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# Spatial Features Analysis of Automatically Annotated Images

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***Abstract***

*In this paper, a new method for spatial features based image retrieval is proposed. These are the features specifying location of an image segment in an image and relative spatial location between two image segments etc. Spatial feature adds extra capability of the system in addition to texture, color and shape based object recognition system. Heuristic and semantic features of the image segments are identified from low level color, texture descriptors and directly stored into the image database and easily retrieved also. Position of image segments in the image is detected and stored in the image database that will be accessed for retrieval process later. Object ontology is used to determine the spatial relation between heuristics. These spatial relations and corresponding concept are identified and stored. Spatial rank between two segments will be calculated and stored along with segment ids. Spatial rank is calculated by a new technique. Proper concepts are associated with image segment based on ontology based spatial relation.*

***Keywords:*** *Spatial feature, spatial relation, spatial rank, object ontology, heuristic feature, semantic based image retrieval*

## 1. Introduction

Spatial database stores spatial data like points, lines, polygons *etc.* Then spatial query can be executed from spatial database for retrieving information from multiple segments. Spatial index like R-tree, quad-tree based index on spatial database speed up database performance. So for small image objects in an image like eyes, nose, and mouth in a face, existing spatial database based approach is useful. But for automatically annotated images converting image segment to minimum bounding polygon is very difficult. If minimum bounding rectangle is used a lot of space of the rectangle may not contains segment portion. Hence exact execution of spatial query is not possible. Proposed system executed spatial queries on a database of automatically annotated image segments. Spatial feature is introduced with color and texture semantics of image retrieval method. This is a text query based image retrieval method. Proposed system will be able detect ratio of area between image segment with specific heuristic vs. complete image and location of image segment in an image. There are various techniques to identify spatial relationship among objects in an image like 2D String, 2D-C Strings technique *etc.* 2D String technique uses centroid of the objects for representing the relationship. 2D-C String technique overcomes the deficiencies of 2D Strings by representing the relationship among boundary of the objects. Proposed system will also find relative positions or spatial rank between image segments. Spatial rank is calculated using a new technique. Object ontology is used to describe semantic objects and relation between semantic objects. Object ontology can be applied for position of image objects and relative positions between image objects. Object ontology is useful for querying image objects where position is specified. Concept

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hierarchy can also be derived from object ontology. The system will create a concept relation from spatial relations among available heuristics in real world. This concept will be used for assigning concept to heuristic.

## 2. Related Work

The works on semantic based image retrieval [1-2] discusses about different semantics like heuristic, semantic color based image retrieval. Image segments are identified and proper heuristic and semantic color is associated with each segment. Semantic concepts can be mapped to low level descriptors [3]. These low level descriptors include color, texture, shape, absolute spatial arrangement, spatial coherency, and dimension. Vocabulary is defined for mapping low level descriptor values to intermediate level descriptor values. Techniques such as 2D string and 2D-C string [4] are used to represent the spatial relationship among objects. 2D string uses a set of relational operators {=, <, :} for specifying spatial relationship among image objects along the x-axes and y-axes. 2D-C string uses boundary of image objects instead of centroid of 2D string and introduce a new set of relational operators {<, =, |, %, [,], /}.

The spatial rank has the values from 1 to 9 as defined in 2D String. For example, rank 1 represents top of, rank 2 represents top-left of and so on.

| | | |
|---|---|---|
| 2 | 1 | 8 |
| 3 | 9 | 7 |
| 4 | 5 | 6 |

**Figure 1. Spatial Rank of Objects**

Techniques and systems for image and video retrieval [5,11] discusses spatial relationship (such as left of, inside, above) among objects in an image and how these relations have been employed. Different types of semantic queries are possible. In simple visual feature query, user has to specify the feature along with its percentage. In localized feature query, user has to specify the feature along with its position in the image. Position of an image object in an image is an important factor for region based image retrieval using object ontology [6]. Domain knowledge about spatial relations among objects [7] helps in consistent image classification. For example, “water above sky is not water” is domain knowledge. Fuzzy Multimedia Ontology [8] has been built using visual, conceptual, contextual and spatial knowledge about image concepts in order to model image semantics in an effective way. Contextual information is co-occurrence frequency of a pair of concepts like ‘sofa’ and ‘dining table’ in ‘living room’, whereas spatial relation is the relative position of concepts an image. Prototype [9] is also useful for categorizing images on the basis of semantic concepts. Prototype attributes hold information about which amount certain concept is presents in particular image category. For example, sand attribute of river/lake prototype is zero, but sand attribute but sea prototype has some value. The reason is there will be sand besides sea but not besides river/lake.

 

## 3. System Description

Image is segmented using color and texture properties of the image. Heuristics and semantics of each image segment are calculated. Then spatial features of each image segment and relationship among the segments are analyzed.

### 3.1. Creating Relation of Concepts

A relation of concepts Concept_Relation is created on the basis of spatial relation between two heuristics. If the spatial relation is not possible then concept is a false. Otherwise it is a true concept or we can give it a proper name. For example, the structure of the relation can be as following:

Concept_Relation (Heuristic1, Heuristic2, Spatial_Relation, Concept)

### 3.2. Spatial Feature Analysis

Spatial feature of image segments like percentage related to total image, spatial position and relative spatial position with respect to other segments are analyzed in this phase.

