Comparison and Combination of Textual and Visual Features for Interactive Image Retrieval

ImageCLEF 2004: Volume I, pp. 621-630

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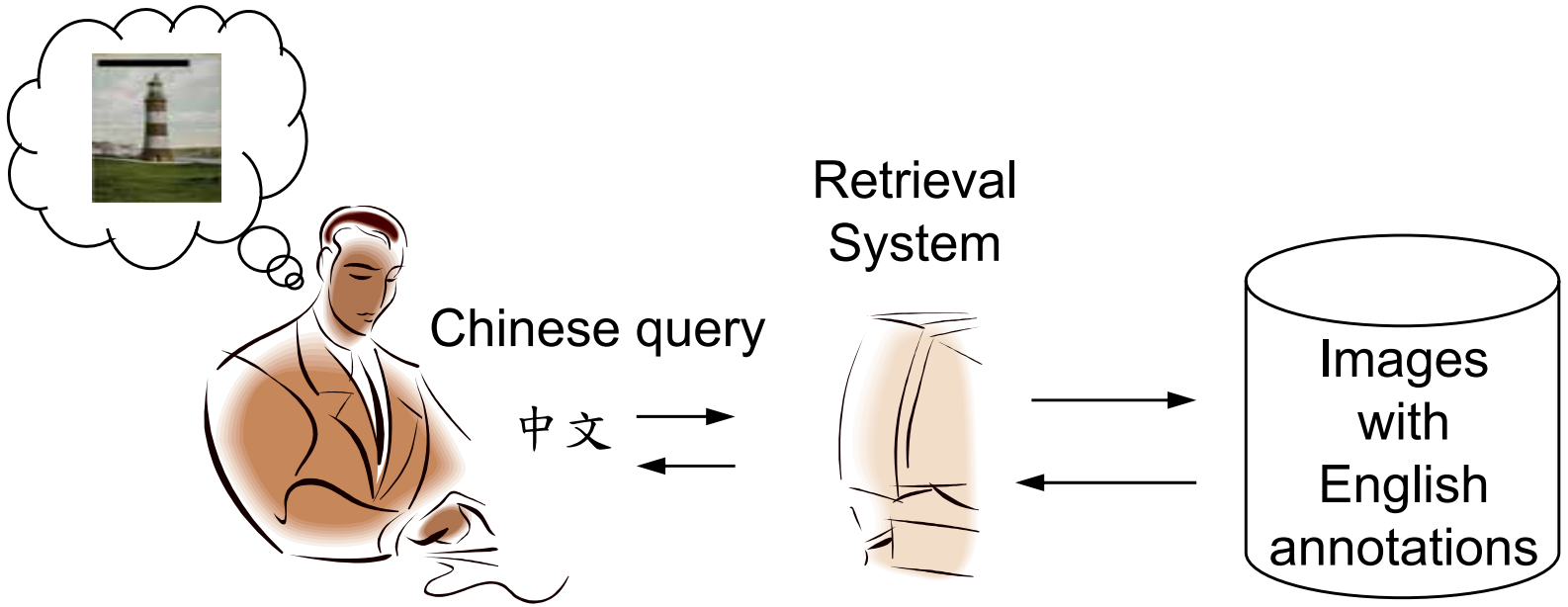
Outline

- The user-centered search task
- What helps find out relevant images?
- Interactive search process
  - Cross-language image retrieval
  - Relevance feedback
- Proposed systems
  - T_ICLEF: Textual based retrieval system
  - VCT_ICLEF: Textual & Visual based Retrieval system
- Experimental results
- Conclusion

The user-centered search task

- **Goal:** to investigate how native speakers of languages other than English interact with a CL image retrieval system.
- **Aims:** to investigate research issues, such as browsing support, automatic and interactive query expansion, relevance feedback, query formulation using both image and text, presentation of search results



St. Andrews collection

- St. Andrews University Library photographic collection.
- Photos are primarily historic in nature from areas in and around Scotland.
- Dataset Overview
  - 28133 SGML documents consist of text and images.
  - 946 categories

<DOC>
<DOCNO>stand03_2093/stand03_16381.txt</DOCNO>
<HEADLINE>Dunoon. A Hearty Greetin' frae. Composite of four views, motto and crying child in glengarry.</HEADLINE>
<TEXT>
<RECORD_ID>JV-A.004919</RECORD_ID>
A Hearty Greetin' frae Dunoon. From West; East Esplanade and Pier; East Bay; Pier and
.....
<CATEGORIES>[piers & landing stages],[seaside promenades],[statuary],[Argyll all views],[Collection - J Valentine & Co]</CATEGORIES>
<SMALL_IMG>stand03_2093/stand03_16381.jpg
</SMALL_IMG>
<LARGE_IMG>stand03_2093/
stand03_16381_big.jpg<LARGE_IMG>
</TEXT>
</DOC>

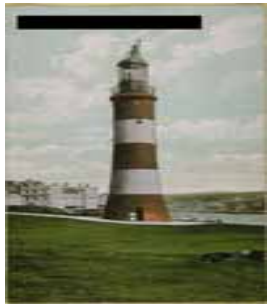
What helps find out relevant images?

- Query by keyword
  - A user must understand the background of a target image to describe it correctly
  - Different users use different keywords.
- Query by visual features of image
  - Hard to fully describe a visual query
  - Trivial: Most people have common visual perception
- User feedback: Learning a user's need
  - Help to indicate the system "real-relevant" images, and find out an image in a fewer iterations

Textual or visual?

