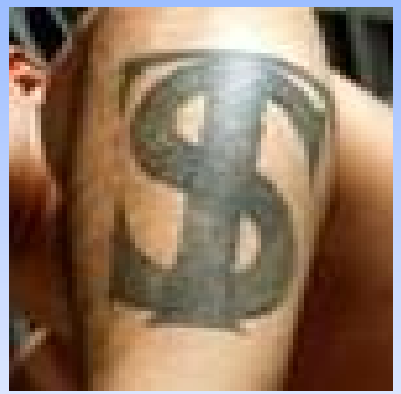
- Tattoos often imply gang membership, religions beliefs, previous conviction & military service
- Useful for victim and suspect identification

(a)

(b)



(c)



(d)

(a) and (b) body parts with tattoos found in a state park in Florida. Victim was identified based on tattoos within 12 hours (c) Teardrop criminal tattoo (person has killed someone or had a friend killed in prison); (d) Texas Syndicate (TS) gang tattoo

ANSI/NIST Tattoo Classes

ANSI/NIST ITL 1-2000 Tattoo Classes

Class description	Class code
Human Forms and Features	HUMAN
Animals and Animal Features	ANIMAL
Plants	PLANT
Flags	FLAG
Objects	OBJECT
Abstractions	ABSTRACT
Insignias & Symbols	SYMBOL
Other Images	OTHER

ANSI/NIST ITL 1-2000 Animal Tattoo Subclasses

Subclass	Subclass code
Cats & Cat Heads	CAT
Dogs & Dog Heads	DOG
Other Domestic Animals	DOMESTIC
Vicious Animals (Lions, Tigers, etc.)	VICIOUS
Horses (Donkeys, Mules, etc.)	HORSE
Other Wild Animals	WILD
Snakes	SNAKE
Dragons	DRAGON
Birds (Cardinal, Hawk, etc.)	BIRD
Spiders, Bugs, and Insects	INSECT
Abstract Animals	ABSTRACT
Animal Parts	PARTS
Miscellaneous Animal Forms	MANIMAL


Human


Animal


Plant


Flag


Object


Abstract


Symbol


Other

Tattoo Matching: Current Practice

- Find similar tattoos based on class labels
- ANSI/NIST labels are not precise: "Abstract" class
- Same tattoo image can have multiple labels

