

Graffiti-ID: Matching and Retrieval of Graffiti Images

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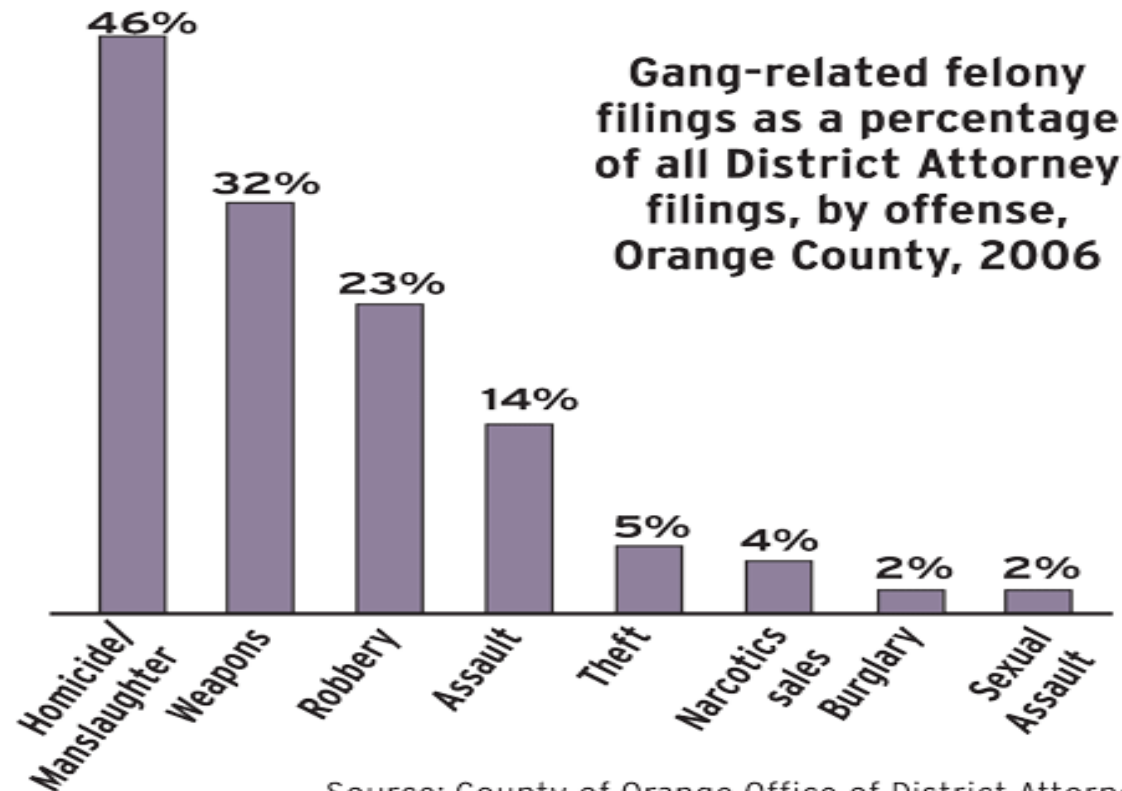
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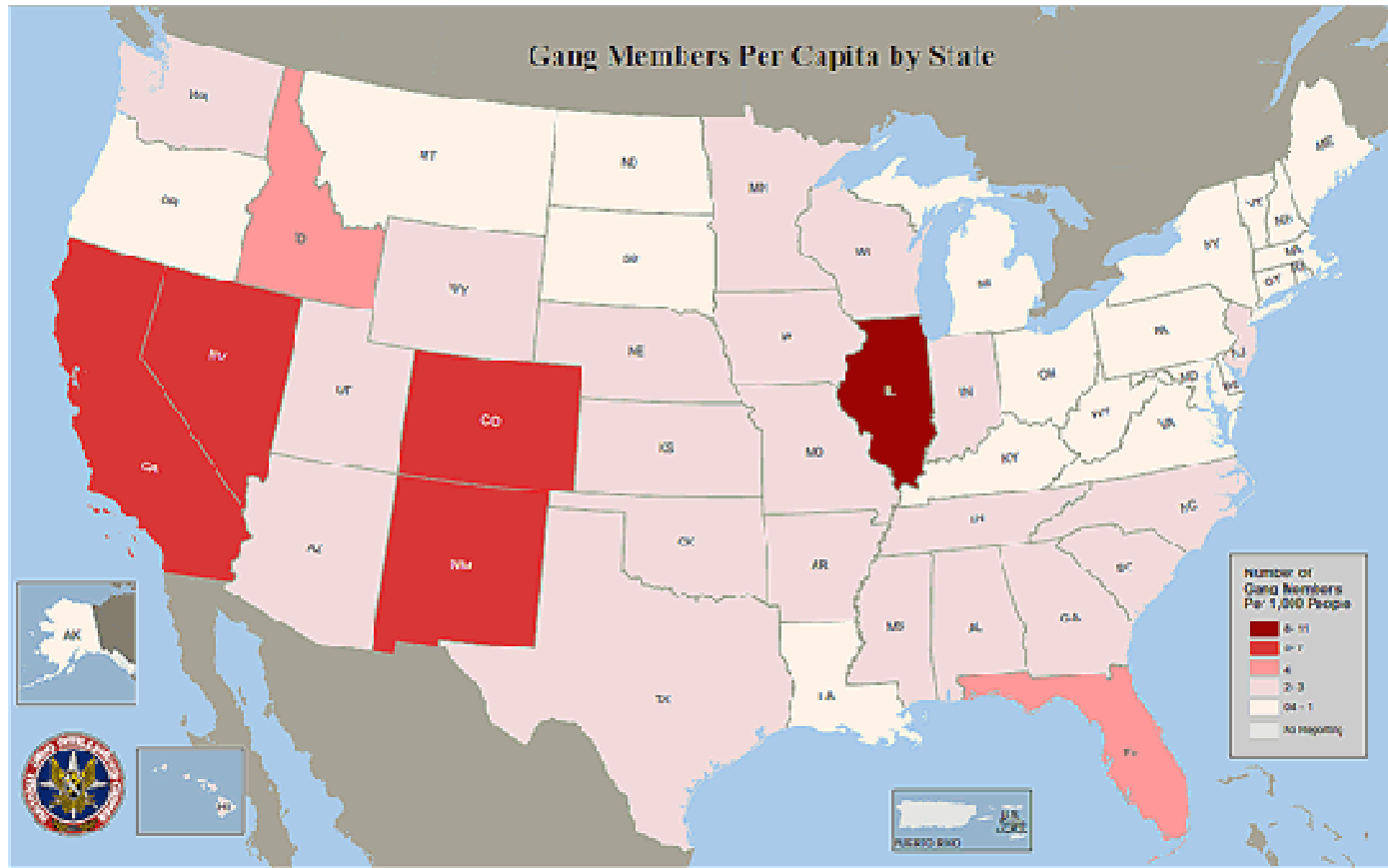
Gang Crimes

