

# NovaSearch at Medical ImageCLEF 2013

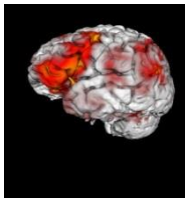
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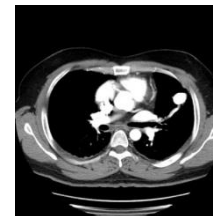
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Portugal

# ImageCLEFmed

- First participation on ImageCLEF
- Evaluation campaign is aligned with our work on an experimental multimodal retrieval framework:
  - Complex text and image queries
  - Domain specific query expansion

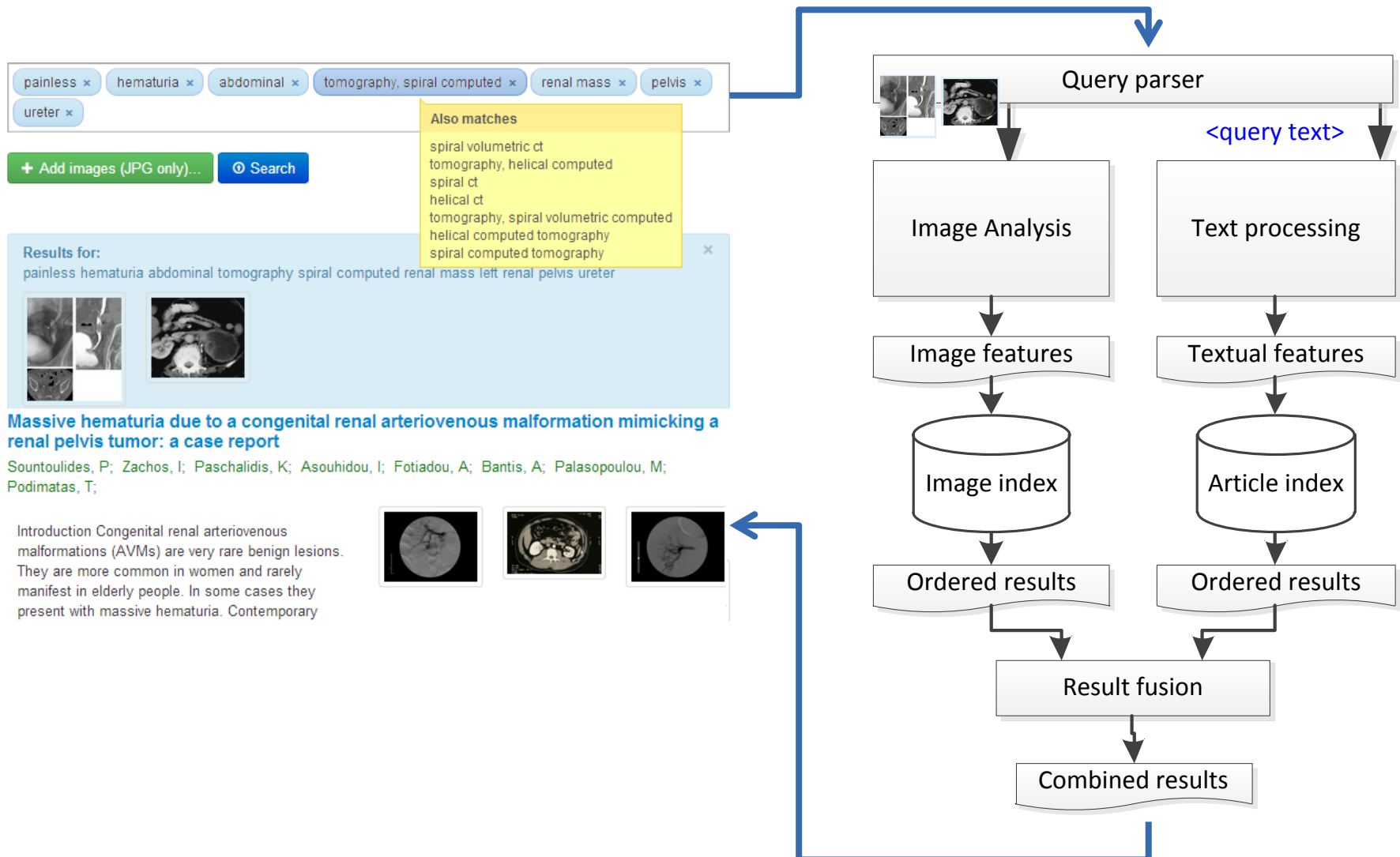


osteoporosis x-ray images



A woman in her mid-30s presented with dyspnea and hemoptysis. **CT scan** revealed a cystic mass in the right lower lobe. Before she received treatment, she developed right arm weakness and aphasia. She was treated, but four years later suffered another stroke. Follow-up **CT scan** showed multiple new cystic lesions.