All these 12 tattoos belong to the FLAG category

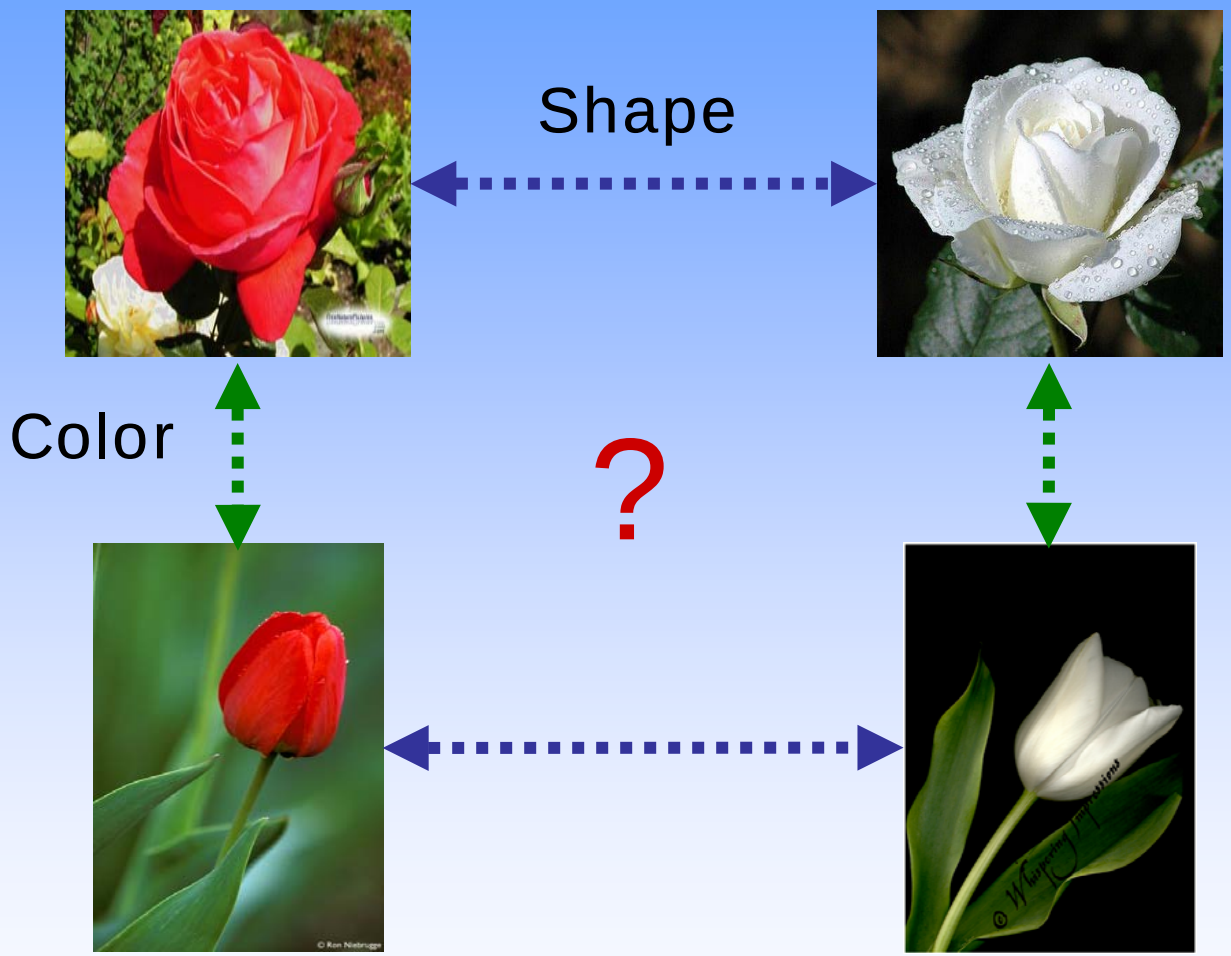
Image-based Tattoo Matching

- Given a tattoo image query, find the top-N most visually similar images in the database

