Coarse Detection and Fine Color Description for Region−Based Image Queries

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http://www-rocq.inria.fr/~fauqueur/ADCS/

Main Problems of Image Retrieval by Regions in generic image database:

How to automatically detect regions in an image?
− regions must correspond to areas of interest for the user
− regions must be visually characteristic

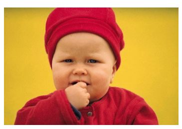
How to describe and compare their appearence?
− regions are more homogeneous than images:
−> a finer description must be found with a suitable similarity measure

Our approach: Coarse Detection and Fine Description

COARSE REGION DETECTION BY CLASSIFICATION OF LDQC's

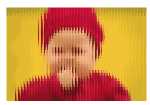
The region extraction is based on the classification of the **Local Distributions of Quantized Colors (LDQC's)** with CA (see 1).
The LDQC primitive naturally integrates the diversity of colors in large pixel neighbourhoods.
Besides global spatial information is integrated in segmentation process with the use of the Region Adjacency Graph (RAG).

Segmentation workflow:

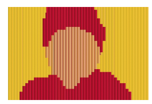


Original image

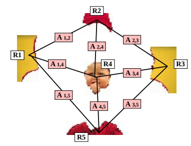
1. Image color quantization using CA (see 1)



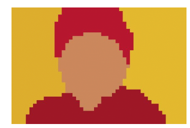
2. Computation of LDQC's



3. LDQC's classification using CA (see 1)



4. Image representation with a RAG for small regions removal



5. Image of detected regions

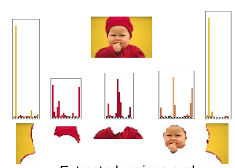
Final segmented image provides a few regions per image which have a discriminent visual "homogeneous diversity" for the user.

REGION DESCRIPTION − ADCS, A FINE COLOR VARIABILITY REGION DESCRIPTOR

Description

Classic color histograms represent only 200 colors (on average) among the millions of a full color space.
Regions contain less colors than entire images and require a finer color resolution to be distinguished from one another in the database.

We propose to describe regions' color variability by their **Adaptive Distribution of Color Shades (ADCS):**
The color shades are the relevant colors present in each region determined at a high resolution.
ADCS is more accurate and more compact than classic color histograms.

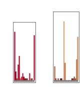


Extracted regions and their respective ADCS index

Retrieval

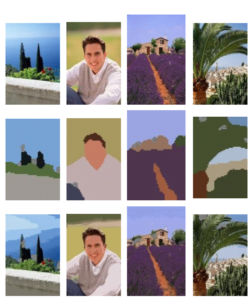
When matching regions, 2 given ADCS descriptors are compared using the color quadratic distance (see 2).

example of 2 ADCS to compare with the color quadratic distance:



RESULTS ON TEST DATABASE

Detection and description



original image

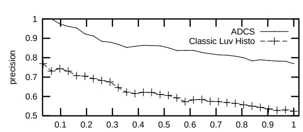
extracted regions with mean colors

image of regions with color shades used for indexing

More examples at: `http://www-rocq.inria.fr/~fauqueur/ADCS/`

Numerical results

total number of regions	15 248
images	2483
different color shades	168 912
regions / image	6
color shades / region	17



Retrievals of lavender regions:
ADCS index vs classic histogram

Region Retrieval

Retrieval from top−left lavender region

1: Competitive Agglomeration (CA) classification algorithm:

CA-classification minimizes the following functional J:
$J = \sum_{i=1}^{C} \sum_{j=1}^{N} u_{ij}^2 d^2(x_j, \beta_i) - \alpha \sum_{i=1}^{C} [\sum_{j=1}^{N} u_{ij}]^2$
with constraint $\sum_{i=1}^{C} u_{ij} = 1, \forall j \in \{1, ..., N\}$
output : C and $\{\beta_i, \forall i \in \{1, ..., C\}\}$

$\{x_j, \forall j \in \{1, ..., N\}\}$: data to clusterize
$\{\beta_i, \forall i \in \{1, ..., C\}\}$: prototypes to determine
$d(x_j, \beta_i)$: distance between data x_j and prototype β_i
u_{ij} : membership degree of feature point x_j to prototype β_i

determines automatically the optimal number of classes for a given classification granularity.

See: H. Frigui & R. Krishnapuram, "Clustering by competitive agglomeration", Pattern Recognition 1997

2: Color Quadratic Distance:

Unlike L1 or L2, it provides an accurate distance between two color distributions since the inter−bin similarity is taken into account.

original form:

$d_q(x, y)^2 = (x - y)^T A (x - y)$
where $A = [a_{ij}]$ gives the similarity between colors i and j: $a_{ij} = (1 - d_{ij}/d_{max})$,
where d_{ij} is the Euclidean distance in Luv space.

developed form:

$$d_q(X, Y)^2 = \sum_{i,j=1}^{n_X} p_i^X p_j^X a_{c_i^X c_j^X} + \sum_{i,j=1}^{n_Y} p_i^Y p_j^Y a_{c_i^Y c_j^Y} - 2 \sum_{i=1}^{n_X} \sum_{j=1}^{n_Y} p_i^X p_j^Y a_{c_i^X c_j^Y}$$

See: J. Hafner & al., "Efficient Color Histogram Indexing for Quadratic Form Distance Functions", PAMI 1995