	Textual query	Visual query
Semantic query	yes	very little
Easily used for a user	yes	no
Easy to formula a query	yes	no
Background knowledge	needed	not require
Cross-language problems	yes	no
Visual description	no	yes
Matching metric	strict	vague

•Example

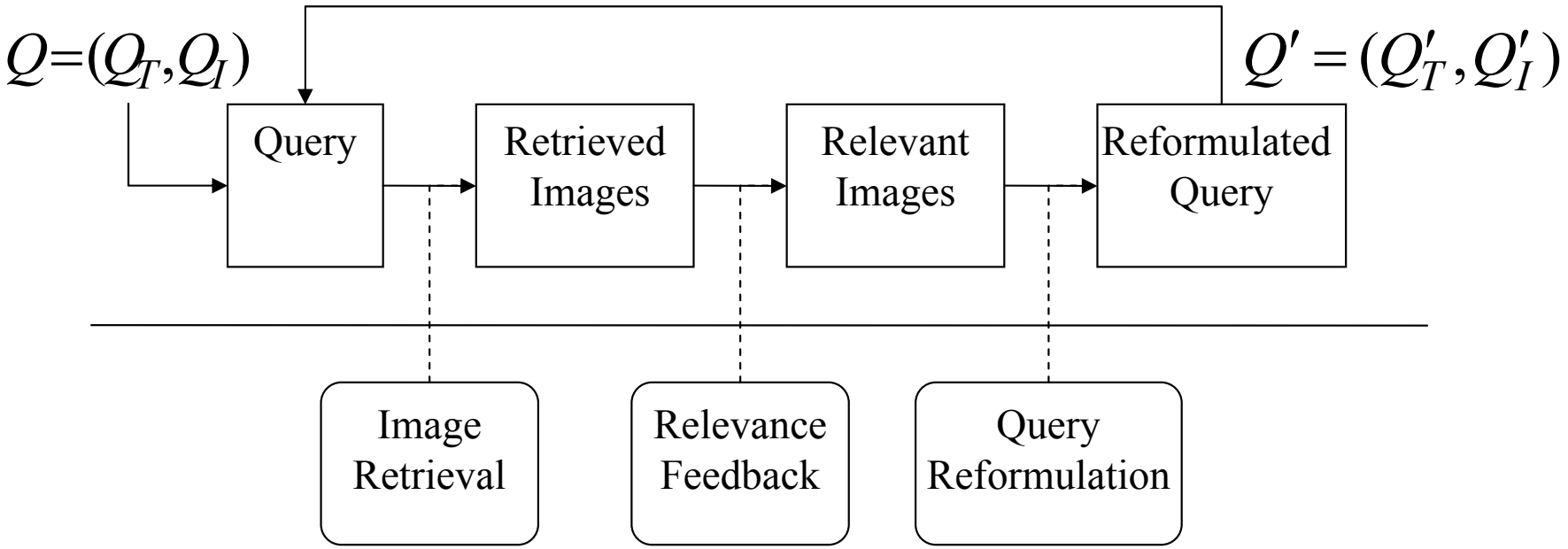


Query:

燈塔

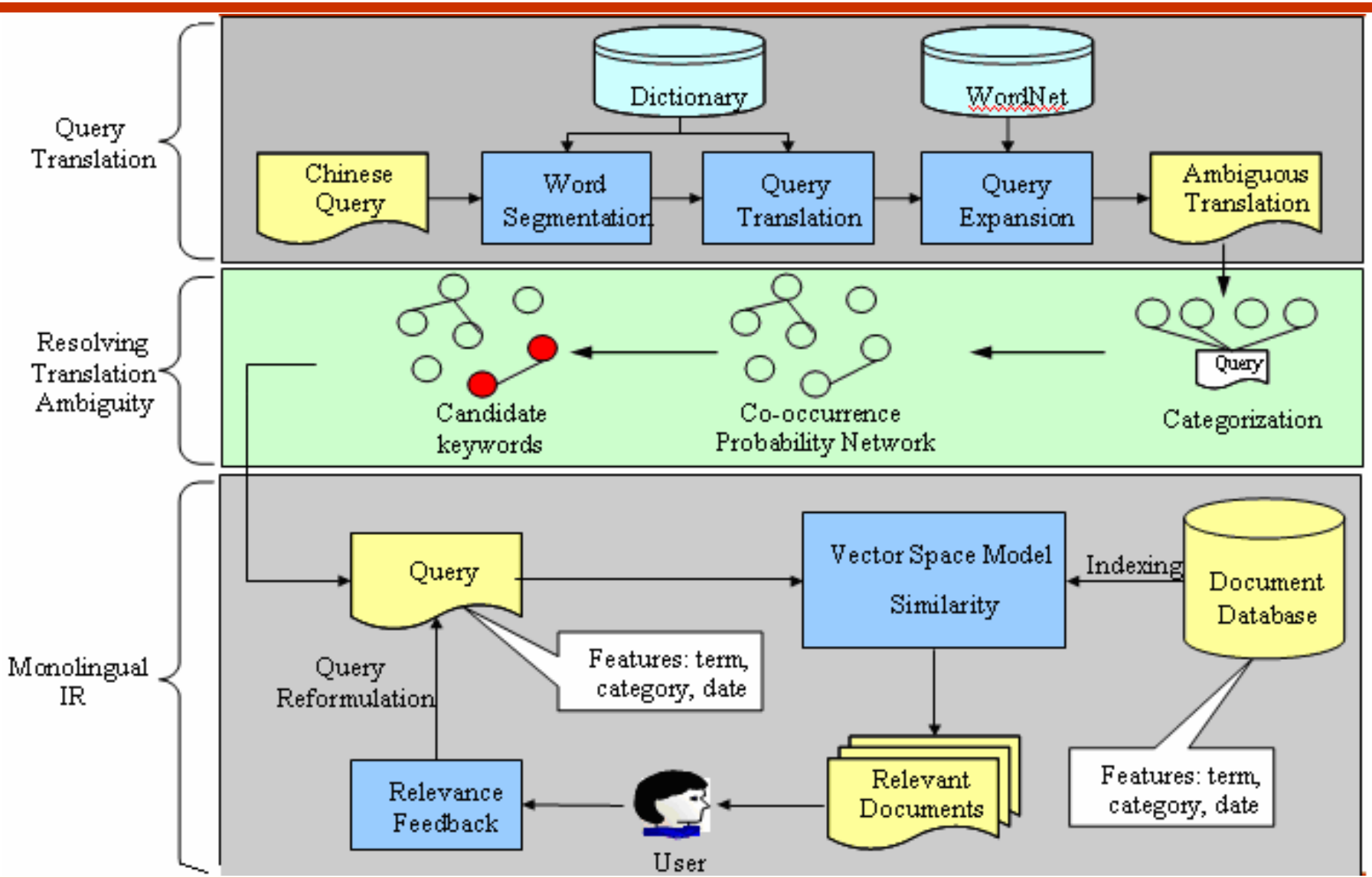
(A lighthouse)