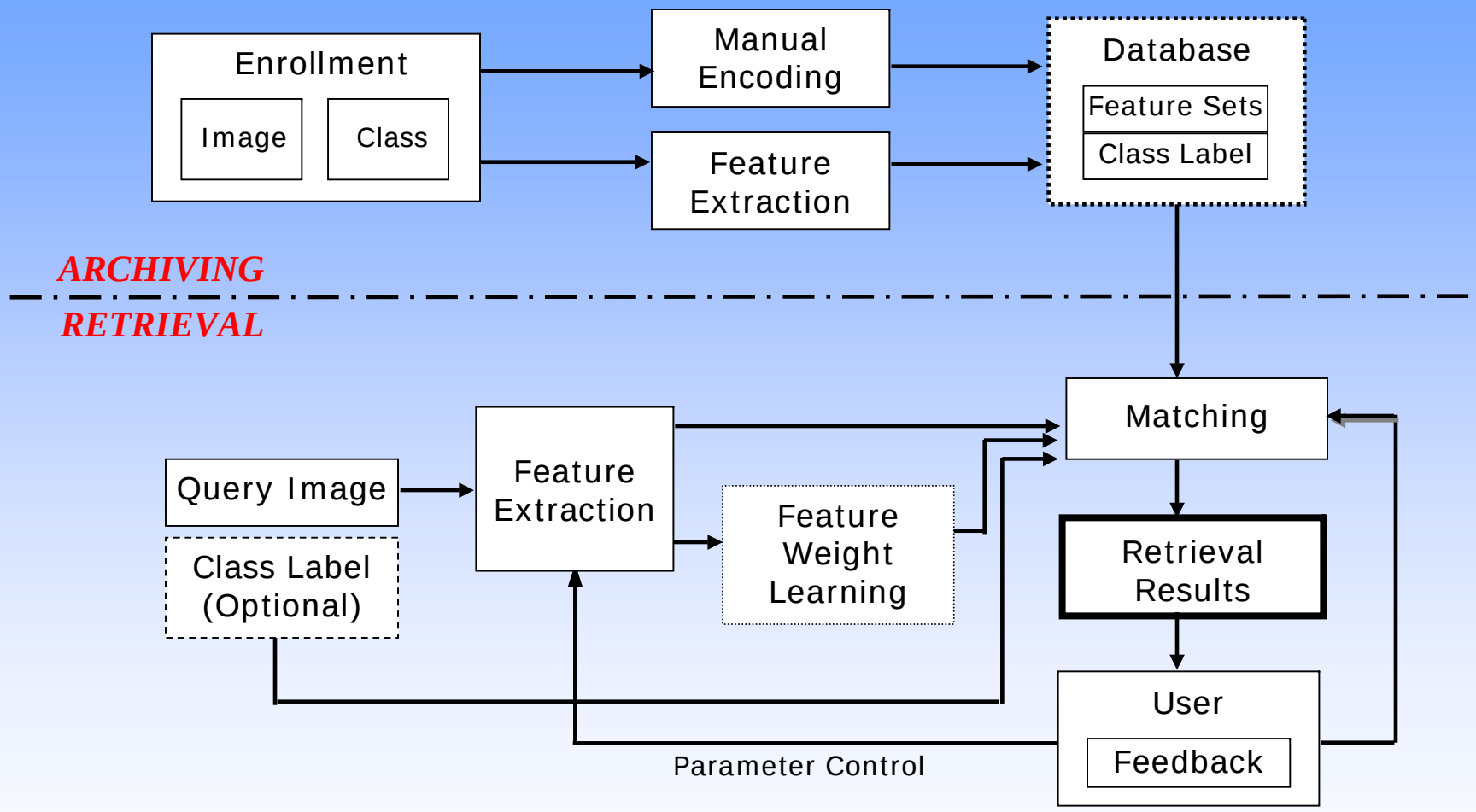
Query

Top-8 most similar tattoos for the query “star” tattoo

Image Similarity



Tattoo-ID System

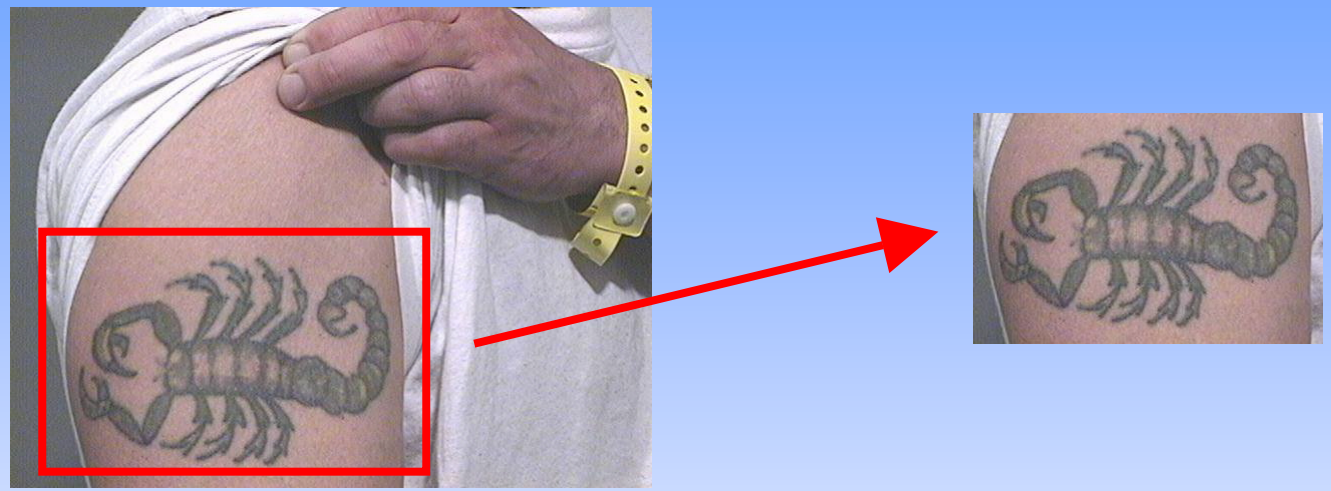


Michigan State Police Database

70,000 images

Image Preprocessing

- Manually crop & annotate



Skull
Fire
Weapon
Wording
Symbol

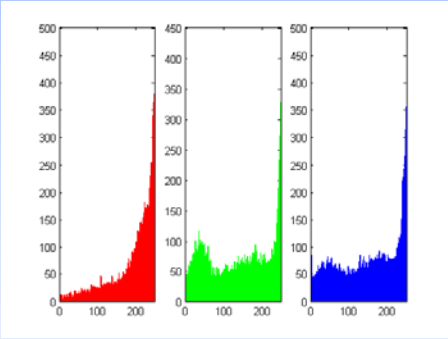
Symbol
Wording
Plant
Flag

Weapon
Object
Snake

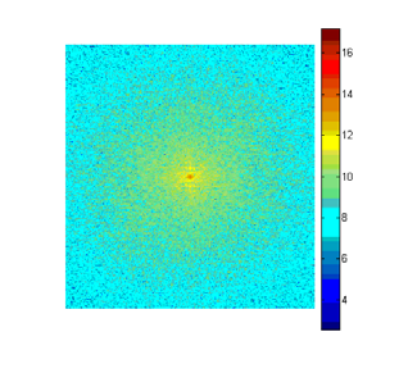
Image Features

- Color: histogram and correlogram
- Shape: invariant moments
- Texture: edge direction coherence

