



Master in Computer Vision *Barcelona*

Module: M1

Project: Content Based Image Retrieval

Coordinator: Ramon Morros, Verónica Vilaplana

M1 – Content Based Image Retrieval

- **Main goal**

- To learn the basic concepts and techniques to build a simple query by example retrieval system for finding paintings in a museum image collection.



Can Framis
museum dataset

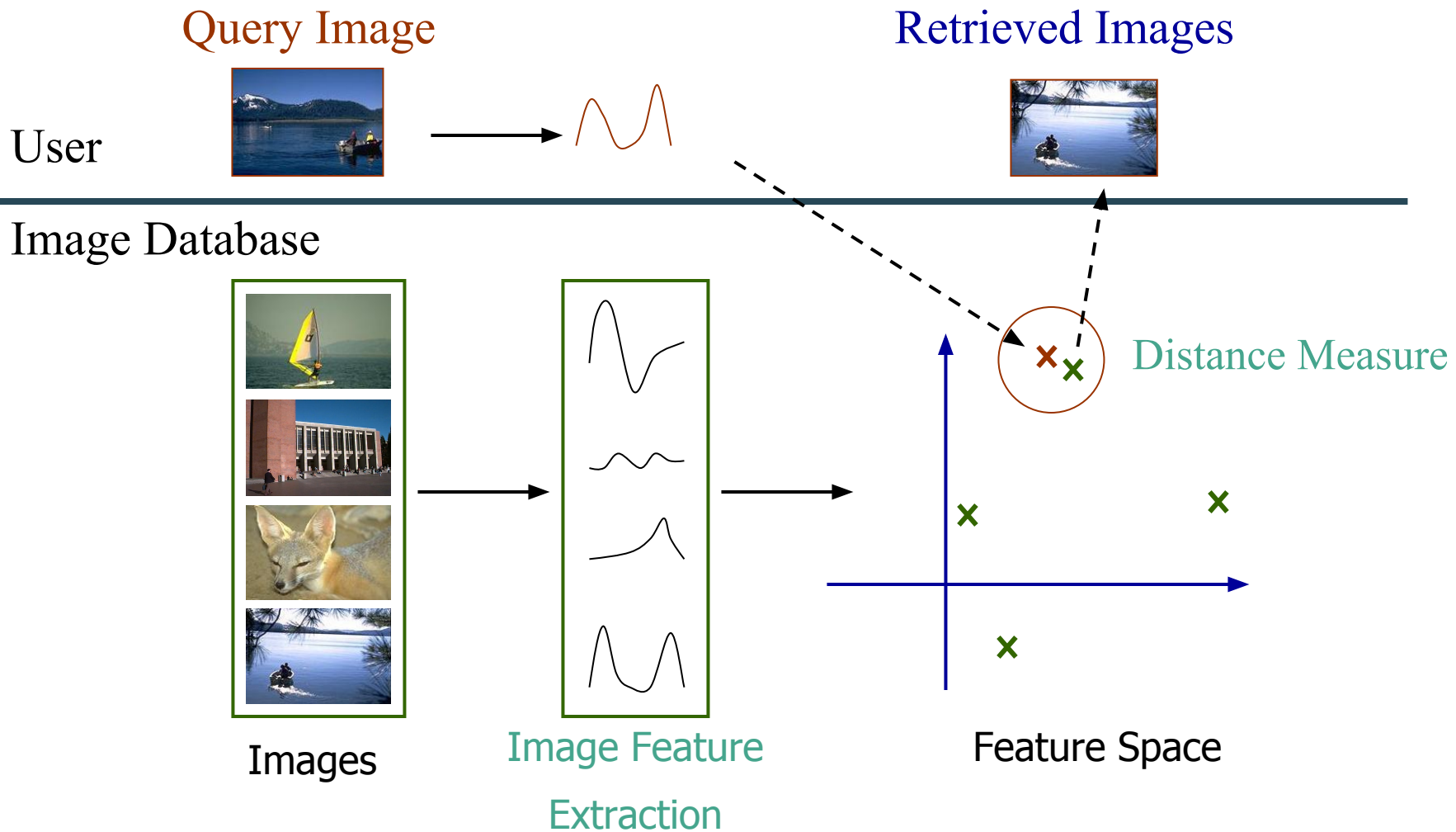
- **Scope**

- Image retrieval based on color, texture, textual information
- Image retrieval based on keypoints and local descriptors
- Denoising, orientation correction and picture cropping
- Morphological filters to detect and remove overlying text from images
- Evaluation of system performance

- **Applicability**

- Almost any (small) query by example problem

M1 – Content Based Image Retrieval



M1 – Content based image retrieval

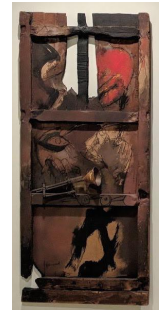
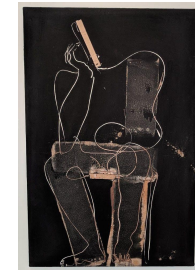
- **Goal:** search images from a large image database (DB) based on visual contents
- **Similarity:** based on visual features: color, shape texture
 - e.g. color:
 - how to characterize ‘color’?
 - how to measure ‘color similarity’?
- **CBIR steps:**
 - Index the DB: generate descriptors (e.g. histograms) for all images; this can be done offline
 - Extract features from the query image (e.g. compute histogram)
 - Compute distances between descriptors from the query image and each DB image descriptor, and order the DB images according these distances

M1 – Dataset

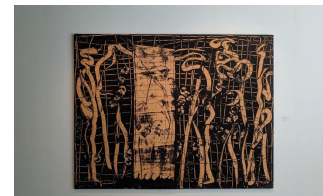
- **Paintings dataset**



- **Query set 1 (QS1):** cropped images, almost no rotation