Interactive search process



An image is represented as $P=(P_T,P_I)$

Cross-language image retrieval



Textual vector representation

$$P_T = < w_{t_1}(P_T), \ldots, w_{t_n}(P_T), w_{c_1}(P_T), \ldots, w_{c_m}(P_T), w_{y_1}(P_T), \ldots, w_{y_k}(P_T) >$$

Term | Category | Temporal

Term:
$$w_{t_i}(P_T) = \frac{tf_{t_i, P_T}}{\max tf} \times \log \frac{N}{n_{t_i}}$$

Category:
$$w_{c_i}(P_T) = \begin{cases} 1 & \text{if } P \text{ belongs to } c_i, \\ 0 & \text{otherwise} \end{cases}$$

Temporal:
$$w_{y_i}(P_T) = \begin{cases} 1 & \text{if } P \text{ was published in } y_i, \\ 0 & \text{otherwise} \end{cases}$$

Textual vector representation (cont.)

$$Q_T =< w_{t_1}(Q_T),\ldots,w_{t_n}(Q_T), w_{c_1}(Q_T),\ldots,w_{c_m}(Q_T), w_{y_1}(Q_T),\ldots,w_{y_k}(Q_T) >$$

$$w_{t_i}(Q_T) = \begin{cases} \dfrac{tf_{t_i,Q_T}}{\max tf} \times \log \dfrac{N}{n_{t_i}} \end{cases}$$

$$w_{c_i}(Q_T) = \begin{cases} 1 & \text{if } \exists j, e_j \in AfterDisambiguity(Q_T) \text{ and } e_j \text{ occurs in } c_i, \\ 0 & \text{otherwise} \end{cases}$$

$$w_{y_i}(Q_T) = \begin{cases} 1 & \text{if } Q_T \text{ contains } ''\text{Y年以前,}'' \text{ and } y_i \text{ is before Y,} \\ 1 & \text{if } Q_T \text{ contains "Y年之中,"} \text{ and } y_i \text{ is in Y,} \\ 1 & \text{if } Q_T \text{ contains } ''\text{Y年以後,}'' \text{ and } y_i \text{ is after Y,} \\ 0 & \text{otherwise} \end{cases}$$

Temporal operator

$$w_{y_i}(Q_T) = \begin{cases} 1 & \text{if } Q_T \text{ contains "Y年以前," and } y_i \text{ is BEFORE Y,} \\ 1 & \text{if } Q_T \text{ contains "Y年之中," and } y_i \text{ is IN Y,} \\ 1 & \text{if } Q_T \text{ contains "Y年以後," and } y_i \text{ is AFTER Y,} \\ 0 & \text{otherwise} \end{cases}$$

- 1900年以前拍攝的愛丁堡城堡照片?

  (Pictures of Edinburgh Castle taken before 1900)

Year	...	1897	1898	1899	1900	1901	1902	...
P_1	0	0	0	1	0	0	0	0
P_2	0	0	0	0	0	1	0	0
Q_T	1	1	1	1	0	0	0	0

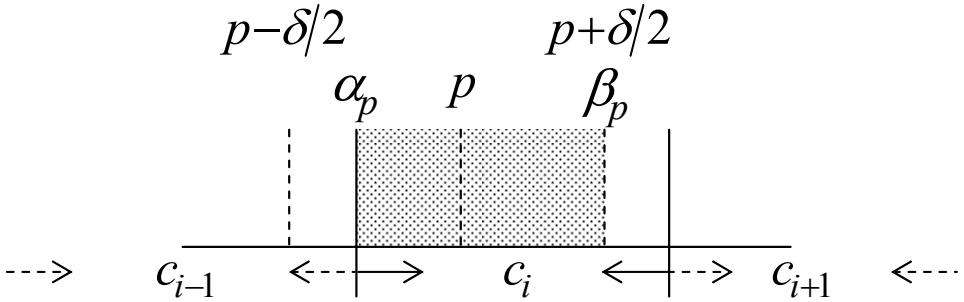
Image vector representation

- Color histogram
- HSV color space (18*2*4+4 gray values)
  - 18 hues, 2 saturations, and 4 values, with additional 4 levels of gray

$$P_I =< h_{c_1}(P_I),...,h_{c_m}(P_I) >$$

$$Q_I =< h_{c_1}(Q_I),...,h_{c_m}(Q_I) >$$

$$h_{c_i}(P_I) = \frac{\sum_{p \in P_I} \frac{|\alpha_p - \beta_p|}{\delta}}{|P_I|}$$



Partial pixel contribution (PPC)

Similarity metric

- Strategy 1 (T_ICLEF): Based on the textual similarity

$$P_T =< w_{t_1}(P_T),...,w_{t_n}(P_T), w_{c_1}(P_T),...,w_{c_m}(P_T), w_{y_1}(P_T),...,w_{y_k}(P_T) >$$

$$Q_T =< w_{t_1}(Q_T),...,w_{t_n}(Q_T), w_{c_1}(Q_T),...,w_{c_m}(Q_T), w_{y_1}(Q_T),...,w_{y_k}(Q_T) >$$

$$Sim_1(P,Q) = \frac{\vec{P}_T \cdot \vec{Q}_T}{|\vec{P}_T||\vec{Q}_T|}$$

- Strategy 2 (VCT_ICLEF): Based on both the textual and the image similarity

$$Sim_2(P,Q) = \alpha \cdot Sim_1(P,Q) + \beta \cdot Sim_3(P,Q)$$

where

$$P_I =< h_{c_1}(P_I),...,h_{c_m}(P_I) >,$$

$$Q_I =< h_{c_1}(Q_I),...,h_{c_m}(Q_I) >,$$

$$Sim_3(P,Q) = \frac{H(P_I) \cap H(Q_I)}{|H(Q_I)|} = \frac{\sum_i \min(h_{c_i}(P_I), h_{c_i}(Q_I))}{\sum_i h_{c_i}(Q_I)}$$