- Gang-related crimes are rapidly growing; they account for **~80 % of the crimes** in the United States
- *“The ferocity of the thuggery has surged; ... the fighting has become **more codeless, more arbitrary and more brutal than ever.**”*



Source: County of Orange Office of District Attorney

Gangs in the United States



- Illinois has **~10 gang members** per 1,000 residents
- California, Colorado, Nevada, and New Mexico have **~6 gang members** per 1,000 residents

(Source: National Drug Threat Survey 2008; field program specialist field surveys of state and local law enforcement 2008; and U.S. Census population estimates 2006.)

MS-13 Gang

- MS-13 is one of the largest street gangs; ~50K members worldwide and ~10K in the U.S.
- The gang is known for its highly violent ways, including drugs & weapons, robbery, extortion and murder



(a)



(b)



(c)



(d)

Representing Gang membership of MS-13:

(a) hand signal (b) tattoo (c) symbol and (d) graffiti

Graffiti

- Any type of public marking from simple written words to elaborate wall paintings
- Used to communicate social/political messages



(a)



(b)



(c)

Examples of Graffiti: (a) Pagan graffiti depicting a man worshipping a crucified donkey dated the second century. The words are translated as “Alexamenous respects God”. It is presumed to be making fun of a Christian Soldier; (b) Protest of the dissolution of George W. Bush’s 2004 decision to delete WhiteHouse.gov; (c) Modern artistic graffiti.