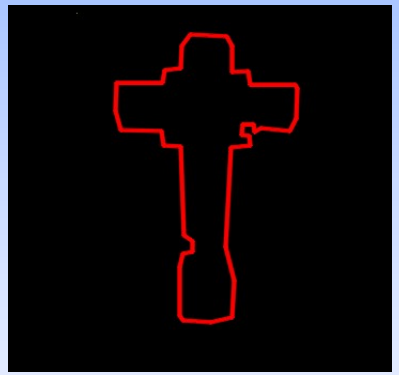
Image



Color Histogram

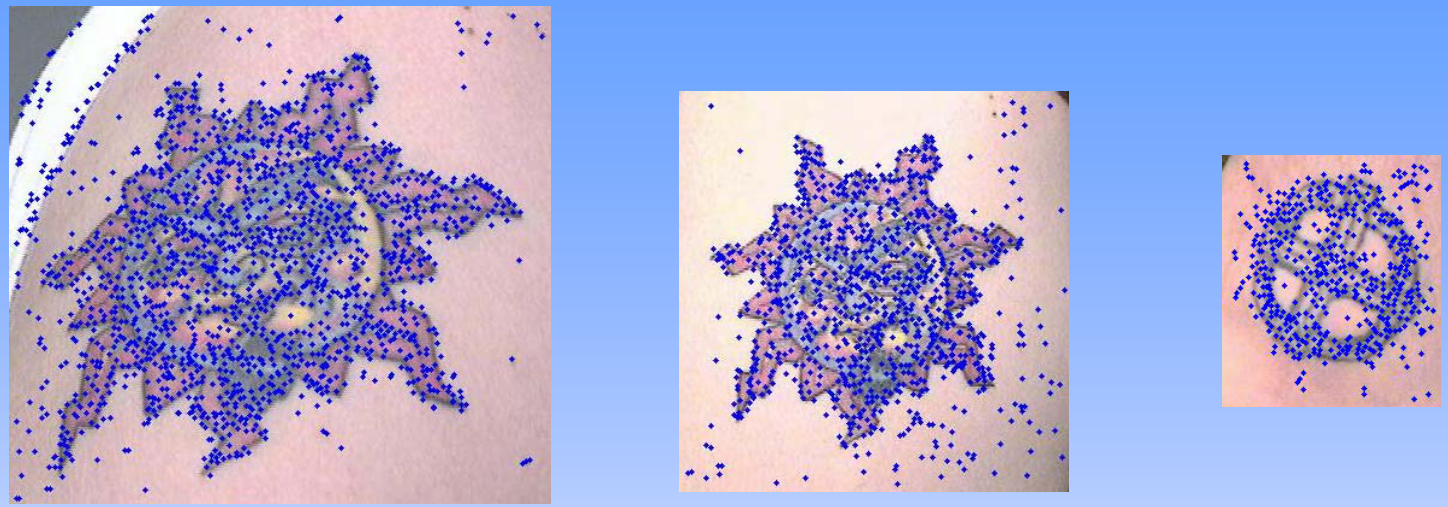


Texture

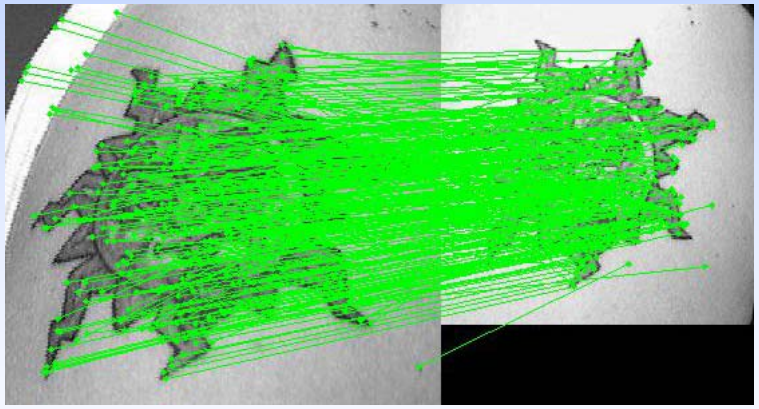


Shape

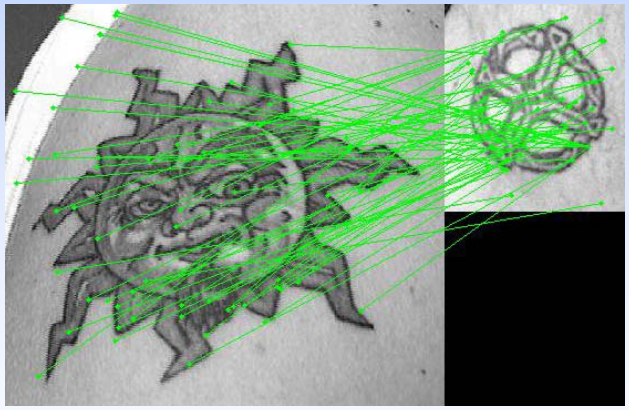
SIFT Keypoint Matching



SIFT keypoints



(a) 370

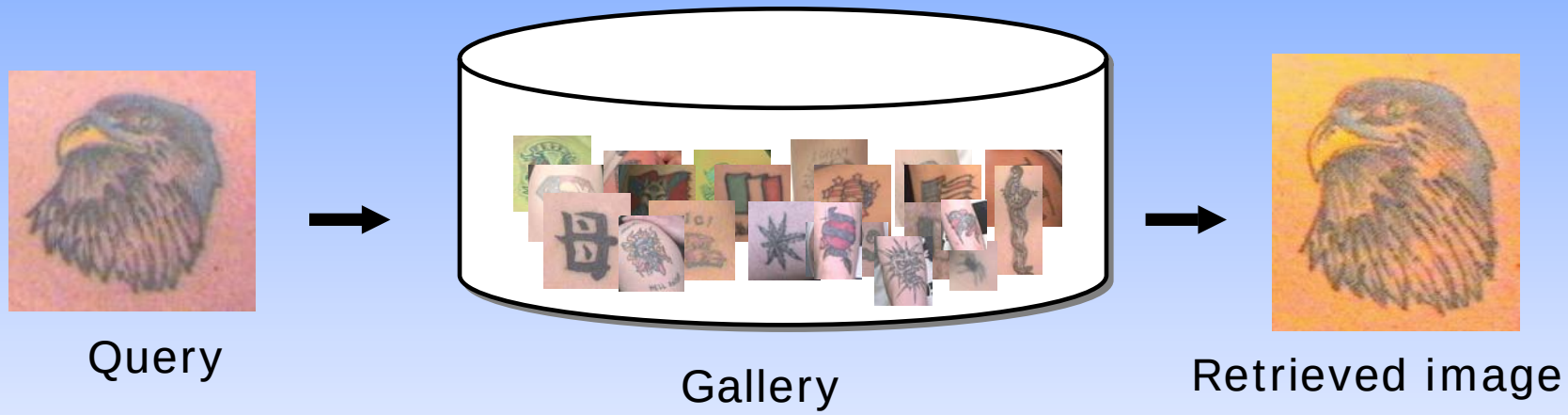


(b) 64

Numbers of matching points between (a) similar and (b) different images

Retrieval Experiment

- Duplicate tattoos used as queries
  - Query: 500 duplicates; Gallery: 11,000 images



- Rank-1 accuracy = 91.2%
- Rank-20 accuracy = 96.7%

Retrieval Examples

Query

Top-7 Retrieved Images with no. of matching keypoints

Difficult Queries

Rank 539

Rank 6684

Rank 1106

Rank 4046

Rank 1419

Rank 2432

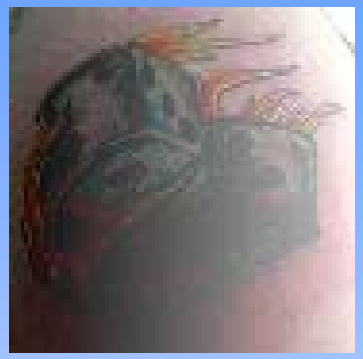
Future Work

- Utilize ANSI/NIST labels
- Image enhancement
- Large body tattoos
- Automatic annotation
- Relevance feedback
- Database filtering