Query reformulation

original query $Q = (Q_T, Q_I)$

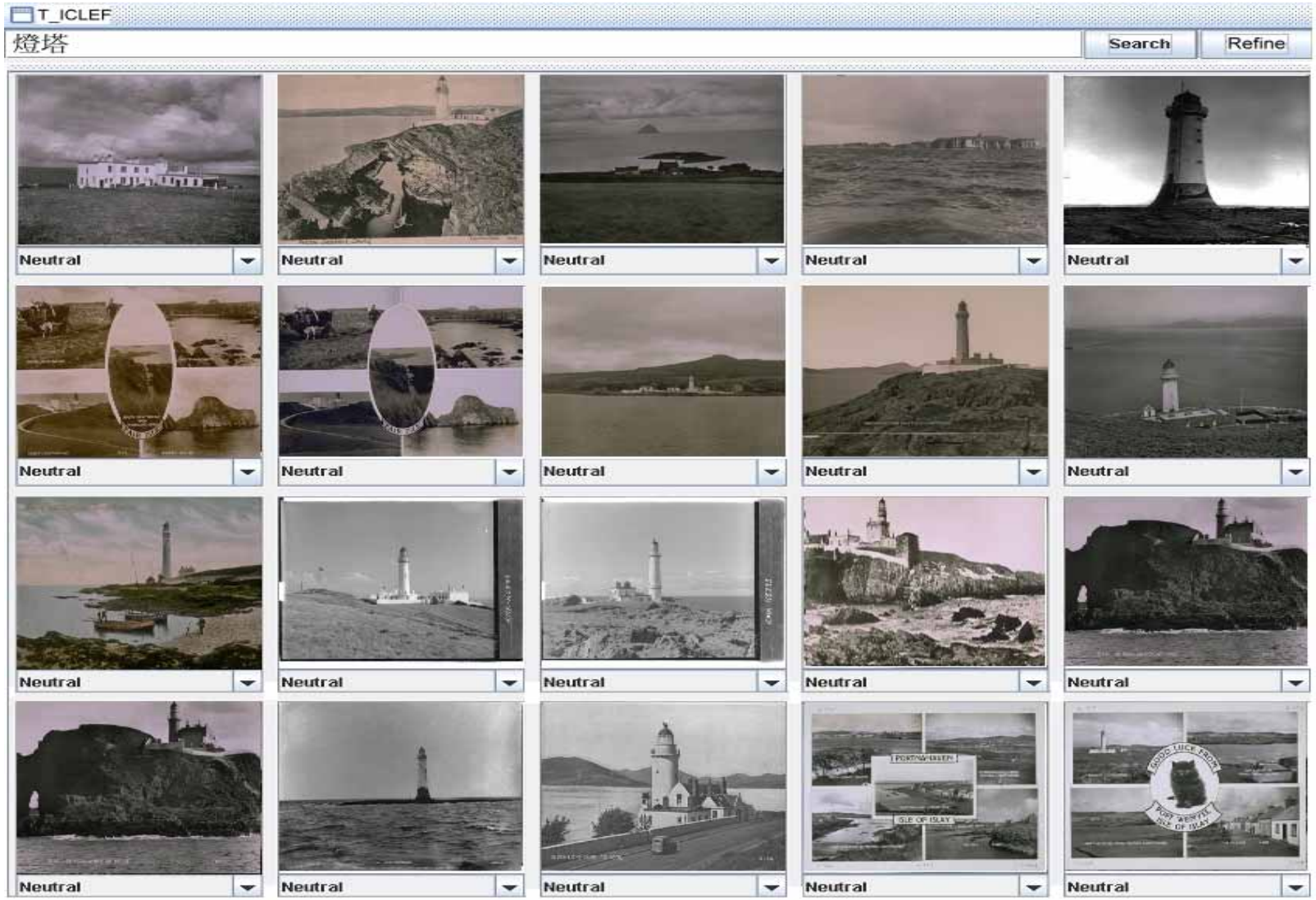
new query $Q' = (Q'_T, Q'_I)$

$$Q'_T = \alpha \cdot Q_T + \frac{\beta}{|REL|} \sum_{P_T \in REL} P_T - \frac{\gamma}{|NREL|} \sum_{P_T \in NREL} P_T$$