Gang Graffiti

- Used to transmit messages, symbolize gang's power, advertise drug sale and declare territorial boundaries
 - Gangs use graffiti as a “newspaper”, or “bulletin board”
- Graffiti indicates gang activity in a community
 - If graffiti is not erased, generally more graffiti follow
 - **Broken Window Theory**: If a broken window is left unfixed, it encourages more crime and vandalism in the neighborhood
 - Identification of gang graffiti can assist in **uncovering the extent of a gang's territory** and **understanding criminal intention**

Gang Graffiti



African-American gang graffiti of the Six Duce East Coast Crips of Los Angeles. The bottom left of the image depicts the gang's animosity towards the police in the inscriptions "Police K" and "LAPD 187." The "K" means Killer and "LAPD" stands for the Los Angeles Police Department and "187" means murder, from the California penal code. Law enforcement agencies view these writings as direct threats.

Automatic Graffiti Matching

- Given a graffiti **query**, find the top-N **visually similar** images in the graffiti database

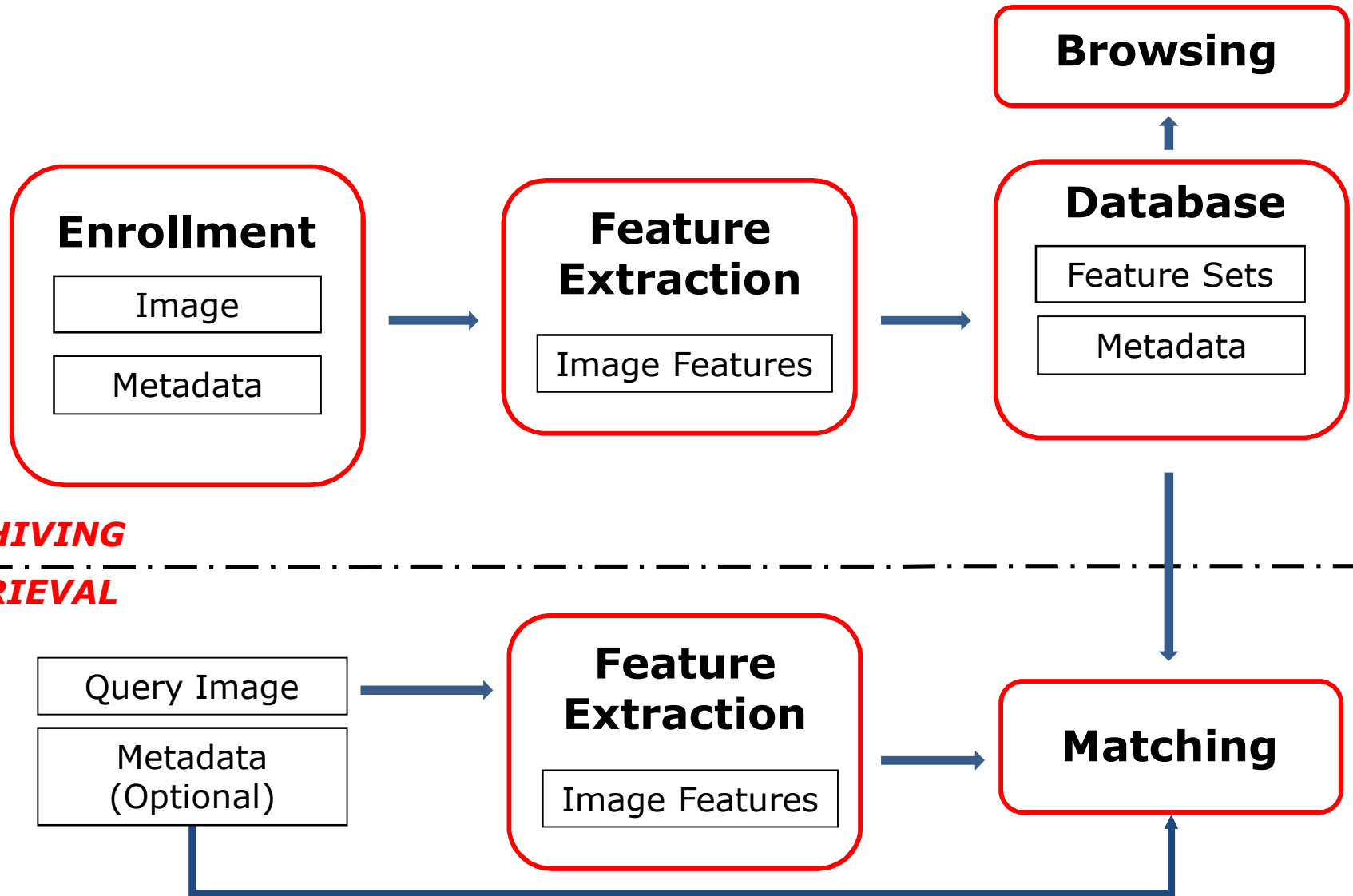


Query



Retrieved images

Graffiti-ID System



Database: Web-DB

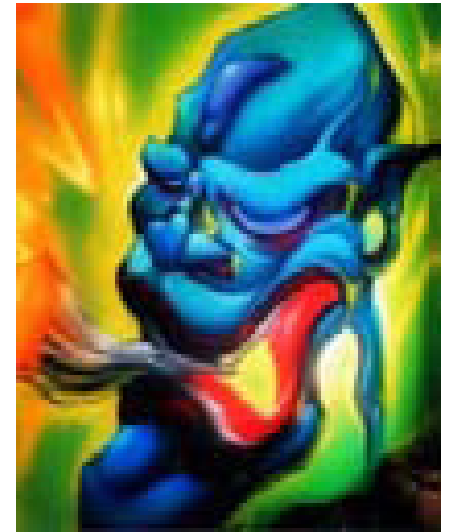
- 1,265 images downloaded from the Web
- Classified into two groups
 - 198 gang-related (“tags”): Mostly lines & letters with plain colors
 - 1,067 general graffiti: wall paintings with rich colors and textures



(a)



(b)



Examples of graffiti images in Web-DB: (a) gang-related (tags) and (b) general graffiti images

Database: CAL-DB

- Contains 5,000 graffiti from the city of Riverside, CA
- These images are not of as good quality as web-DB
- ~15% of the images have duplicates (i.e., two or more instances of the same graffiti)



(a)



(b)



(c)

Examples of (a) good, (b) bad and (c) ugly graffiti in CAL-DB

Graffiti in CAL-DB



5,000 color images (1280x960)

Image Features

- Scale Invariant Feature Transform (SIFT) is used to extract distinctive and salient feature points
- SIFT is invariant to image scale & rotation; robust to distortion, view point, noise & illumination