Image Enhancement

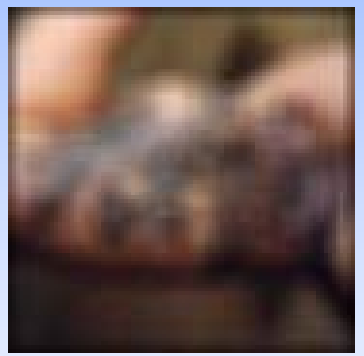
(a) 542

(a') 1

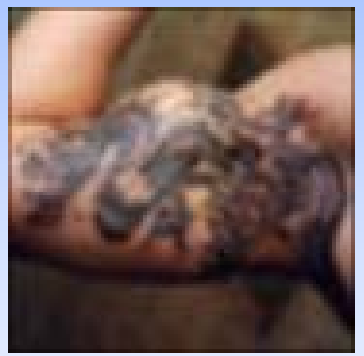


(b) 78

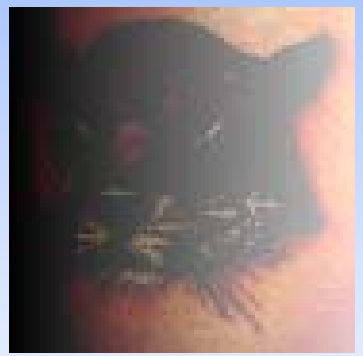
(b') 12



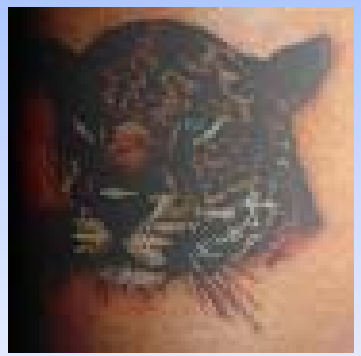
(c) 2342



(c') 172



(d) 1942

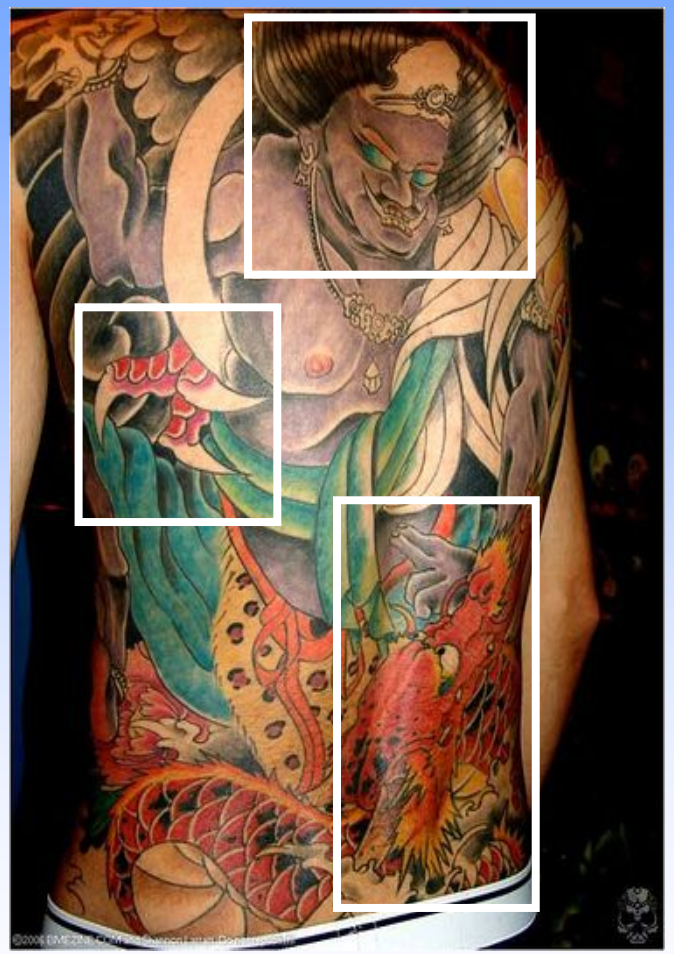


(d') 8

Degraded images (a,b,c,d) and ranks at which correct retrieval was found. Performance improves after enhancement (a', b', c', d')

