NovaSearch at Medical ImageCLEF 2013

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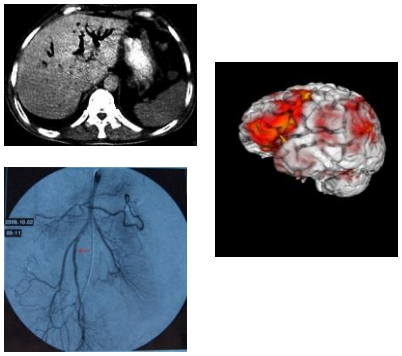
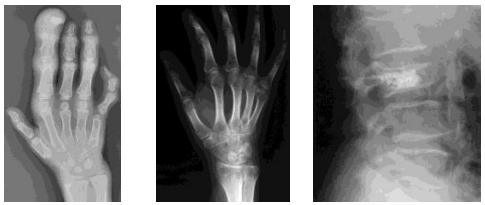
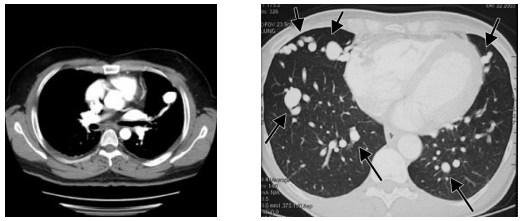
ImageCLEFmed

