Fast Identification of Visual Documents Using Local Descriptors

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Image Identification

- Find the original of a document (and its metadata) in the absence of references
Image Identification

- Image retrieval in cultural institutions
  - Identification of clippings
  - Recovery of accidental document / metadata separation

Query

Original found
Image Identification

• Image retrieval in cultural institutions
  – Identification of clippings
  – Recovery of accidental document / metadata separation

• Copyright violation identification
  – Detect unauthorised use
  – Link « stolen » images to their originals
Image Identification

- To be robust to (sometimes very strong) transformations
Image Identification Systems

Database of images

Describe each image

Store the descriptors

Offline

Query image

Describe query image

Compare query descriptors with stored descriptors

Show the most similar images
Image Identification Systems

Global descriptors

Local descriptors

SIFT
Image Identification Systems

Global descriptors

Local descriptors

SIFT
Database of Images

Find the PoI of Each Image

Describe Each PoI

Index all Descriptors

\{ 63, 4, 25, 30, 128, ... \}

Offline

Query Image

Find the PoI

Describe Each PoI

Descriptor Matching

Refined Results

Geometric Consistency

Brute Results

Online
Hypothesis

• Large number of descriptors
  – Need to accelerate the matching
• High dimensional descriptors
  – SIFT: 128 dimensions
  – Dimensionality not easily reduced: local, non-linear data correlation
• Restrictions due to implementation
  – Favorise sequential access, avoid random access

⇒ Optimise high-dimensional descriptor matching
kNN Search

• *k* nearest neighbours or similarity search
• Find, in the data space, the *k* nearest to the query
• Linear search too expensive for large databases
  – Cost proportional to the number of entries: \( O(n) \)
• Indexation to allow accelerating the search
  – Logarithmic cost (ideally): \( O(\log n) \)
A classical solution: KD-tree

- **K Dimensional Trees**: binary search trees where each node divides the space accordingly to one of the dimensions [Bentley 1975, Friedman 1976]
A classical solution: KD-tree

- During the search, the leaf node (bucket) nearest to the query is explored and one performs the backtracking as needed, with pruning.
KD-tree and Border effects

- If the query falls near to a border, the algorithm is forced to explore the neighbouring regions.
Multiple Subindexes

• Basic idea
  – Give the query the opportunity to fall into a « good region »
  – Reduce the dimensionality of individual subindex
MEDRANK
Our Method: Projection KD-Forest

\[ d_D \rightarrow d_i \rightarrow d_n \rightarrow \text{subspaces of subindexes} \]

\[ \text{space of database} \rightarrow \text{subspaces of subindexes} \]

\[ d_1, d_i, d_{n_{trees}} \]

\[ n_{trees} \]
Projection KD-Forest
Projection KD-Forest

• Multiple trees:
  – More chance of falling on the « good region »
  – Reduction of the dimensionality of each individual tree
  – Control of random accesses
Test Database

- APM
  - 1,500 transformed images from 100 originals
  - 100 queries: original images
  - Task: find transformed
  - 2,871,300 descripteurs

Images from Arquivo Público Mineiro
Matching Results

- Projection KD-Forest vs. KD-Tree vs. OMEDRANK.
  - $k = 20$
System Results

Using sequential search
• MAP = 0.9696

Using projection KD-Forest
• MAP = 0.9623

➤ But speed up of up to 25!
Conclusion

• Good indexing allows using local descriptors, while minimising the performance penalties

• Projection KD-Forest
  – Performs better than the KD-Tree
    • Conquers border effects
  – Performs better than MEDRANK
    • Better correlation between distance on subindex and distance on space
    • Less collisions
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