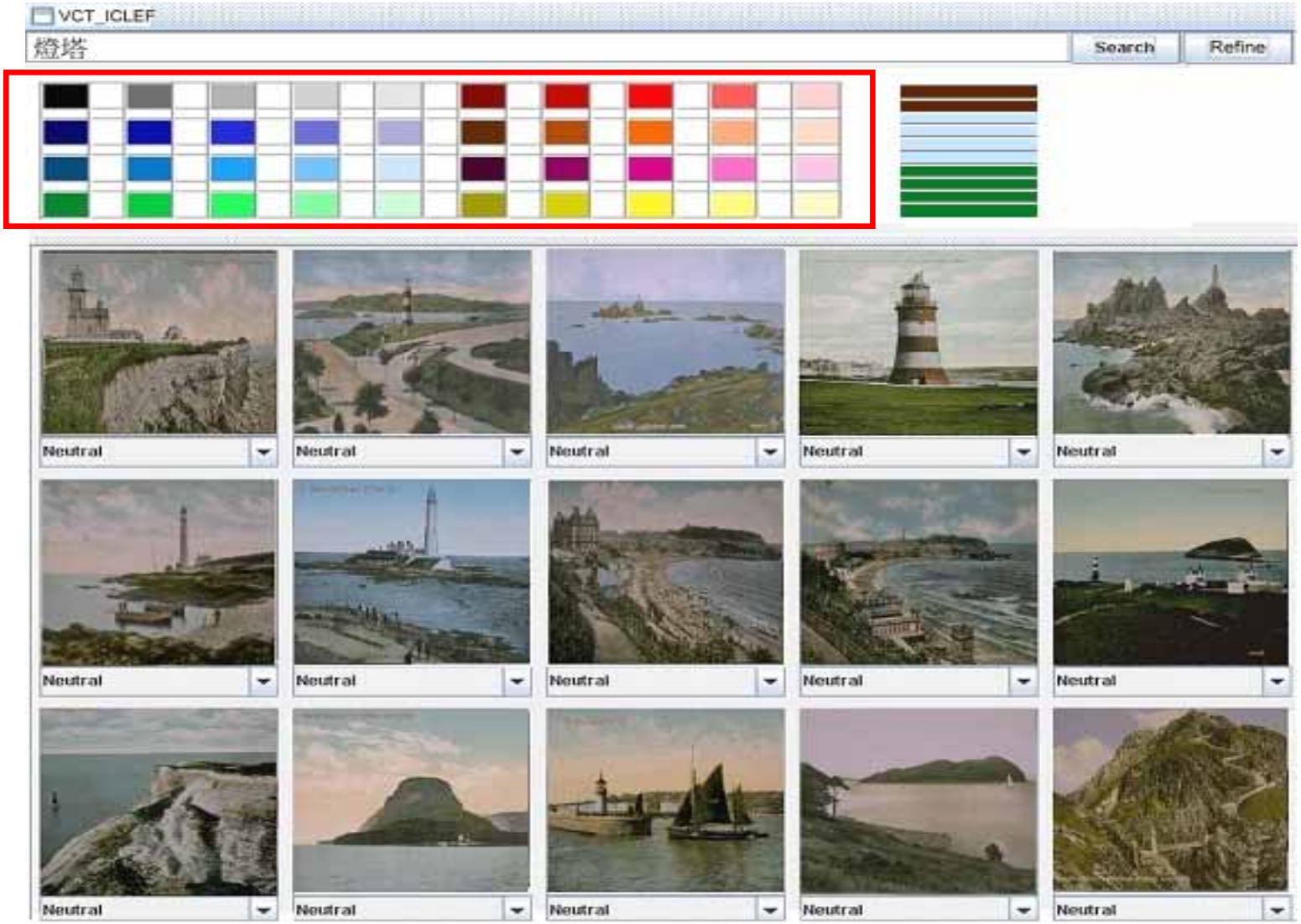
$$Q'_I = \frac{1}{|REL|} \sum_{P_I \in REL} P_I$$

- REL: relevant images
- NREL: irrelevant images

T_ICLEF



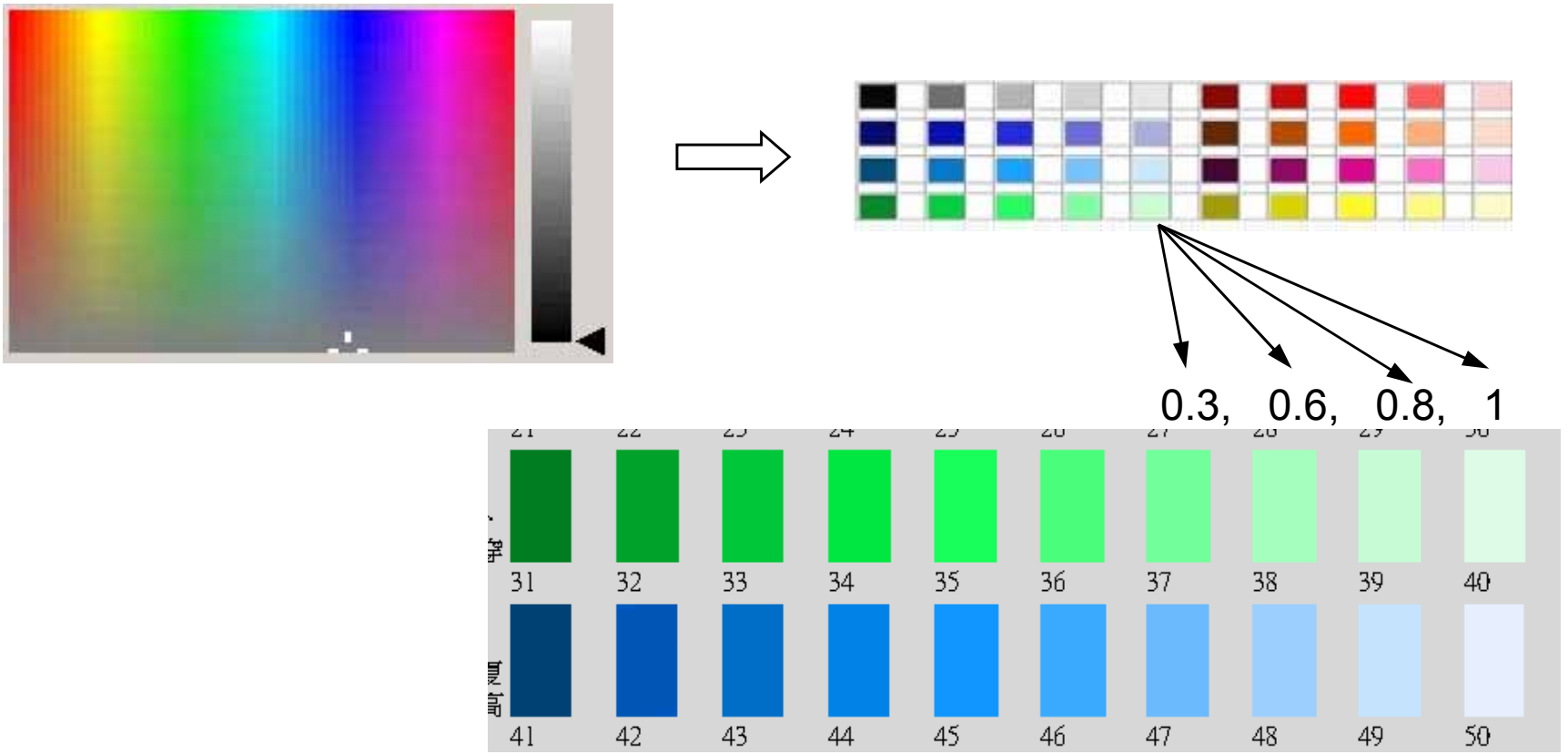
VCT_ICLEF



back

Design of the color table

- A full color table is hard for a user to describe a visual query.
- The retrieval system will expand the visual query automatically