- 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



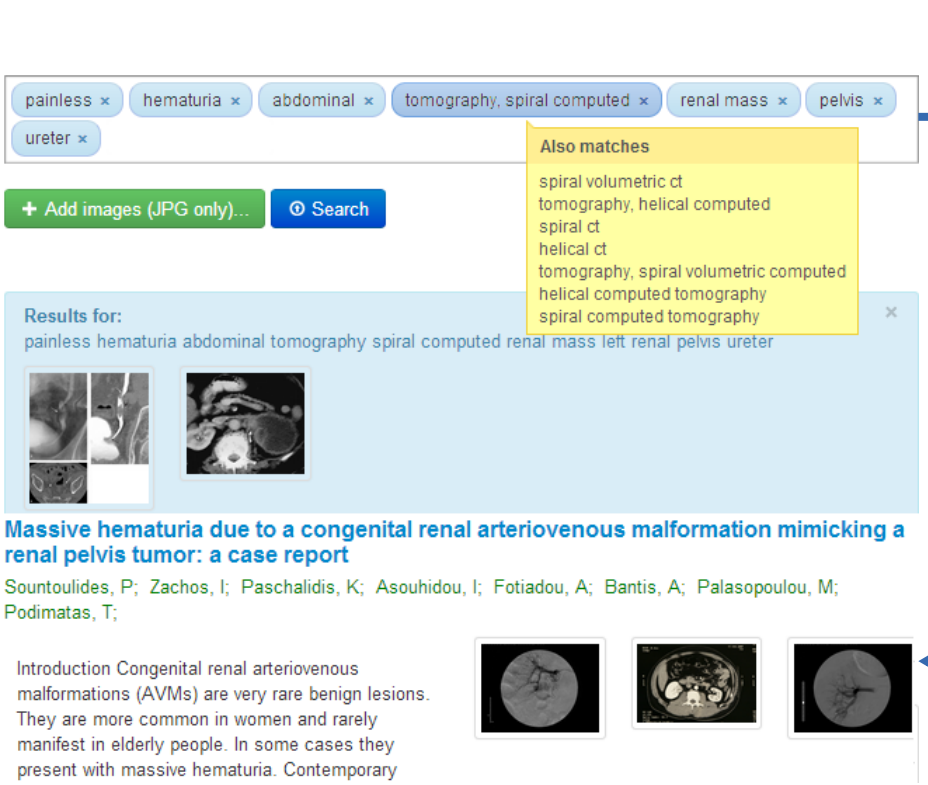


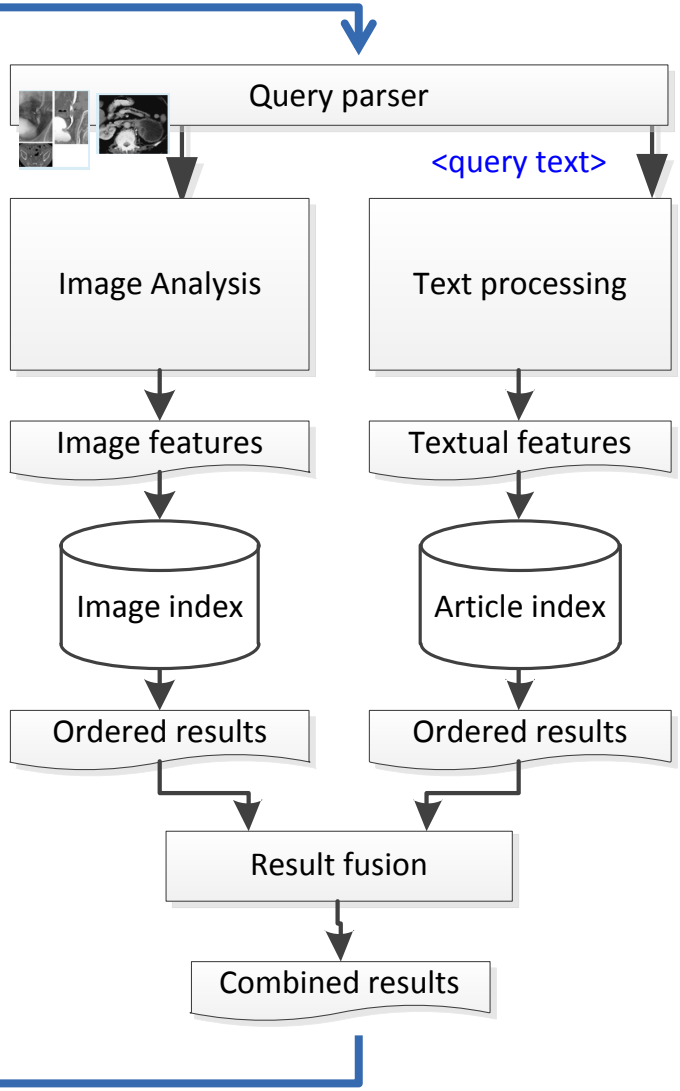
osteoporosis x-ray images



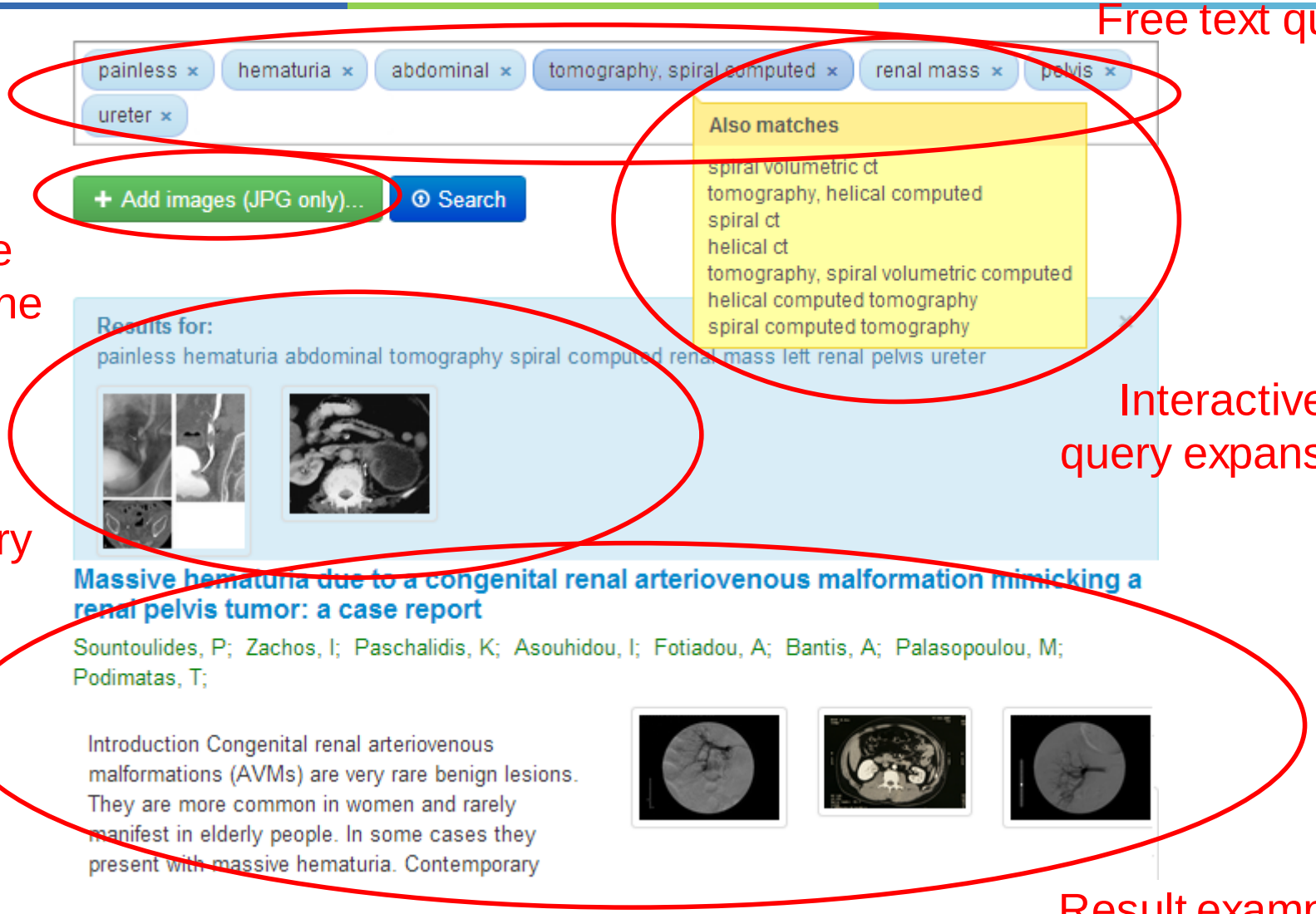
*A woman in her mid-30s presented with dyspnea and hemoptysis. **CT scan** revealed a cystic mass in the right lower lobe. Before she received treatment, she developed right arm weakness and aphasia. She was treated, but four years later suffered another stroke. Follow-up **CT scan** showed multiple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