- **Query set 2 (QS2):** uncropped image (background)



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- Given the museum and the query dataset.
For each image in the query dataset, retrieve the K most similar images in the Museum dataset, ordered by score
- Image descriptor: image gray-level / color histograms (1D)

Task 1: Create Museum and query image descriptors (BBDD & QS1)

Task 2: Implement / compute similarity measures to compare images

Task 3: Implement retrieval system (retrieve top K results)

Task 4: Evaluation using map@k

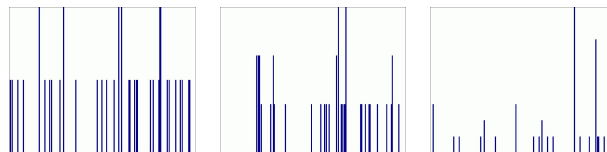
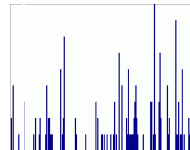
Task 5: Background removal using color (QS2). Compute descriptor on foreground (painting)

Task 6: Evaluation of picture masks and retrieval system (QS2)

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Task1: Compute image descriptors (QS1)

- Color Histogram:
 - gray level / concatenate color component histograms
 - color space RGB, CieLab, YCbCr, HSV



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Task 2: similarity measures

- Euclidean distance
- L1 distance
- χ^2 distance
- Histogram intersection (similarity)
- Hellinger kernel (similarity)
- ...

$$D(h_1, h_2) = \sqrt{\sum_{i=1}^N (h_1(i) - h_2(i))^2}$$

$$D(h_1, h_2) = \sum_{i=1}^N |h_1(i) - h_2(i)|$$

$$D(h_1, h_2) = \sum_{i=1}^N \frac{(h_1(i) - h_2(i))^2}{h_1(i) + h_2(i)}$$

$$I(h_1, h_2) = \sum_i^N \min(h_1(i), h_2(i))$$

$$K(h_1, h_2) = \sum_{i=1}^N \sqrt{h_1(i) h_2(i)}$$

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Task 3: For each image in QS1, compute similarities to museum images

