Exploiting Contextual Information for Image Re-Ranking

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Abstract. We present a novel re-ranking approach based on contextual information used to improve the effectiveness of Content-Based Image Retrieval (CBIR) tasks. In our approach, image processing techniques are applied to ranked lists defined by CBIR descriptors. Conducted experiments involving shape, color, and texture descriptors demonstrate the effectiveness of the method.

1. Introduction

Basically, given a query image, a CBIR system aims at *retrieving the most similar images* in a collection by taking into account image visual properties (such as, shape, color, and texture). Collection images are ranked in decreasing order of similarity, according to a given image descriptor.

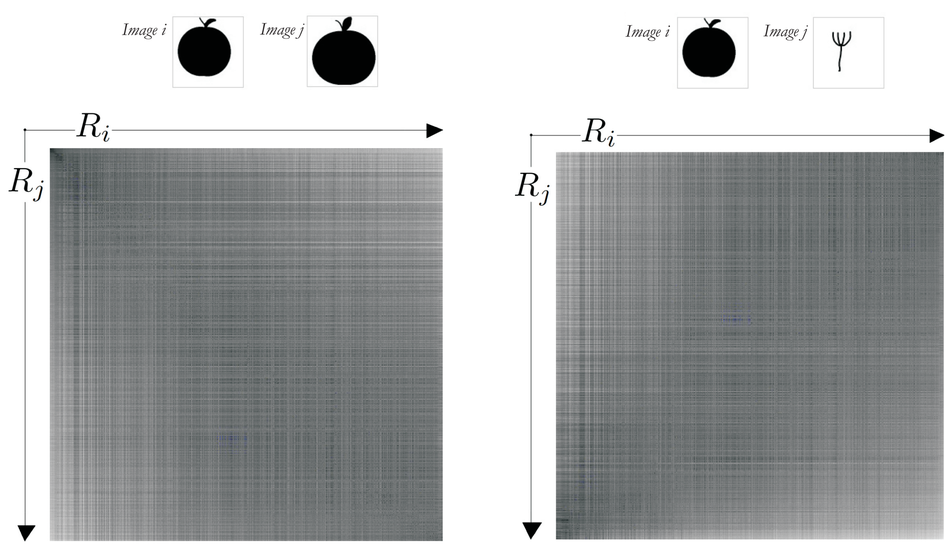
However, in general, these approaches perform only *pairwise image analysis* and compute similarity (or distance) measures considering only pair of images, ignoring the rich information encoded in the *relations among several images*.

We present a new post-processing method that re-ranks images by taking into account *contextual information*. The use of *image processing techniques* for contextual information representation and processing is the main novelty of our work.

2. Contextual Information

- **Objective:**
  Given two reference images img_i and img_j, to construct a *Context Image* $\hat{I}$ for exploiting contextual information

- **The Context Image Î:**
  Consider two reference images img_i and img_j and their ranked lists R_i and R_j.
  The Context Image Î is given by a *gray scale image*, where the axis of the image are ordered according to the order defined by ranked lists R_i and R_j.
  Each pixel represent the distance (normalized in interval [0,255]) between images defined by ranked lists.



- **Similar Images:**
  Dark region at the top left corner of context image.

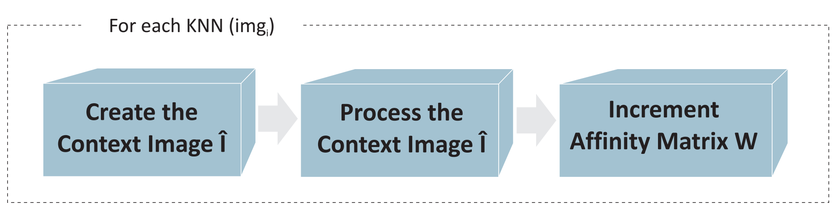
3. Re-Ranking Algorithm

- **Iterative Algorithm:**
  For each iteration, an affinity matrix W and a new distance matrix A_{t+1} is computed
- **Context Image Î:**
  A *context image* is constructed for each KNN of each collection image
- **Computing the affinity matrix W:**
  Image processing techniques are applied to context image for analyzing contextual information and incrementing affinity matrix W

- **Algorithm Outline:**

Perform along T iteractions:

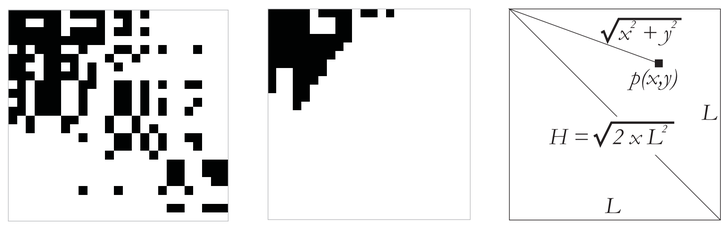
For each collection image: img_i



Compute Distance Matrix A_{t+1} *(from Affinity Matrix W)*

Perform Re-Ranking *(based on A_T)*

- **Processing Context Image:**
  1. Limiarization
  2. Median Filter
  3. Incrementing Affinity Matrix W



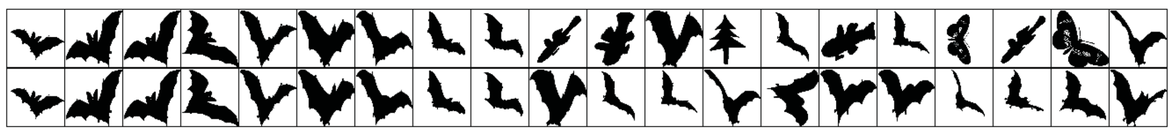
- Incrementing Affinity Matrix W:

$$W[imgj_x, imgi_y] = W[imgi_x, imgi_y] + [(K - k)(H / \sqrt{x^2 + y^2})]$$

where (x,y) represents the pixel posistion, k the current neighbor, K the number of neighbors to be considered and H the diagonal size of top left region of context image being processed.

4. Experimental Results

- **Shape Descriptors:**
  Dataset: MPEG-7

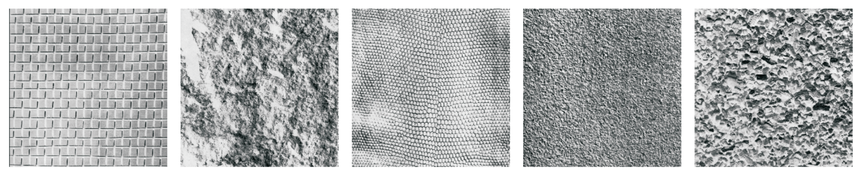


- **Results** *(Recall@40)*:

Algorithm	Descriptor	Score[%]	Gain
CFD	-	84.33%	-
IDSC+DP	-	85.40%	-
Graph Transduction	IDSC+DP	91.00%	+6.56%
Distance Optimization	CFD	92.56%	+9.63%
Constrained Diffusion Process	IDSC+DP	93.32%	9.27%
Mutual kNN Graph	IDSC+DP	93.40%	9.37%
Contextual Re-Ranking	**CFD**	**94.55%**	**11.99%**

- **Color and Texture Descriptors:**
  Color Dataset: Soccer Dataset

  Texture Dataset: Brodatz Dataset



- **Results** *(MAP)*:

Descritor	Type	Dataset	Score[%]	Contextual Re-Ranking	Gain
SS	Shape	MPEG-7	37.67%	43.23%	**+14.75%**
BAS	Shape	MPEG-7	71.52%	75.88%	**+6.09%**
ISC+DP	Shape	MPEG-7	81.70%	86.65%	**+4.83%**
CFD	Shape	MPEG-7	80.71%	91.28%	**+13.09%**
GCH	Color	Soccer Dataset	32.24%	32.52%	**+0.87%**
ACC	Color	Soccer Dataset	37.23%	39.05%	**+4.89%**
BIC	Color	Soccer Dataset	39.26%	41.8%	**+6.50%**
LBP	Texture	Brodatz	48.40%	49.59%	**+2.46%**
CCOM	Texture	Brodatz	57.57%	63.48%	**+10.27%**
LAS	Texture	Brodatz	75.15%	78.39%	**+4.31%**

5. Conclusions

Contributions:

- A new re-ranking method based on contextual information;
- Use of image processing techniques for analysing contextual information;
- Applicability of the method to several image retrieval tasks based on shape, color and texture descriptor;

6. Acknowledgment

Authors thank CAPES, FAPESP and CNPq for financial support. Authors also thank DGA/UNICAMP for its support in this work.