NovaMedSearch





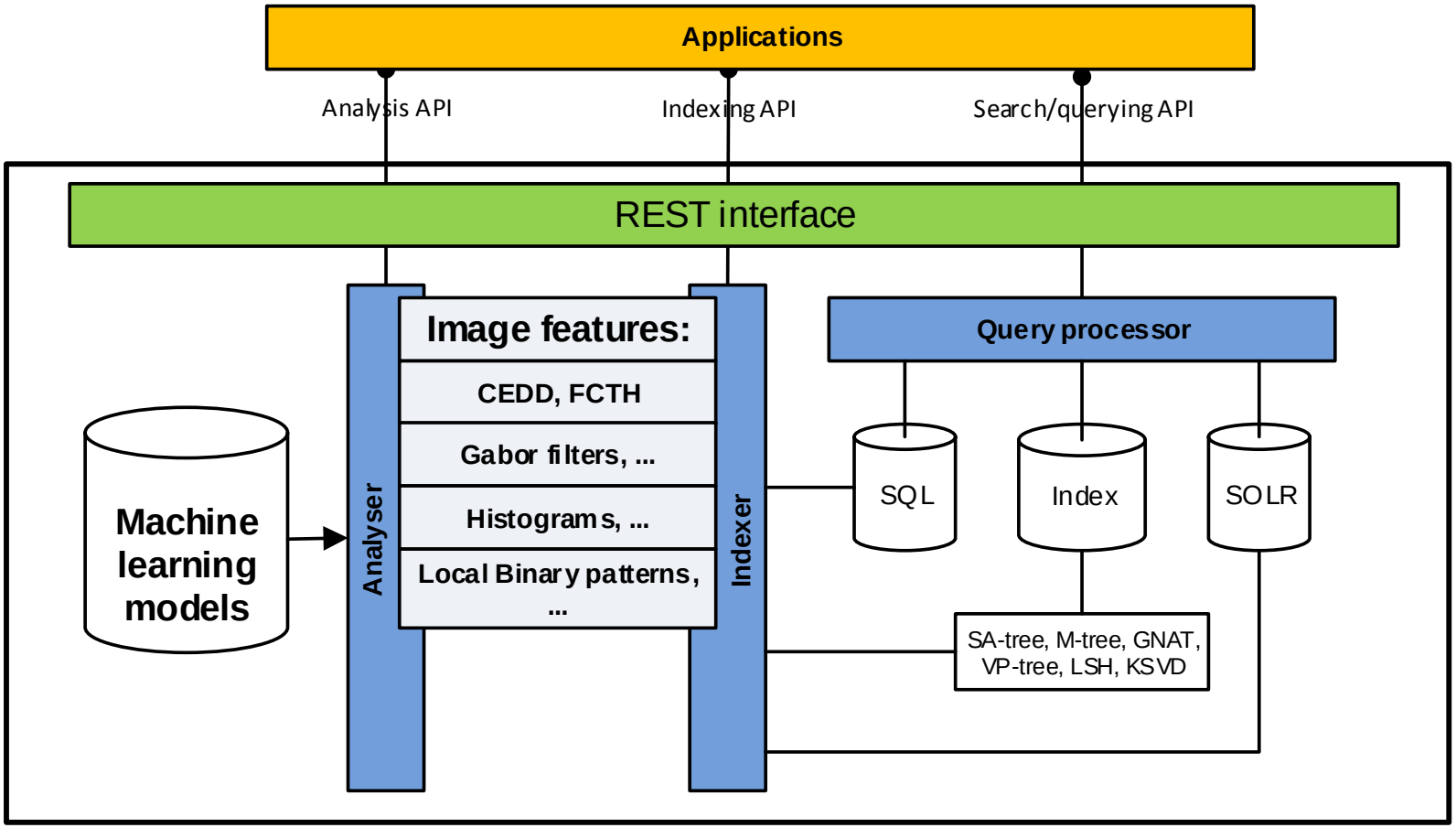
NovaMedSearch: http://medical.novasearch.org



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
  - Acessed through REST: programers use existing endpoints to develop new applications
  - Focus on multimodality: combining image and textual features for better performance