Large Body Tattoos

- Tattoo may cover large area; query may cover only small portion



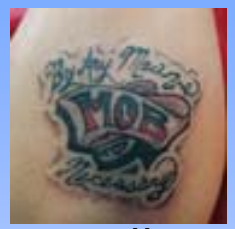
Automatic Annotation

- Use a training set to annotate tattoo database

Object
Fire
Wording

Symbol
Other
Fire

Other
Symbol
Fire



Wording
Object

Symbol
Animal

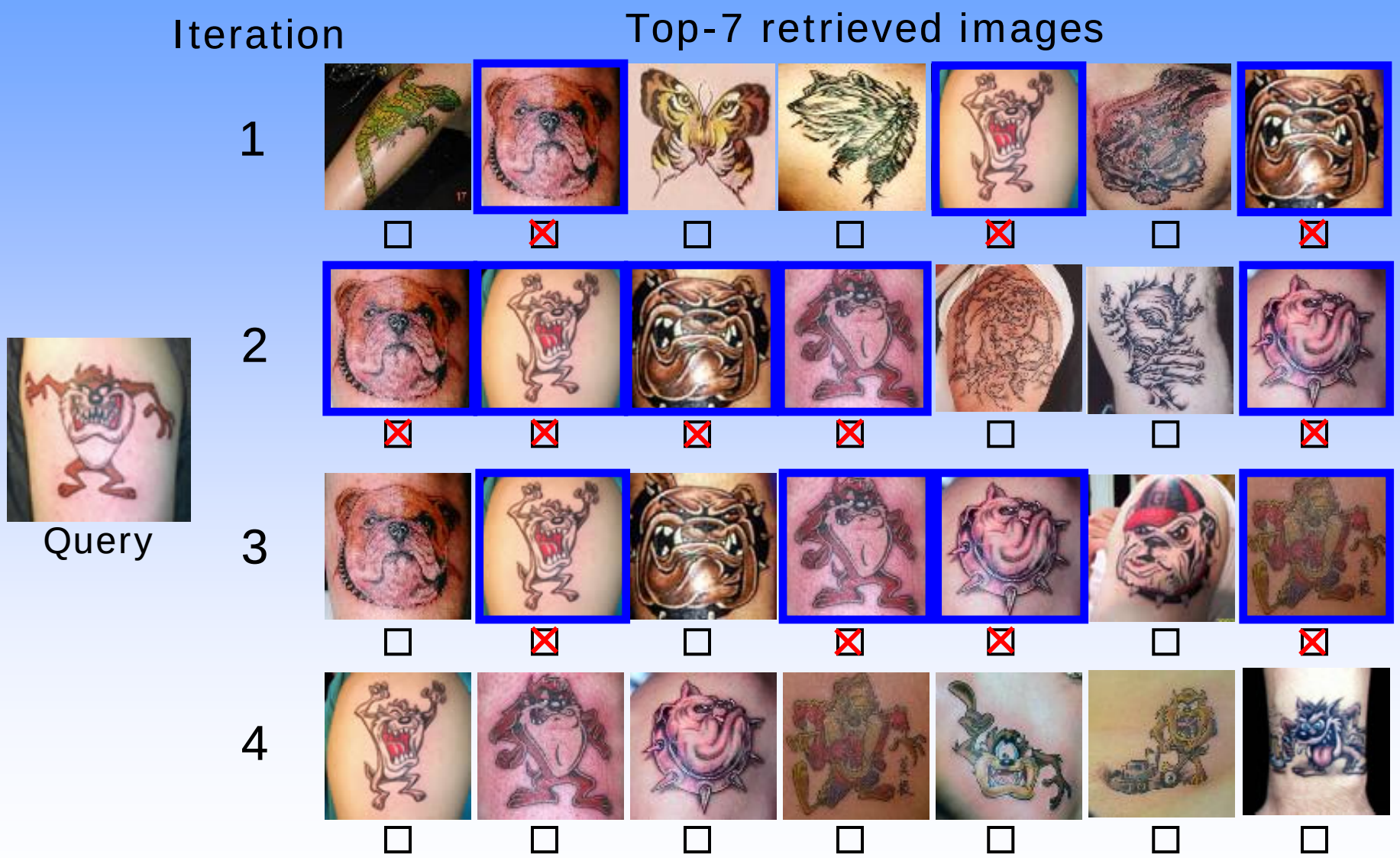
Animal
Object
Star

Object
Symbol
Fire
Star

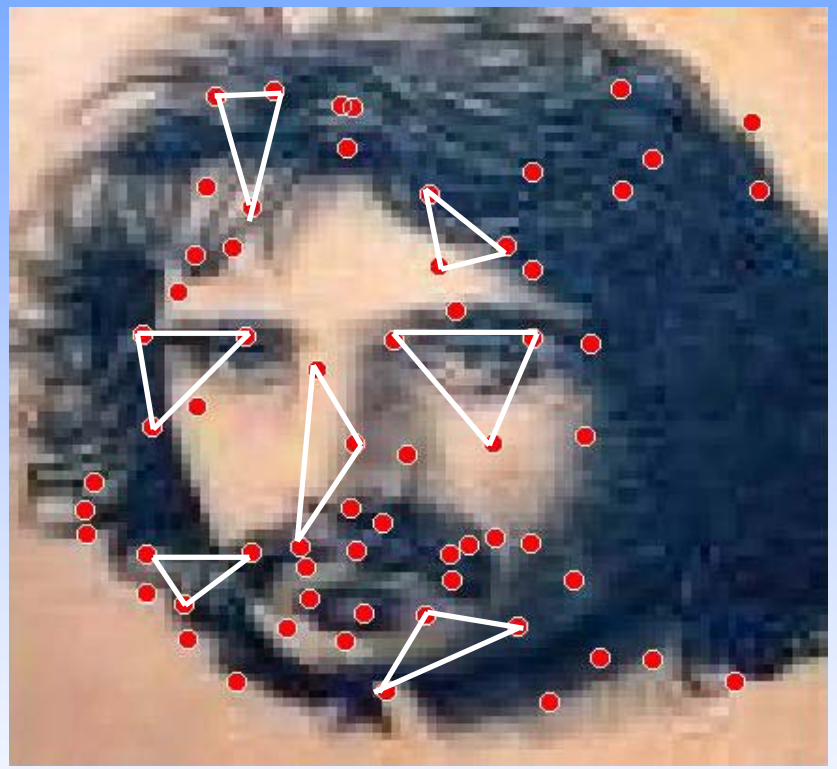
Human
Role

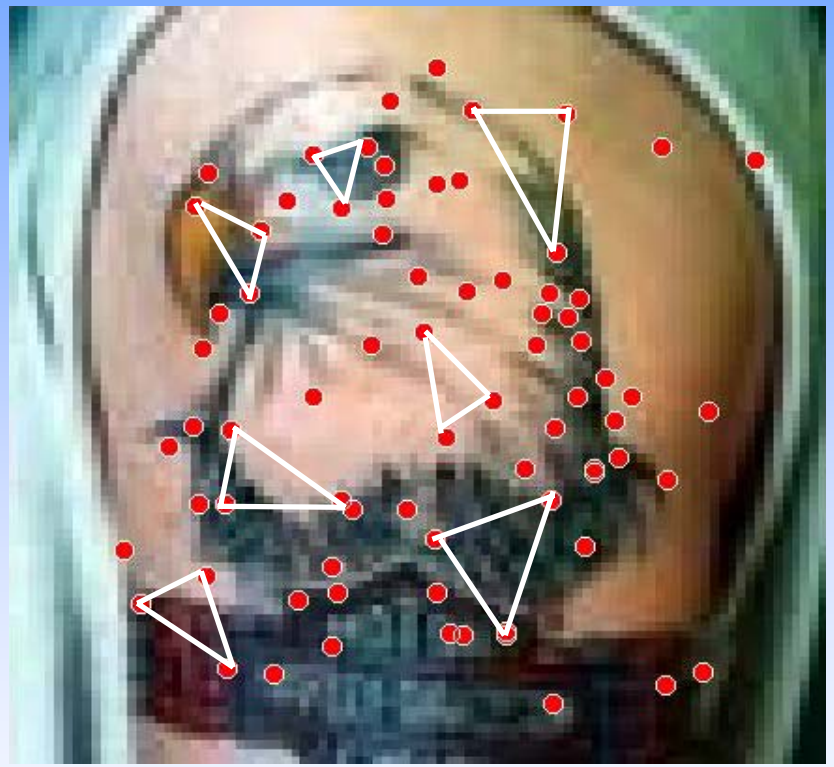
?

Relevance Feedback



Database Filtering





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