(a) 266



(b) 678

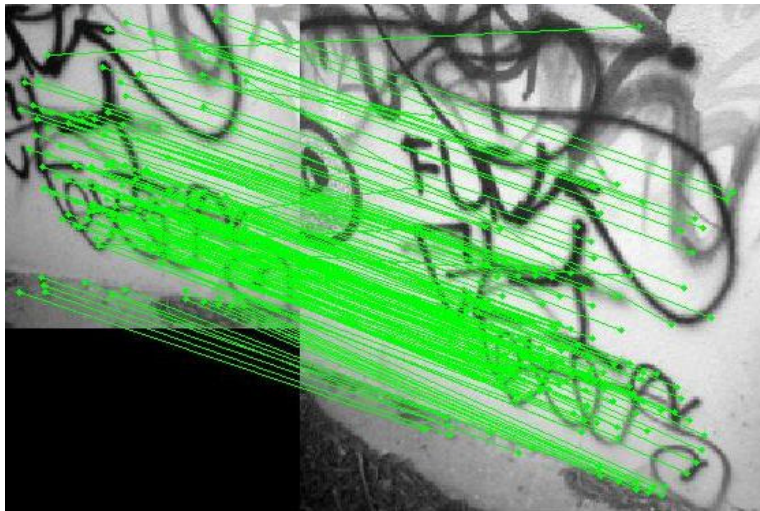


(c) 247

Examples of SIFT keypoints in graffiti

Keypoint Matching

- Find the **nearest neighbor** of each query keypoint in the gallery image



(a) 185

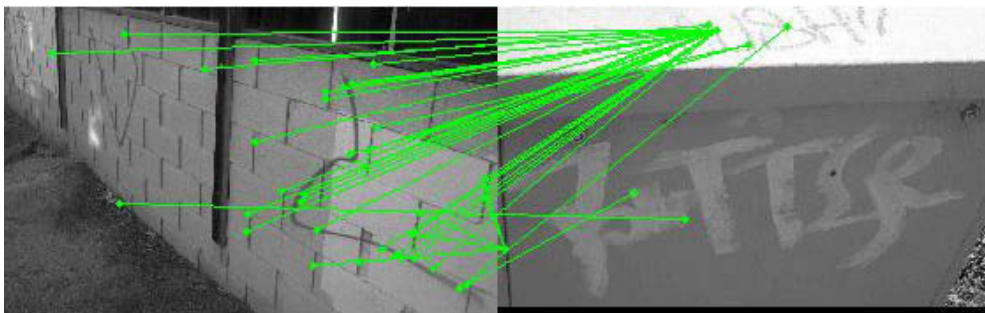


(b) 10

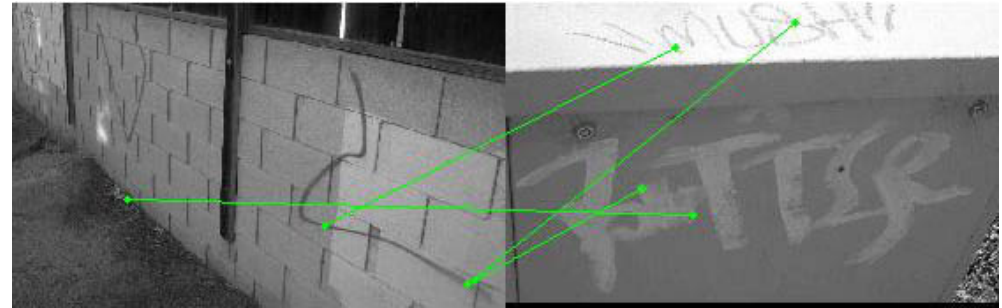
Matching (a) two similar and (b) different graffiti images with matching scores

Constrained Keypoint Matching

- Multiple keypoints in a query could be matched to a single keypoint in a gallery image
- Local geometric constraints reduce no. of false matches
 - If area covered by multiple keypoints is larger than a threshold t , they are regarded as false matching



(a) 45



(b) 4

Matching (a) without and (b) with geometric constraints along with the match score

Matching Example (Same graffiti)



Matching Example (Different graffiti)



Retrieval Experiments

	Query Size	Gallery Size
Web-DB	792 synthetically generated queries	1,265
CAL-DB	200 duplicates	4,999

Avg. time is **1.08 sec** for feature extraction and **27.33 sec** for matching.
(on Intel Core 2, 2.66 GHz, 3 GB RAM processor)



(a)



(b)



(c)



(d)

TPS is applied to a graffiti in Web-DB (a) to generate queries (b), (c) and (d)



(a)