Framework for rapid multimodal prototyping

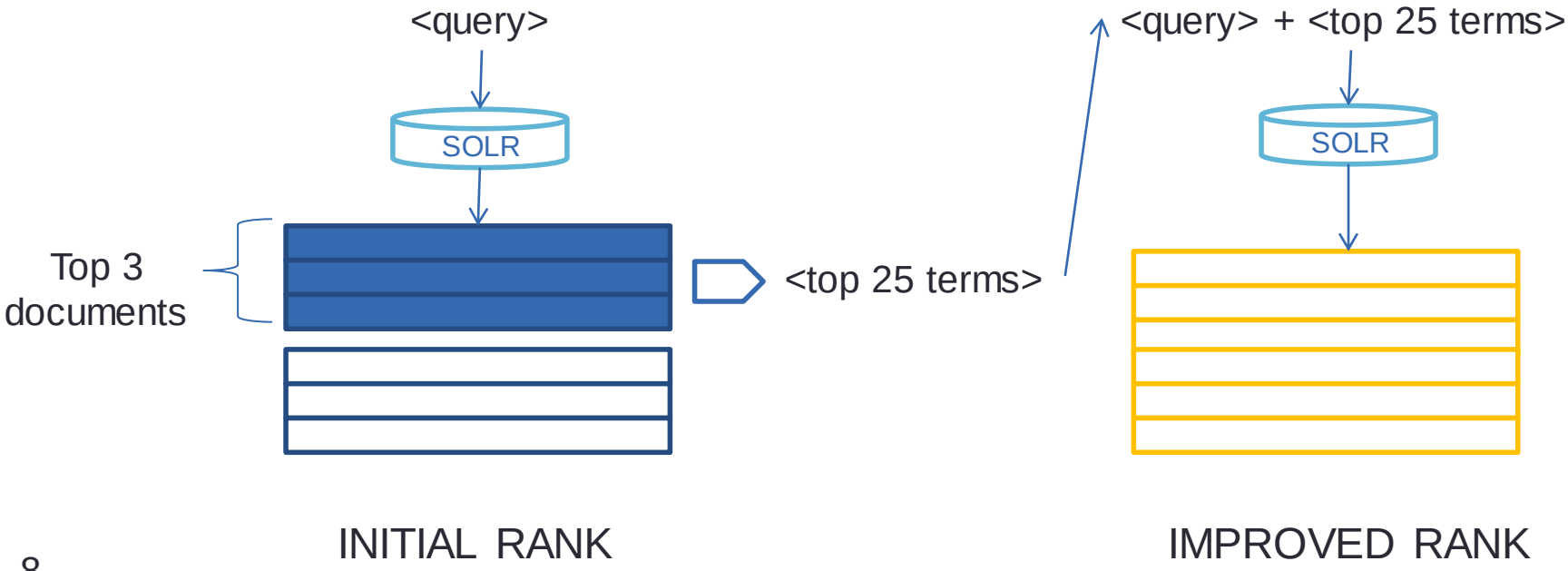


Framework: image retrieval

- 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)

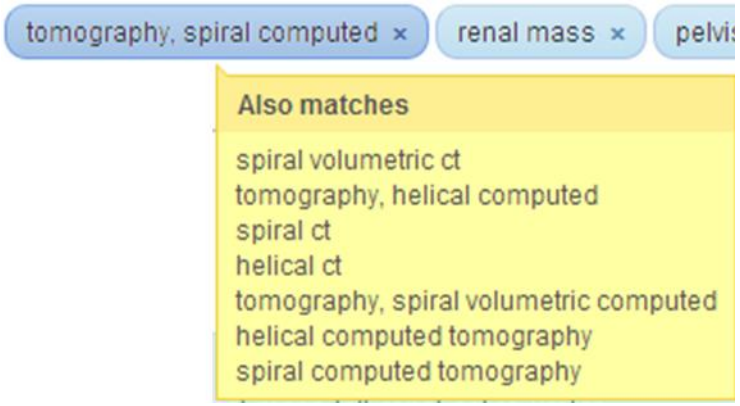
Framework: text retrieval

- 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

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 `(label - prediction)^2`
  - One-vs-all linear classifier

Modality classification results

Run Name	Type	Correctly classified	
IBM_modality_run1	Textual	64.17%	
words	**Textual**	**62.35%**	
IBM_modality_run4	Visual	80.79%	
CEDD_FCTH	**Visual**	**57.62%**	
IBM_modality_run8	Multimodal	81.68%	
All	**Multimodal**	**72.92%**	**(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

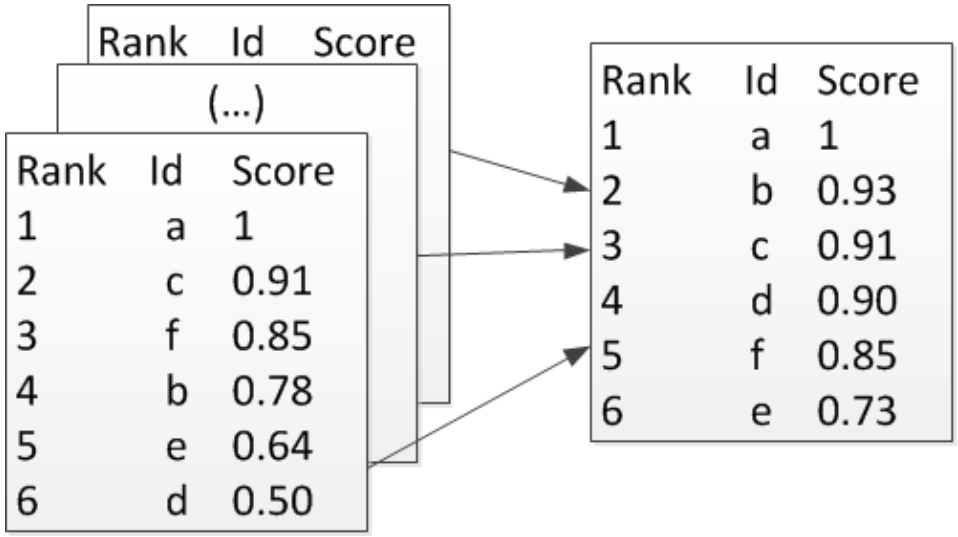
- Normalization
- Lower case filter
- Stop word removal

