Query Enrichment for Image Collections by Reuse of Classification Rules

Nicolas Spyratos[1], Peter Stanchev[2,3],
Krassimira Ivanova[2], Iliya Mitov[2]

1: Université Paris-Sud

2: Institute of Mathematics and Informatics, BAS, Bulgaria

3: Kettering University, Flint, USA

Abstract

User queries over image collections, based on semantic similarity, can be processed in several ways.

Here we propose to reuse the rules produced by rule-based classifiers in their recognition models as query pattern definitions for searching in image collections.

Reuse = "not reinventing the wheel"

- 1960s: macros and subroutines libraries
- main principle of today's object-oriented programming
- source code, components, development artifacts, patterns, templates…
- from program code to data content and user interaction

Rule-based Classifiers

They form a human comprehensive recognition model

- **decision trees**: in spite of their specifics, based on split-and-conquer techniques, their recognition model can easily be transformed into a set of rules.
- **decision rules**: the learned model is represented as a set of IF-THEN rules, produced on the basis of a depth-first induction strategy.
- **association rules**: they distinct strong associations between frequent patterns (conjunctions of attribute-value pairs) and class labels.

Image Retrieval

- Search:
  - by textual metadata
  - on the basis of their content (CBIR)
- Semantic gap:
  - user queries are based on semantic similarity
  - the computer processes low-level feature similarity

-> **higher level concepts** comprehensive by humans, but based on the processing of **low level features**

- Way for bridging this gap:
  - categorization algorithms that allow the system "to learn" how to make these decisions.

More precisely

The classification on a test dataset in an image collection supplied with low-level attribute metadata (MPEG-7, SIFT, ORB,...) using rule-based classifiers can produce quite good recognition results for some high-level semantic concepts (indoors-outdoors, scene types, artists' practices, emotional evokes, ...).

The set of produced rules in the recognition model can be interpreted as semantic profiles of corresponding class-labels.

We can use these sets as patterns in the query module, using the set of rules as disjunctive-conjunctive sequence of conditions, and naming them with the name of class-label.

In this way the user operates with well-known high-level concepts and this saves him the trouble of understanding and analysing the low-level features, captured by the image analysis.

Example

- 600 images representing Renaissance, Baroque, Romanticism and Impressionism.
- MPEG-7 descriptors - DC, SC, CL, CS, EH, HT.
  The low-level visual information consists of 339 values named with A1 to A339.
- Learning set of images (120) are labeled with high level semantic information - movement in which their techniques belong (other variants - “indoor/outdoor”, scene type, artists' name…)
- We provide 10-fold cross-validation over this learning dataset using BFTree Classifier (86.67% classification accuracy)

```
A64 < 9.5
|  A4 < -25.0: Romanticism
|  A4 >= -25.0: Baroque
A64 >= 9.5
|  A88 < 0.5
|  |  A23 < 2.5
|  |  |  A114 < 3.0: Romanticism
|  |  |  A114 >= 3.0: Impressionism
|  |  A23 >= 2.5
|  |  |  A206 < 1.5: Romanticism
|  |  |  A206 >= 1.5: Renaissance
|  A88 >= 0.5
|  |  A11 < -7.5: Renaissance
|  |  A11 >= -7.5: Impressionism
```

The recognition model, produced by BFTree

Transformed set of rules, used as query patterns

Query Name	Search Pattern
Renaissance like	(A64>=9.5) and (A88<0.5) and (A23>=2.5) and (A206>=1.5) or (A64>=9.5) and (A88>=0.5) and (A11<-7.5)
Baroque like	(A64<9.5) and (A4>=-25.0)
Romanticism like	(A64<9.5) and (A4<-25.0) or (A64>=9.5) and (A88<0.5) and (A23<2.5) and (A114<3.0) or (A64>=9.5) and (A88<0.5) and (A23>=2.5) and (A206<1.5)
Impressionism like	(A64>=9.5) and (A88<0.5) and (A23<2.5) and (A114>=3.0) or (A64>=9.5) and (A88>=0.5) and (A11>=-7.5)

Conclusion

The satisfaction of user queries, which are are based on semantic similarity can be achieved in at least three ways:

1) by supplying text annotations of the digital items by humans;
2) by trying to annotate automatically with concepts that are comprehensive by humans, based on the processing of low level features using different categorization algorithms; or
3) by using some advantages of the previous step dynamically:
   - not making an annotation in advance and storing metadata, which are not sure that will be used
   - but storing the query patterns that are formed as a result of previous test annotation (when showed enough recognition accuracy) and apply them only when the user query affects the defined concept.

Thank you for your attention!

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