SPIRE:
A new method for similarity-based partial image retrieval

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Outline

Motivation
- Content-based image retrieval
- Region-based approach

Proposed method: SPIRE
- Basic concept
- Acceleration techniques

Experiments

Future work and conclusions

Discussions
Motivation

**Content-based image retrieval (CBIR)**

- Object-based approach
  - Commonly used
  - Attempt to decompose an image into individual objects
  - Provide indexes or keywords for decomposed objects

Keywords: Elephant
Content-based approach

– Object-based approach

Problems

- Generally, decomposing objects is a very hard task
- Require domain-specific constraints to improve the accuracy
Content-based image retrieval (CBIR)

- Region-based approach
  - Determine similarities between whole images based on partial similarities between images
  - Divide an image into partial images without finding individual objects or considering their positions
Motivation (cont.)

Content-based image retrieval (CBIR)

– Region-based approach

Problems

- Require a huge amount of calculation for matching features
- Require a huge amount of storage space for indexes
SPIRE
(Sparse-index-based Partial Image REtrieval)

A basic algorithm for similarity-based partial image retrieval

Basic concept (presented at ICME2004)
- Reduce storage space for indexes
- Theoretically guarantee to provide the same search results as exhaustive matching

Acceleration techniques (presented at ICPR2004)
- Reduce the amount of matching calculation
Architecture

Preprocessing

Database image → Block feature extraction → Matching feature extraction → Indexing

Query → Block feature extraction → Matching feature extraction → Index searching

Precise matching → Results
Basic concept

- Greatly reduce the size of indexes by extracting images portions sparsely
- Theoretically guarantee to provide the same search results as exhaustive (dense) matching by setting margins appropriately
Basic concept (cont.)

- Extract image portions with a constant spacing from each image of the database
- Extract image portions from a query by using a sliding window
Determine margins

The following inequality must be satisfied to prevent false dismissals

\[ q_x \geq w_x + m_x, \quad q_y \geq w_y + m_y \]

- Any window of the same size as the query on the database images must include at least one matching window.
Examples: margin setting

Suppose that $q_x = q_y = 80$

- **Left**: $w_x = w_y = 64$, $m_x = m_y = 16$ (overlap)
- **Center**: $w_x = w_y = 36$, $m_x = m_y = 36$ (disjoint)
- **Right**: $w_x = w_y = 24$, $m_x = m_y = 36$ (sparse)
Acceleration techniques

Reduce the computational cost while maintaining search accuracy by introducing multistage vector quantisation.

Not always give the same search results as those obtained without multistage VQ.
Block VQ

Block features are quantised based on a VQ codebook

Matching region

Original features

VQ Codebook
(Typical block feature patterns)

Matching feature $f_D$
Feature VQ

Features are classified based on another VQ codebook
Selecting relevant features

The global pruning method (Kimura et al. 2001, 2003) is applied

select relevant clusters that may contain a feature whose distance from the query feature is smaller than the threshold without any false dismissals
Experiments

We evaluated:
- Storage space required for indexes
- Search time required after a query is given

Conditions
- Database: Real-life image data set from Pennsylvania State Univ.
  1000 images, 384x256 pixels
- Query: Extracted from the database
  10 partial images, 80x80 pixels
- PC: Intel Pentium 4 2.8GHz, 2.0G Memory
- OS: Redhat 9.0
- Size of matching window: 64x64 pixels
Data set

Database images

Query images
Test (1) : Required storage space

![Graph showing storage space for indexes vs. margins. The x-axis represents margins in units of 1, 4, 8, 12, and 16. The y-axis represents file size in bytes, with values ranging from 1E+05 to 1E+09. The graph indicates that as margins increase, file size decreases. At 123 Mbytes for 1 margin, the file size is around 1E+09 bytes. At 480 Kbytes for 16 margins, the file size is around 1E+05 bytes.](image-url)
Test (2) : search time vs. margin

![Graph showing search time vs. margin](image-url)
Test (3) : Effect of VQ

Time for searching

Without feature VQ

Number of clusters of feature VQ

- without block VQ
- With block VQ

- baseline
- 128 clusters
- 256 clusters
- 512 clusters
Future works

- Region-based image retrieval
  - Similarity synchronisation
    - Integrating partial similarities
- Extension to video retrieval
  - Spatiotemporal structure of video shots
Conclusion

We have proposed a similarity-based partial image retrieval method called SPIRE.

– Basic concept
  - Reduce storage space for indexes
  - Theoretically guarantee to provide the same search results as exhaustive matching

– Acceleration techniques
  - Reduce the computational cost for matching calculation