Query

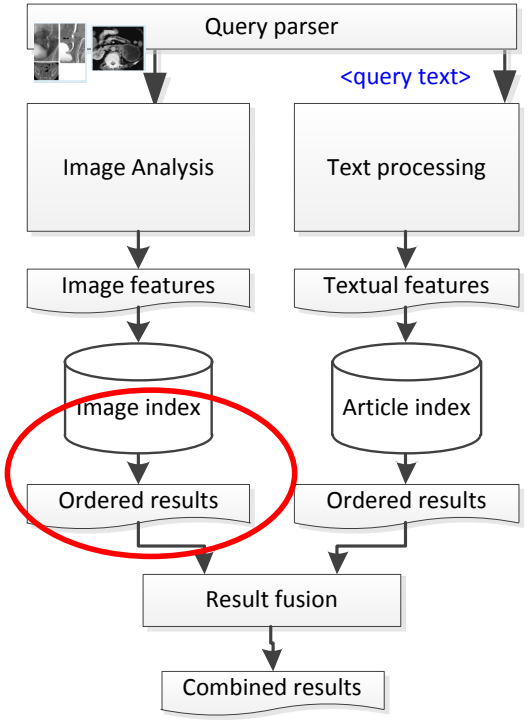
- Normalization
- **MeSH expansion**
- Lower case filter
- Stop word removal
- **Remove duplicates**

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:

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

sum of scores for i

nº of lists with document i

- Rank-based:

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

sum of Inv. rank for i

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

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

sum of inv. sqaured ranks for i

nº of lists with document i

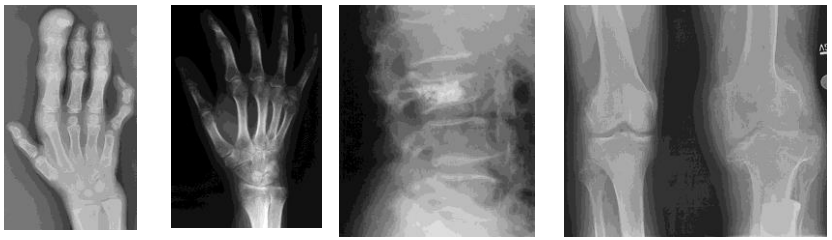
Case-based retrieval results

Run Name	Type	MAP	P@10	P@30
FCT_CB_MM_rComb (ISR)	**Multimodal**	**0.1608**	**0.1800**	**0.1257**
medgift_mixed_nofilter_casebased	Multimodal	0.1467	0.1971	0.1457
FCT_CB_MM_MNZ (CombMNZ)	**Multimodal**	**0.0794**	**0.1371**	**0.0810**
SNUMedinfo9	Textual	0.2429	0.2657	0.1981
FCT_LUCENE_BM25L_MSH_PRF	**Textual**	**0.2233**	**0.2600**	**0.1800**
FCT_LUCENE_BM25L_PRF	**Textual**	**0.1992**	**0.2343**	**0.1781**
FCT_SEGHIST_6x6_LBP	**Visual**	**0.0281**	**0.0429**	**0.0238**
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
FCT_SOLR_BM25L_MSH	**Textual**	**0.2305**	**0.0482**	**0.2316**	**0.2971**	**0.2181**
FCT_SOLR_BM25L	**Textual**	**0.2200**	**0.0476**	**0.2280**	**0.2657**	**0.2114**
DEMIR4	Visual	0.0185	0.0005	0.0361	0.0629	0.0581
FCT_SEGHIST_6x6_LBP	**Visual**	**0.0072**	**0.0001**	**0.0151**	**0.0343**	**0.0267**

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

Questions?