Task 4: Evaluation

- Return the top k images (highest score, lowest distance)
- Evaluation with MAP@k (Mean Average precision at K)
 - Average precision computed for each query
 - Mean over all queries

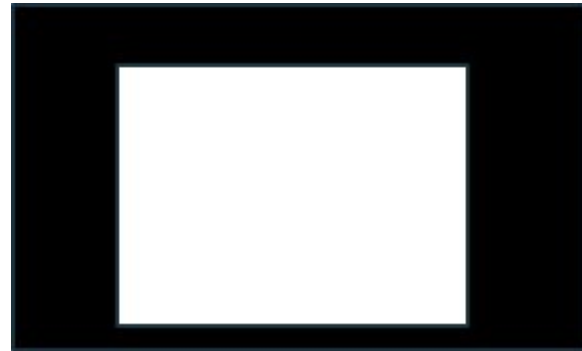
Metric available at: <https://github.com/benhamner/Metrics>

$$AP@K = \frac{\sum_{i=1}^K P@i}{K}$$

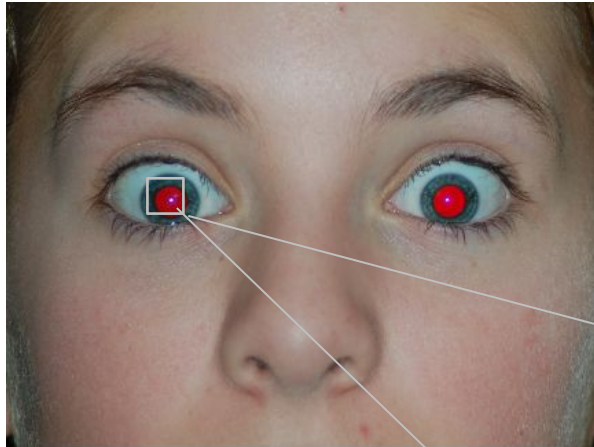
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Task 5: For each image in the QS2, remove background **using the background color** (e.g. model background distribution, color thresholds)

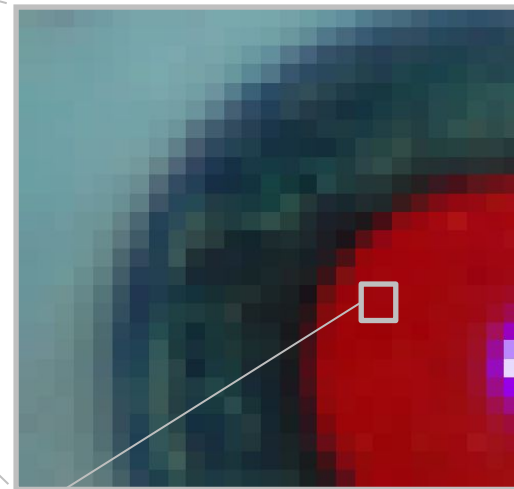
- Create a binary mask to evaluate the method
- Compute the descriptors on the foreground pixels.
- Do not use contour detectors, object detectors, etc. Just color!



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EXAMPLE SEGMENTATION



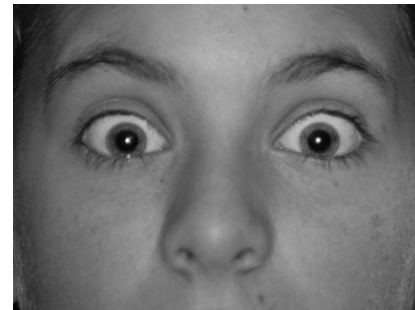
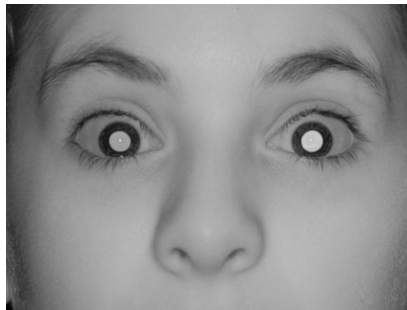
Pixel value can be between 0 and 255 (in a typical 8 bits/channel image)
This pixel is (R,G,B)=(169,5,9)