Experiment

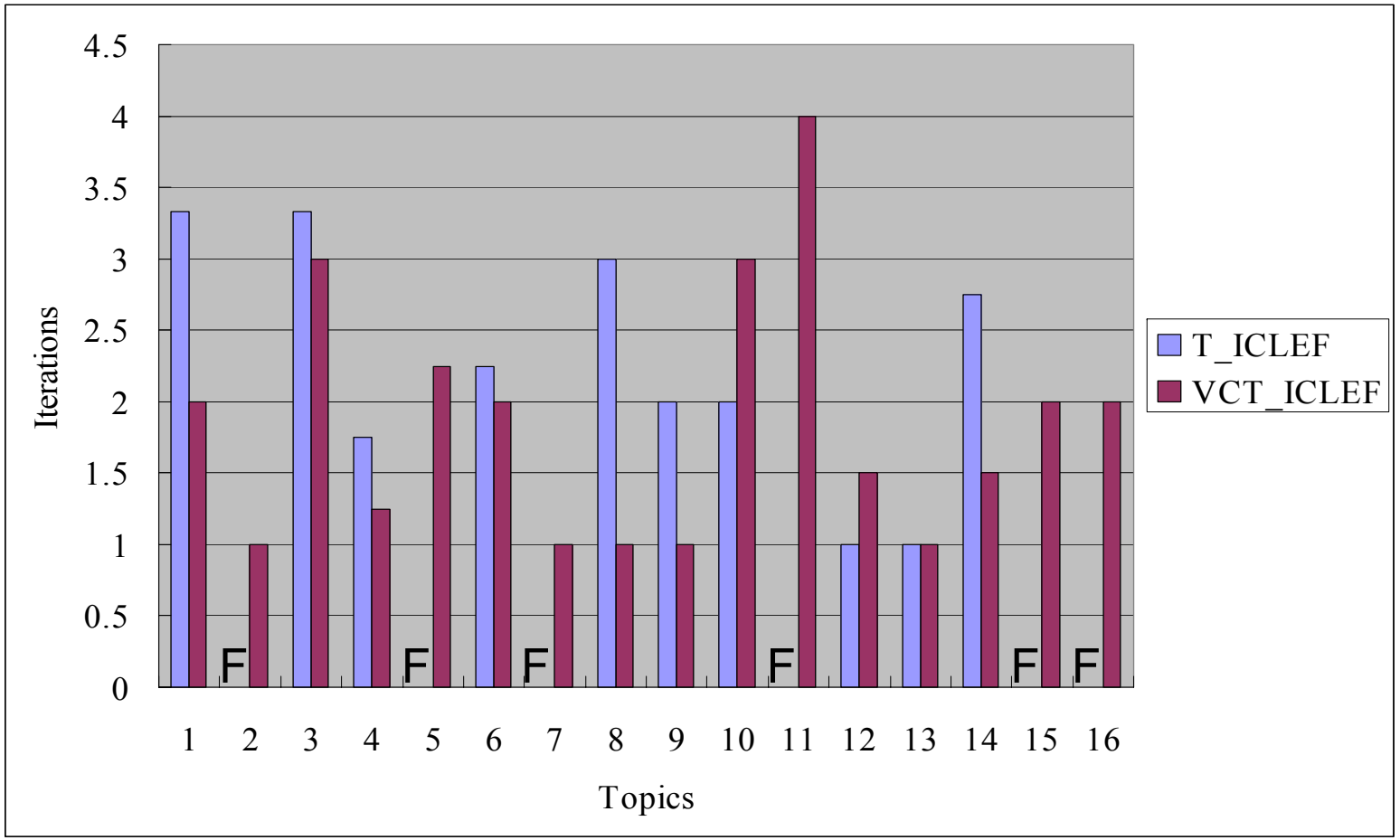
- An experimental procedure similar to iCLEF 2003.
- 8 users are asked to test each system with 8 topics
- Topics and systems will be presented to a user in a latin-square combination.

Searcher background

- 5 male and 3 female searchers.
- Average age is 23.5, with the youngest of 22 and the oldest of 26.
- Three of them major in computer science, two major in social science, and the others are librarians.
- All of them have an average of 3.75 years accessing online search services.
- Only a half of them have experiences in using image search services.