#### 3.2.1. Spatial Ratio Calculation

Spatial ratio calculation is required where user specifies heuristic along with percentage. For example, ‘Retrieve images where more than 50% of the image is sky’. If s is the image segment with heuristic ‘sky’ then f is the binary image of image segment.

if s(x, y)>0

f(x, y)=1

else f(x, y)=0

Then spatial ratio r of image segment will be

$$r = \sum f(x, y) / mn \qquad (1)$$

Here m, n is the length and width of the image respectively. The ratio r is stored along with heuristic of the image. The relation Segment for storing segments can be designed as following:

Segment( Imagename, heuristic, saturation, intensity, color, spatial_ratio)

#### 3.2.2. Spatial Position Detection

Spatial position detection is required for those types of queries where user specifies heuristic along with spatial location. For example, ‘Retrieve images where more than 80% of top portion is sky’. The image I can be subdivided into 16 equal parts as in following figure. Different spatial portions of the image are identified by combining the above regions. Some of the regions are top{1-8}, bottom{9-16}, centre{6,7,10,11}, top-left{1,2,5,6}, bottom-right{11,12,15,16}*etc.* These regions will be used to create masks that will be used to determine an image segment is in specific position or not.

| | | | |
|---|---|---|---|
| 1 | 2 | 3 | 4 |
| 5 | 6 | 7 | 8 |
| 9 | 10 | 11 | 12 |
| 13 | 14 | 15 | 16 |

**Figure 2. Image Regions for Creating Masks**

For checking an image is in top portion of image we have to create a binary mask g with same size of the complete image. The values of pixels for the top portion of the mask will be ones, values of all other pixels will be zero. If s is the image segment with heuristic ‘sky’ then portion of the image if extracted by applying mask g is following:

if (g(x,y)=1 & s(x,y)>0)

f(x,y):=1

else f(x,y):=0

Now ratio r of image segment to top portion of image is following:

$$r = \sum f(x,y) / \sum g(x,y) \qquad (2)$$

If the ratio crosses a specified threshold (in this example 80%) then we can say image segments available at the said spatial location of image. Along with heuristic and features of a segment spatial location will be stored in image database that will be used for retrieval process. The relation R for storing segments can be modified as following:

R (Imagename, heuristic, saturation, intensity, color, spatial_ratio, spatial_location)

#### 3.2.3. Spatial Rank Detection of Image Segments

Two segments are neighbors or not can be detected at the time of segmentation. Take the boundary pixels between two segments. Identify pixels of both segments with same x-coordinates of the boundary pixels. If value of y-coordinates of most of the pixels of one segment is greater than value of y-coordinates of other segment then we can say previous segment is top of next segment or it is in spatial rank 1 with respect to next segment. Then spatial rank between two heuristics can be compared with concept relation. Segment_relation will store concept along with spatial rank as following.

Segment_relation(Imagename,Heuristic1, Heuristic2, spatial_rank, concept)

Spatial rank 7 will be calculated as follows. Take the boundary pixels between two segments. Identify pixels of both segments with same y-coordinates of the boundary pixels. If value of x-coordinates of most of the pixels of one segment is greater than value of x-coordinates of other segment then we can say previous segment is right of next segment or it is in spatial rank 7 with respect to next segment. If conditions for spatial rank 1 and spatial rank 7 both are satisfied then we can say actual spatial rank is 8. Similarly other spatial ranks will be easily calculated.

## 4. Result and Discussion

Table 1 is an instance of concept relation. The concept of ‘Water above sky’ is ‘No’. ‘Sand beside water’ can be taken as ‘Beach’. Similarly ‘Water beside grassland’ can be taken as lake.

 

**Table 1. An Instance of Concept Relation**

| Heuristic1 | Heuristic2 | Spatial Relation | Concept |
|---|---|---|---|
| Water | Sky | Above | No |
| Sky | Water | Above | Yes |
| Sand | Water | Beside | Beach |
| Water | Grassland | Beside | Lake |

Images from VisTex color image database [10] and downloaded from the online Google search engine have been taken for forming reference image database. Outdoor images are automatically annotated segment wise and used for retrieval.

**Figure 3. Image with Concept Beach, Ocean**

From the above concept relation in Table1, the data are entered in the segment relation Table2 for image named Image1 displayed in Figure3.

**Table 2. An Instance of Segment_Relation**

| Imagename | Heuristic1 | Heuristic2 | spatial_rank | concept |
|---|---|---|---|---|
| Image1 | Sand | Water | 8 | Beach |
| Image1 | Sky | Water | 1 | Yes |

## 5. Conclusion & Future Scopes

This paper proposes a system for spatial feature based image retrieval. Spatial features include location of an image segment and relative position or spatial ranks among the image segments. A new method for calculating spatial rank is proposed. The spatial features are analyzed along with texture and color semantics of the image. Concepts are being created from spatial relations. Spatial ranks between image segments are compared with those concepts for accurate recognition. In future more image heuristics will be used and more concepts will be developed to improve the system.

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