# NovaMedSearch



# NovaMedSearch: <http://medical.novasearch.org>

Free text query

Image dropzone

Query

Interactive query expansion

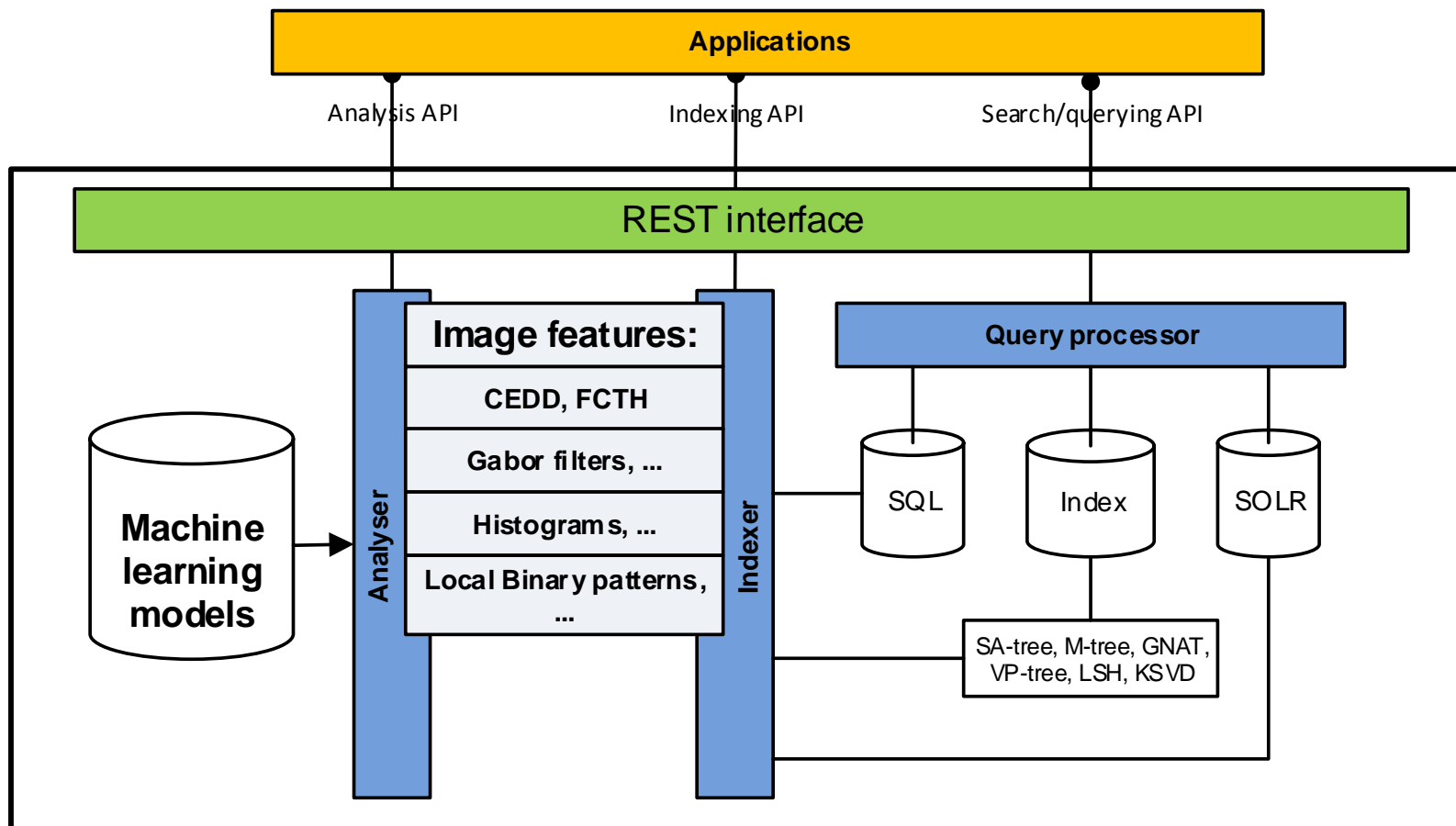
Result example

The screenshot displays the NovaMedSearch web interface. At the top, a search bar contains several tags: 'painless x', 'hematuria x', 'abdominal x', 'tomography, spiral computed x', 'renal mass x', and 'pelvis x'. Below these tags is a green button labeled '+ Add images (JPG only)...' and a blue 'Search' button. To the right of the search bar, a yellow box titled 'Also matches' lists related terms: 'spiral volumetric ct', 'tomography, helical computed', 'spiral ct', 'helical ct', 'tomography, spiral volumetric computed', 'helical computed tomography', and 'spiral computed tomography'. Below the search bar, the 'Results for:' section shows the query terms: 'painless hematuria abdominal tomography spiral computed renal mass left renal pelvis ureter'. This section includes three small medical images. Below the images, the title of the first result is 'Massive hematuria due to a congenital renal arteriovenous malformation mimicking a renal pelvis tumor: a case report'. The authors