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EXAMPLE SEGMENTATION

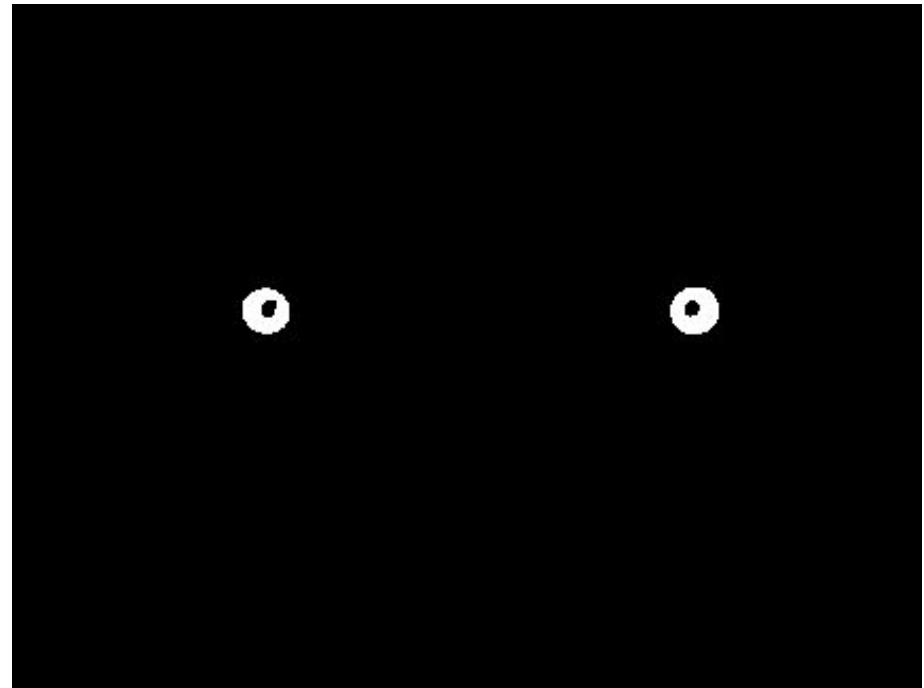
```
im = imageio.imread('BoldRedEye.jpg');
```

```
mask =  $\underbrace{im[:, :, 0] > 100}_{\text{Red channel}} \ \& \ \underbrace{im[:, :, 1] < 50}_{\text{Green channel}} \ \& \ \underbrace{im[:, :, 2] < 50}_{\text{Blue channel}};$ 
```



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EXAMPLE SEGMENTATION



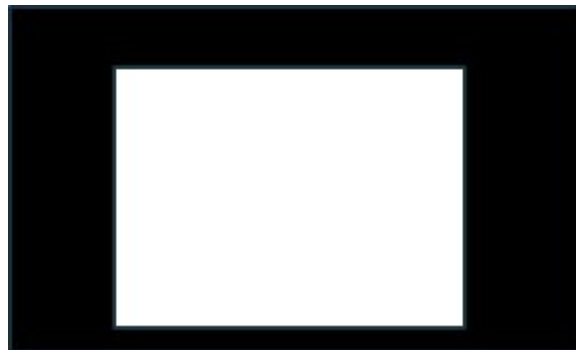
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Task 6: Evaluation

- For background removal: precision, recall, F1

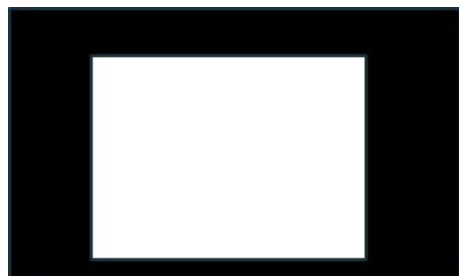


- For retrieval system: MAP@k (Mean Average precision at K)