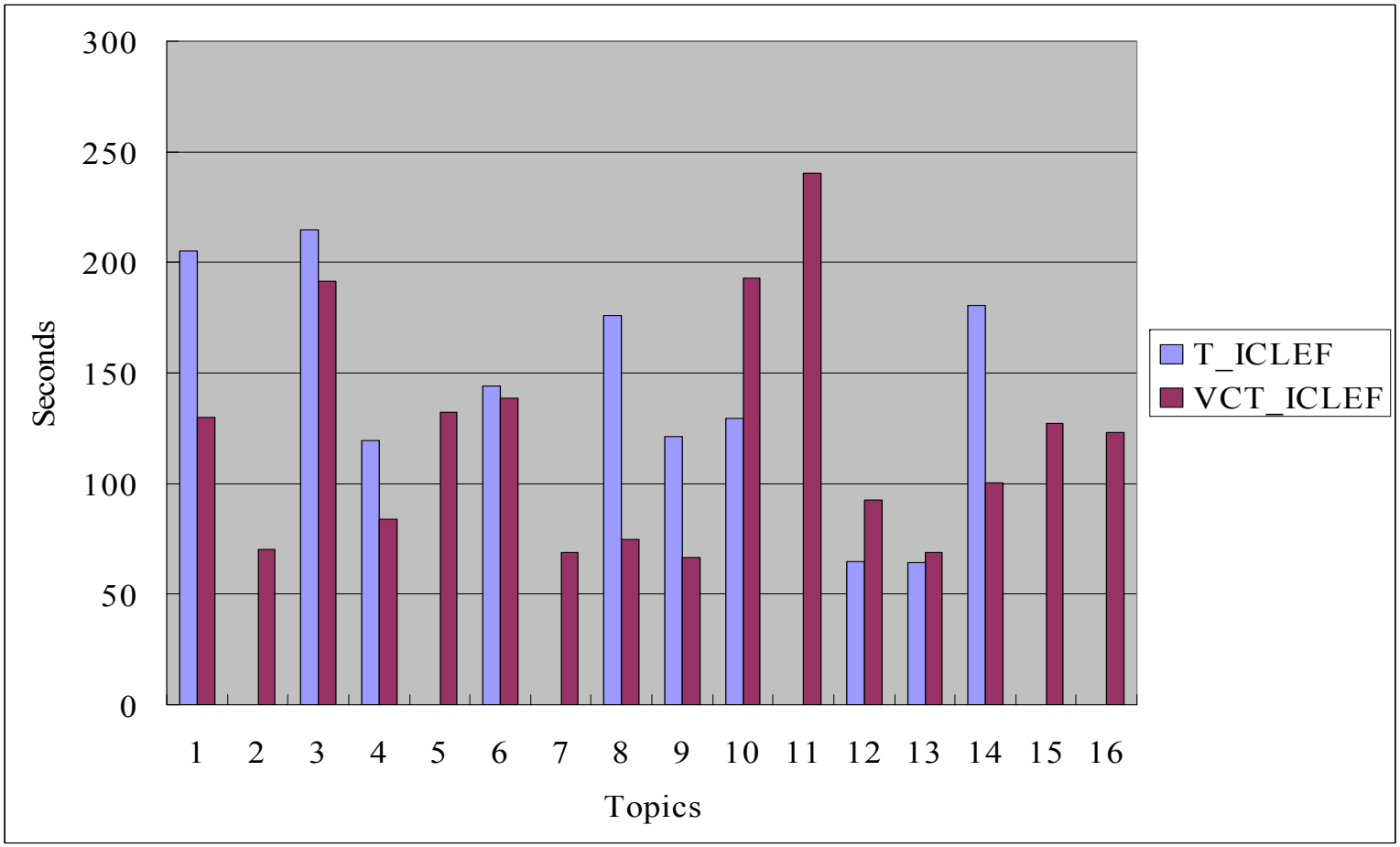
Experiment results

- Average number of iterations spent by a searcher for each topic



Experiment results (cont.)

- The average time spent by a searcher for each topic



Experiment results (cont.)

- Number of searchers who did not find the target image for each topic

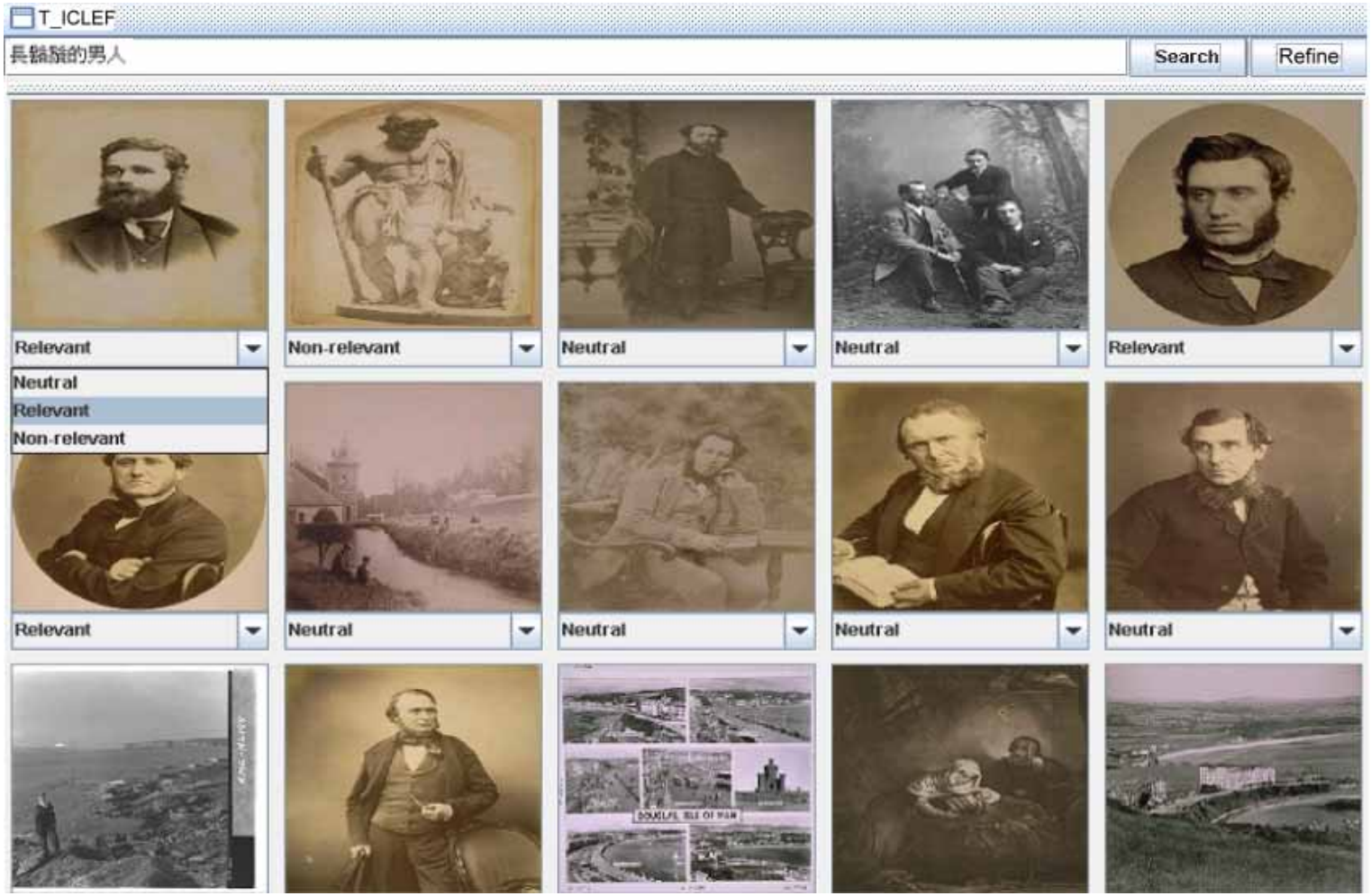
Topic	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
T_ICLEF	1	4	1	0	4	0	4	1	0	1	4	0	0	0	4	4
VCT_ICLEF	1	0	2	0	0	0	0	0	0	0	2	0	0	0	2	0