listed are 'Sountoulides, P; Zachos, I; Paschalidis, K; Asouhidou, I; Fotiadou, A; Bantis, A; Palasopoulou, M; Podimatas, T;'. The introduction text reads: 'Introduction Congenital renal arteriovenous malformations (AVMs) are very rare benign lesions. They are more common in women and rarely manifest in elderly people. In some cases they present with massive hematuria. Contemporary'. To the right of the text are three small medical images.

# NovaSearch framework

- Framework for complex retrieval systems for fast prototyping
  - Implements state-of-the-art image and text retrieval systems, fast indexing and database storage and multiple classifiers
  - Accessed through REST: programmers use existing endpoints to develop new applications
  - Focus on multimodality: combining image and textual features for better performance

# Framework for rapid multimodal prototyping

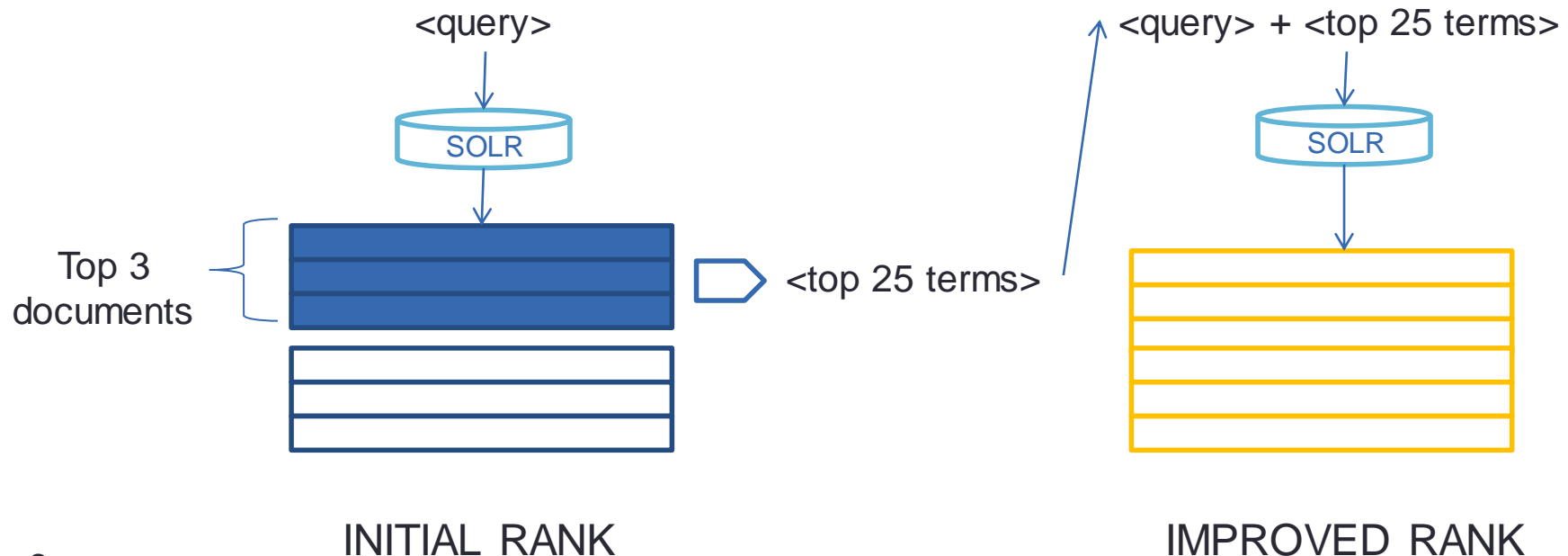


# Framework: image retrieval

- Image features:
  - CEDD, FCTH, Seg. LBP and Color histogram
- Image indexing and search:
  - FLANN: Fast (KD-Tree based)  $L_2$  index
- Classification:
  - Linear classifier with online gradient descent optimization (Vowpal Wabbit)

