Estimating missing features to improve multimedia information retrieval

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http://www.llnl.gov/CASC/sapphire/

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Multimedia Information Retrieval

- Extract "faces" and "captions"
- Represent using features
- Similarity search

Find me objects that are similar to this

**Query**

President George W. Bush

**Database**

Hillary Clinton

Gov. Jeb Bush speaks...

Tq: f1_q f2_q f3_q f4_q .... fn_q

T1: f1_1 f2_1 f3_1 f4_1 .... fn_1
T2: f1_2 f2_2 f3_2 f4_2 .... fn_2
T3: f1_3 f2_3 f3_3 f4_3 .... fn_3

f1

f2
Text-only query with image features estimated

Find a Face for a Name

Estimate Image Features

Improved Results

Text Query

Refine Estimate

George Bush

President George W. Bush

George Bush signs a letter

George W. Bush, left, and his father, ...

Image-only query with text estimated

Find a Name for a Face

Estimate Text Features

Initial Results

Wrong Text

New Image-Text Query

Bush

George Presidents Clinton

Bill Gates Linux ...

Bill Gates ...

Presidents Bush and Clinton

Not a Face

Relevance

NSL 3

NSL 4
Image and Text Features

- **Image Features** (187 total)
  - Angular radial transform (71)
  - Normalized histogram (16)
  - Gabor features (60)
  - Gray level co-occurrence matrices (20)
  - Power spectrum (20)

- **Text Features**
  - TFIDF (text frequency-inverse document frequency)

Completing a partial query: the simple method

**Image Query**

\[ q = \left\langle a_q, q \right\rangle \]

**Retrieved documents**

- **President George W. Bush**
  - \( r_1 = \langle a_1, m_1 \rangle \)
- **Presidents Bush and Clinton**
  - \( r_i = \langle a_i, m_i \rangle \)

**George Bush signs a letter**

\[ r_n = \langle a_n, m_n \rangle \]

**New Image-Text Query**

\[ \hat{q} = \langle a_q, \hat{m}_q \rangle \]
Completing a partial query: with relevance feedback

Image Query

\( q = \langle a_q,? \rangle \)

Retrieved documents

\( r_i = \langle a_i, m_i \rangle \)

\( r_j = \langle a_j, m_j \rangle \)

New Image-Text Query

\( \hat{q} = \langle a_q, \hat{m}_q \rangle \)

\[
\hat{m}_q = \frac{\sum_i \gamma_i m_j}{\sum_i \gamma_i}
\]

\[
\gamma_j = \delta_j e^{-\alpha d(r_j, q)}
\]

\[
\delta_j = \begin{cases} 
1 & j \leq k^* \\
0 & j > k^* 
\end{cases}
\]

\[
d(r, q) = \begin{cases} 
\delta(\langle a_i, \langle a_q \rangle \rangle) & \text{if } q = \langle a_q, \rangle \\
\delta(\langle a_i, m_j \rangle, \langle a_q, m_q \rangle) & \text{otherwise}
\end{cases}
\]

Data Set

- 5,910 candidate faces and associated captions
  - Krystian Mikolajczyk’s face detector
  - faces in the same image have the same caption
  - 619 text features
  - 187 low-level image features
  - 10 known faces (50 queries, 5 per person)

- Collected data set using Google Images Agent*

- Removed words with document frequency less than 3
  - reduced from 37,000 words to 619 words

- Removed classes with less than 100 documents

* G. Rousse http://search.cpan.org/~grousse/
Text-only, completed with simple method matches full query

Text-only query, completed with RF matches full query with RF
Image-only, completed with simple method improved over image-only

Image Query Results

Image-only query, completed with RF approaches full query with RF

Image Query Results
**Conclusions**

- **Text features**
  - Can distinguish individuals
  - Can not distinguish faces from non-faces
- **Image features**
  - Can distinguish faces from non-faces
  - Can not distinguish individuals
- Query completion showed improvement over partial queries (image-only and text-only)
- Text only with estimated image features matches full query
- Query completion with relevance feedback outperforms full query

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