- Average steps to find the target image, and the average spent time

	Avg. Iterations (Not including not found)	Avg. Spent Time for each topic	Avg. percent of searchers who found the target image (#/4×100%)
T_ICLEF	2.24	208.67s	56.25%
VCT_ICLEF	1.84	132.20s	89.00%

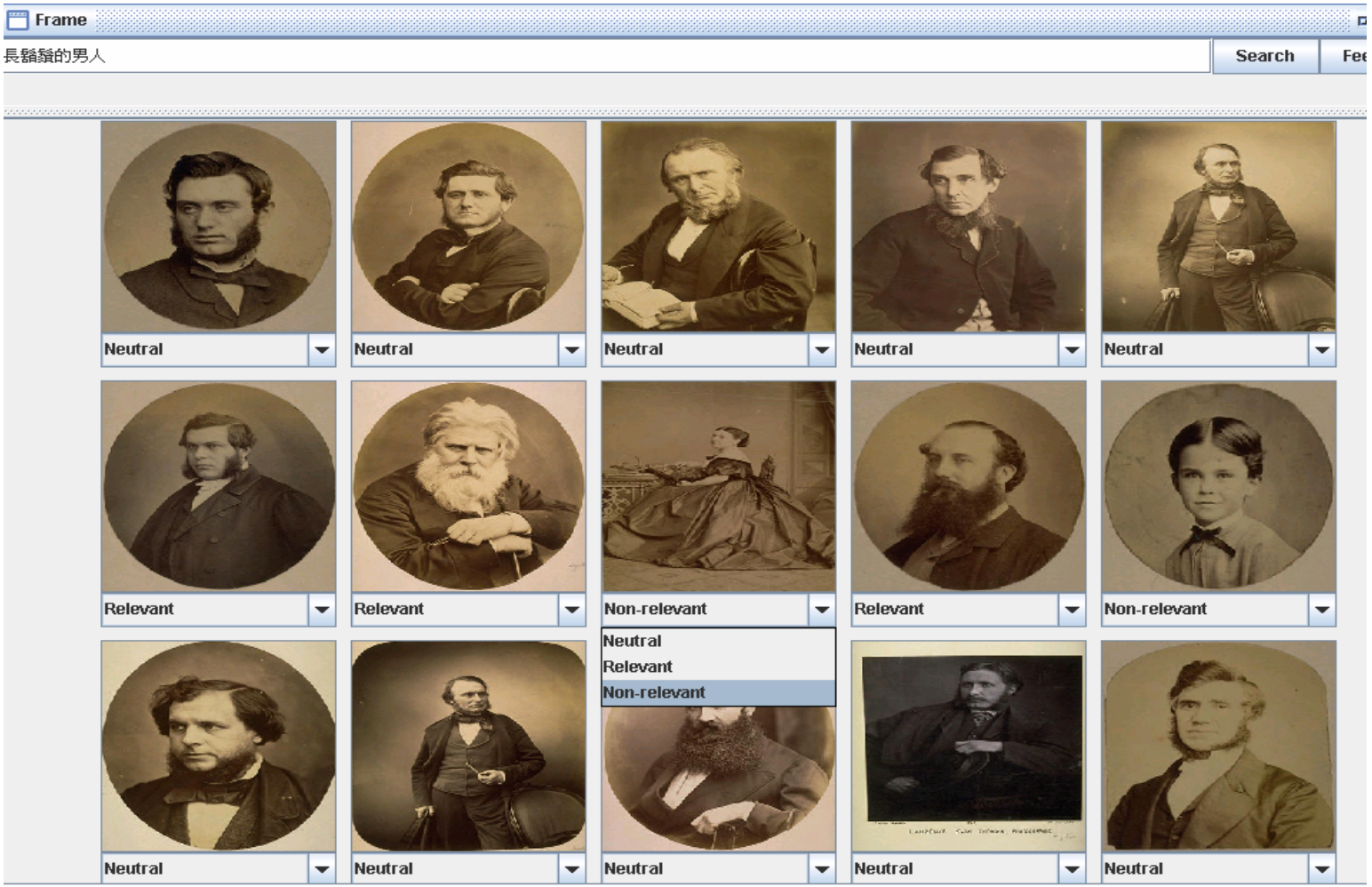
Relevance feedback example

- Results after the initial search : “長鬍子的男人 (A man with a beard)”



Relevance feedback example

- Results after 1 feedback iteration



Relevance feedback example

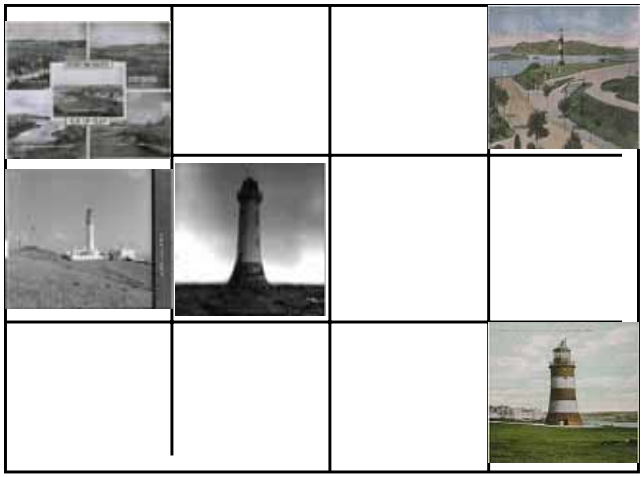
- Results after 2 feedback iterations

User Survey

- 5 searchers thought that color information was helpful
- 4 searchers preferred to search with a text query first
  - The same cases happened while using VCT_ICLEF.
  - But will indicate color information when the system returned images all in black and white.
- 3 searchers preferred to use color information first.
- 2 searchers hoped to use a text query to describe color information
  - e.g., 藍色 (Blue): 
- No one search with a temporal query since it is hard to decide in which year the image was published.

Conclusion

- The VCT_ICLEF has a better performance than T_ICLEF
  - The visual features will improve the performance.
  - The visual features can offer some clues for image retrieval system.
- Future work: a browsing interface
  - SOM (Self-Organizing Map) for image clustering.



Q&A

Thank you