# Framework: text retrieval

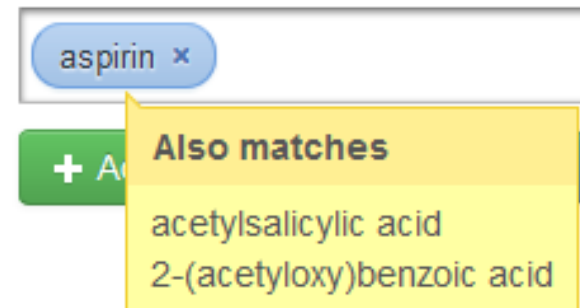
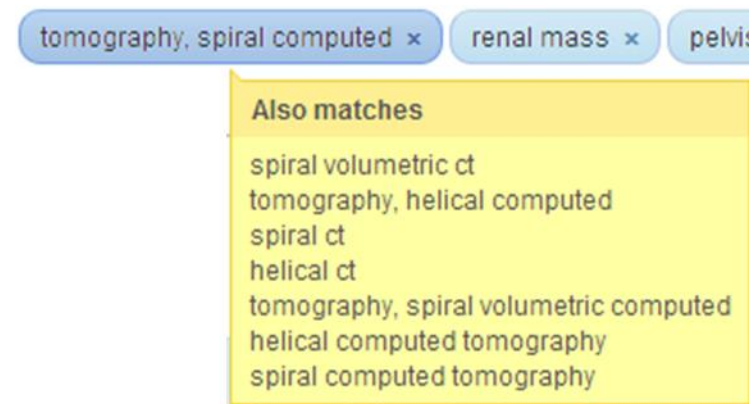
- Apache SOLR with BM25L retrieval function
  - Unigram based
- Query Expansion with Lucene-SKOS: Related terms from MeSH
- Pseudo-relevance feedback: Top 25 terms from top 3 documents





# Framework: query expansion

- Medical domain vocabulary has multiple terms per concepts
- We expand the query terms with related terms from MeSH
- Integrated into Solr using Lucene-SKOS
- Expansion terms weighting



`[Aspirin]^1.0 [Acetylsalicylic acid]^0.7 [benzoic acid]^0.7`

# Our participation at Medical ImageCLEF2013

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Task 1: Modality classification

Task 2: Case-based retrieval

Task 3: Ad-hoc image retrieval

# Task 1: Modality classification

- Features: CEDD, FCTH and captions BOW
  - **Early fusion:** Image and text features are **concatenated** into a **single feature vector**  
`|cedd 3:7.0 26:1.0 27:3.0 50:2.0 (...) |title  
compar studi bind characterist (...)`
- Training data
  - (Provided) images + title + textual captions (removed stopwords and stemming)
  - **No external examples/dataset augmentation**
- Linear classifier (Vowpal Wabbit)
  - Squared loss function  $(\text{label} - \text{prediction})^2$
  - One-vs-all linear classifier

# Modality classification results

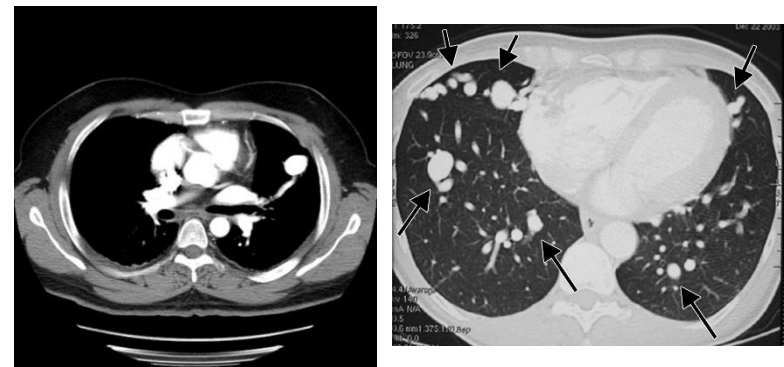
Run Name	Type	Correctly classified
IBM_modality_run1	Textual	64.17%
<b>words</b>	<b>Textual</b>	<b>62.35%</b>
IBM_modality_run4	Visual	80.79%
<b>CEDD_FCTH</b>	<b>Visual</b>	<b>57.62%</b>
IBM_modality_run8	Multimodal	81.68%
<b>All</b>	<b>Multimodal</b>	<b>72.92%</b> (17% better)