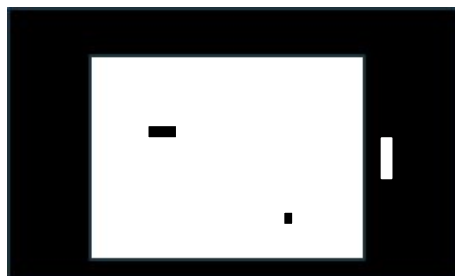


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Mask evaluation using precision, recall and F1-measure



annotation (A)



result1 (O)

Precision

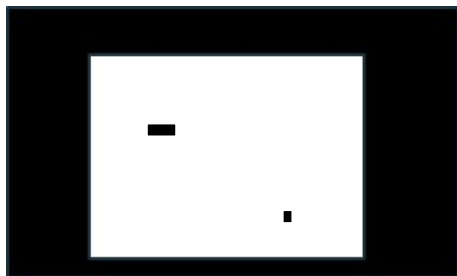
$$P = \frac{TP}{TP + FP}$$

Recall

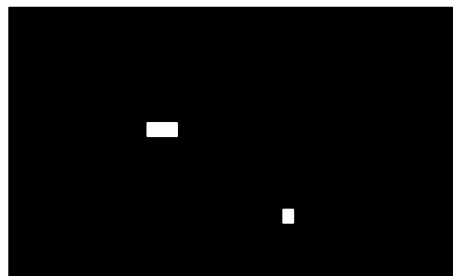
$$R = \frac{TP}{TP + FN}$$

F1-measure

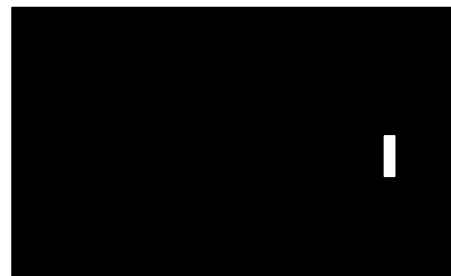
$$F_1 = 2 \frac{PR}{P + R}$$



*True Positive
(TP) = A & O*



*False Negative
(FN) = A & ¬O*



*False Positive (FP)
= ¬A & O*



*True Negative (TN)
= ¬A & ¬O*

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	map@1	map@5
Method 1		
Method 2		
Method 3		

Provide map@k (k=1, k=5) results for the validation query sets 1&2 (QSD1 & QSD2)

	Precision	Recall	F1-mesure
Method 1			
Method 2			
Method 3			

Provide results for the validation query set 2 (QSD2)

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Query sets:

There will be four query sets:

- Two for development (QSD1, QSD2), **already available**
 - Ground truth provided: correspondences & masks
 - Results for these query sets must appear on the slides
- Two for test (QST1, QST2), **released on Friday (October 15) at 10h**
 - Ground truth not provided
 - Teams submit ‘blind’ results for these query sets and we score them automatically

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Submissions:

- For each test query in $QST\{1,2\}$, a list of the $K=10$ best results:
 - Create a python **list of lists**, with the image ids (integer numbers)
 - Example with 3 queries and $k=2$
Query: `[[q1], [q2], [q3]]`
Result: `[[7,2], [76, 4], [43, 12]]`
where 7 corresponds to image 00007.jpg, etc.

Note: Deliver pkl files to GDrive folder:

TeamX/week1/QST1/**method1**/result.pkl

TeamX/week1/QST1/**method2**/result.pkl

- For QST2, the binary masks must also be submitted
TeamX/week1/QST2/**method1**/result.pkl, *.png
TeamX/week1/QST2/**method2**/result.pkl, *.png
- Submit progress slides
- **Deadline results and slides: Friday 15 Oct 2021 at 16:00**
- **Deadline questions to teams: Monday 18 Oct 2021 at 12:00**