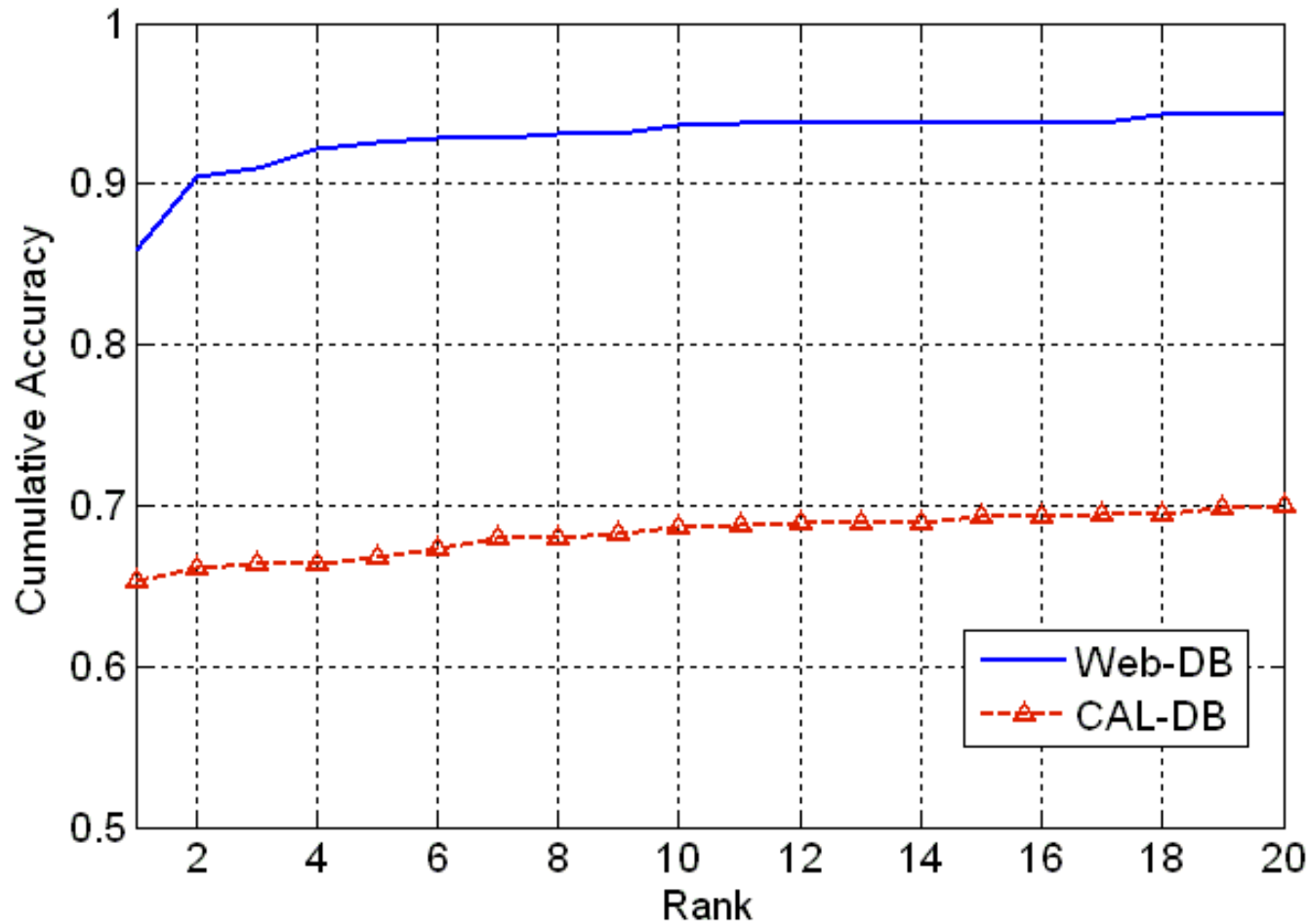


(b)



Two examples of duplicates in CAL-DB

Retrieval Accuracy



Performance on CAL-DB reflects the lower quality graffiti it contains (low resolution and severe viewpoint change)

Successful Retrievals



Query 1 (782)



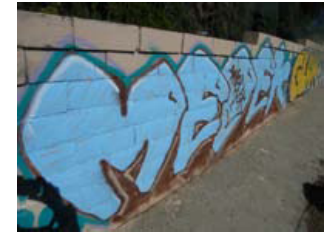
178



54



48



48



45



44



44



44



44



Query 2 (118)



56



54



19



19



19



18



18



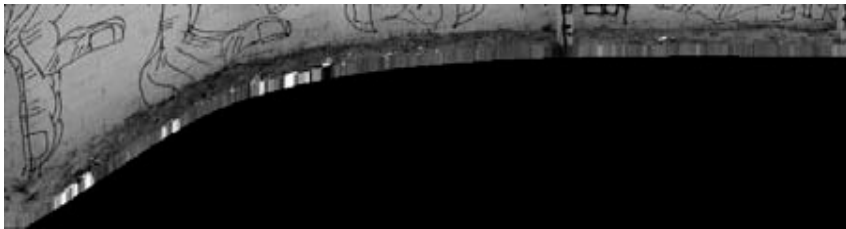
18



18

Each example shows a query with the number of keypoints and top-9 retrieved images with the match score. The red circles indicate the duplicate graffiti present in the image

Failed Matches (Not in Top-20)



(a)



(b)

The correct duplicate of query (a) was retrieved at rank 42 (b)



(c)



(d)



(e)



(f)

Examples of large size differences ((c) and (d)) and large viewpoint differences ((e) and (f)) between two duplicate image pairs in CAL-DB. The red circles indicate graffiti

Summary and Future Work

- Developed a prototype image-based graffiti matching and retrieval system
- Performance on a small operational database is encouraging
- Need to develop more robust features and matching algorithm
- Adopt an indexing scheme to improve the retrieval efficiency for large databases

Need your help in expanding our graffiti database!