3rd overall best team

# Task 2: Case-based retrieval

- The goal is to retrieve cases using a case description and relevant images
  - Query: large description and relevant medical exam images
- Features
  - **Image features:** Seg. Color Histograms and Seg. Local Binary Patterns
  - **Text features:** full article text
- Multimodal rank **Late fusion**
  - Images and text results are combined after retrieval

- Example query:



*A woman in her mid-30s presented with dyspnea and hemoptysis. **CT scan** revealed a cystic mass in the right lower lobe. Before she received treatment, she developed right arm weakness and aphasia. She was treated, but four years later suffered another stroke. Follow-up **CT scan** showed multiple new cystic lesions.*

# Text processing (Indexing and Query)

## Indexing

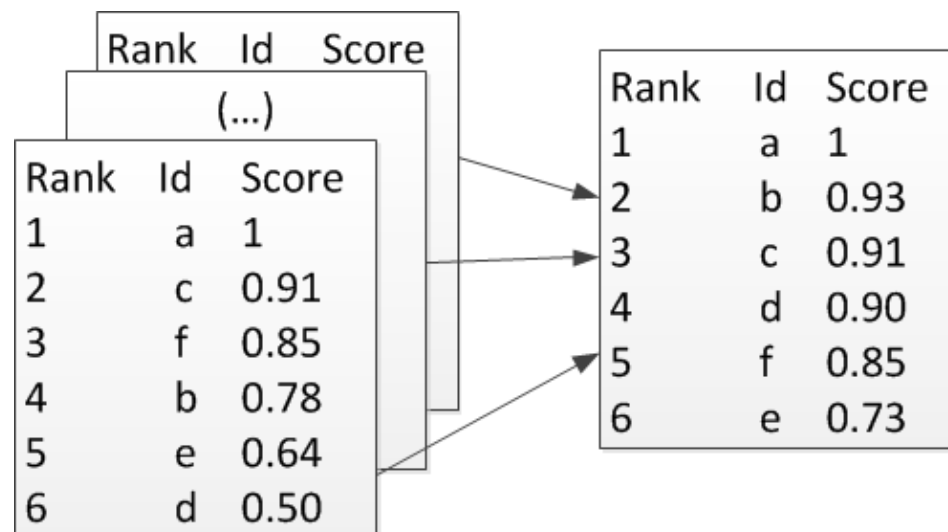
- BM25L
- Normalization
- Lower case filter
- Stop word removal

## Query

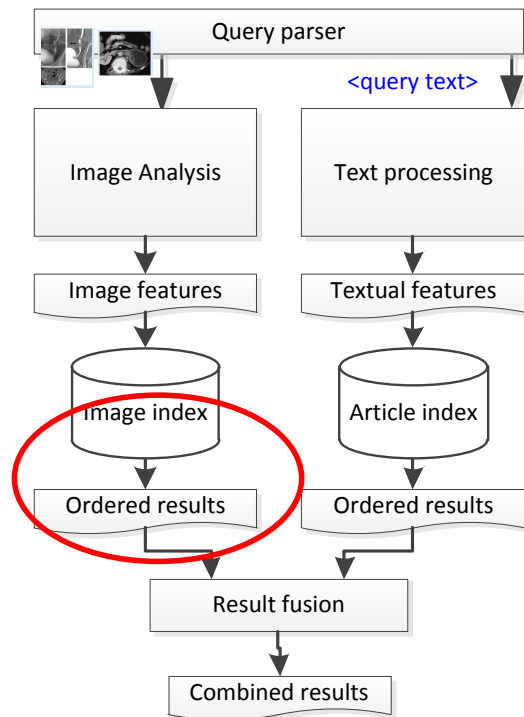
- Normalization
- **MeSH expansion**
- Lower case filter
- Stop word removal
- **Remove duplicates**

# Multimodal rank fusion

- Combining search results lists (ranks) from multiple sources into a single rank
  - Example: Google and Bing, image and text search results
- Fast and unsupervised fusion technique



# Ranking a document with multiple images



- Multi-images queries
  - Image index returns multiple image indexes
- Fusing a document score with multiple score
- CombMAX for fusion:
  - Best image score is used in the final rank

Rank	IRI	Score
1	a2	1
2	b1	0.93
3	b2	0.90
4	c3	0.90
5	a1	0.73
6	c2	0.48

(a)

Rank	DOI	Score
1	a	1
2	b	0.93
3	b	0.90
4	c	0.90
5	a	0.73
6	c	0.48

(b)

Rank	DOI	Score
1	a	1
2	b	0.93
3	c	0.90



# Text and image rank fusion

- CombSUM and variants:

sum of scores for i

$$\text{CombMNZ}(i) = N(i) \times \sum_{k=1}^{N(i)} S_k(i)$$

n<sup>o</sup> of lists with document i

- Rank-based:

sum of Inv. rank for i

$$\text{RRF}(i) = \sum_{k=1}^{N(i)} \frac{1}{R_k(i) + k'}$$

- **ISR (Inverse Squared Rank):**

sum of inv. squared ranks for i

$$\text{ISR}(i) = N(i) \times \sum_{k=1}^{N(i)} \frac{1}{R_k(i)^2}$$

n<sup>o</sup> of lists with document i

# Case-based retrieval results

Run Name	Type	MAP	P@10	P@30
<b>FCT_CB_MM_rComb (ISR)</b>	<b>Multimodal</b>	<b>0.1608</b>	<b>0.1800</b>	<b>0.1257</b>
medgift_mixed_nofilter_casebased	Multimodal	0.1467	0.1971	0.1457
<b>FCT_CB_MM_MNZ (CombMNZ)</b>	<b>Multimodal</b>	<b>0.0794</b>	<b>0.1371</b>	<b>0.0810</b>
SNUMedinfo9	Textual	0.2429	0.2657	0.1981
<b>FCT_LUCENE_BM25L_MSH_PRF</b>	<b>Textual</b>	<b>0.2233</b>	<b>0.2600</b>	<b>0.1800</b>
<b>FCT_LUCENE_BM25L_PRF</b>	<b>Textual</b>	<b>0.1992</b>	<b>0.2343</b>	<b>0.1781</b>
<b>FCT_SEGHIST_6x6_LBP</b>	<b>Visual</b>	<b>0.0281</b>	<b>0.0429</b>	<b>0.0238</b>
medgift_visual_nofilter_casebased	Visual	0.0029	0.0086	0.0067

# Task 3: Ad-hoc image retrieval

- The goal is to retrieve medical images that fill a specific information need:
  - Query: small text and 3-5 images
- Same techniques as with case-based retrieval
  - **Image features:** Seg. Color Histograms and Seg. Local Binary Patterns
  - **Text features:** Captions, title and abstract fields
- Example query:

*osteoporosis x-ray images*



# Ad-hoc image retrieval

Run Name	Type	MAP	GM-MAP	bpref	P@10	P@30
nlm-se-image-based-textual	Textual	0.3196	0.1018	0.2982	0.3886	0.2686
<b>FCT_SOLR_BM25L_MSH</b>	<b>Textual</b>	<b>0.2305</b>	<b>0.0482</b>	<b>0.2316</b>	<b>0.2971</b>	<b>0.2181</b>
<b>FCT_SOLR_BM25L</b>	<b>Textual</b>	<b>0.2200</b>	<b>0.0476</b>	<b>0.2280</b>	<b>0.2657</b>	<b>0.2114</b>
DEMIR4	Visual	0.0185	0.0005	0.0361	0.0629	0.0581
<b>FCT_SEGHIST_6x6_LBP</b>	<b>Visual</b>	<b>0.0072</b>	<b>0.0001</b>	<b>0.0151</b>	<b>0.0343</b>	<b>0.0267</b>

No Pseudo-relevance feedback

MeSH expansion greatly improves results

# Conclusions

- Multimodality strategies
  - Different strategies are necessary for different experiments
- ISR: rank fusion algorithm
  - Performed in line or better than state-of-art aproaches
- Query expansion & pseudo relevance feedback greatly improved performance

Demo available at:  
<http://medical.novasearch.org>

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Questions?