Relevance Feedback Survey

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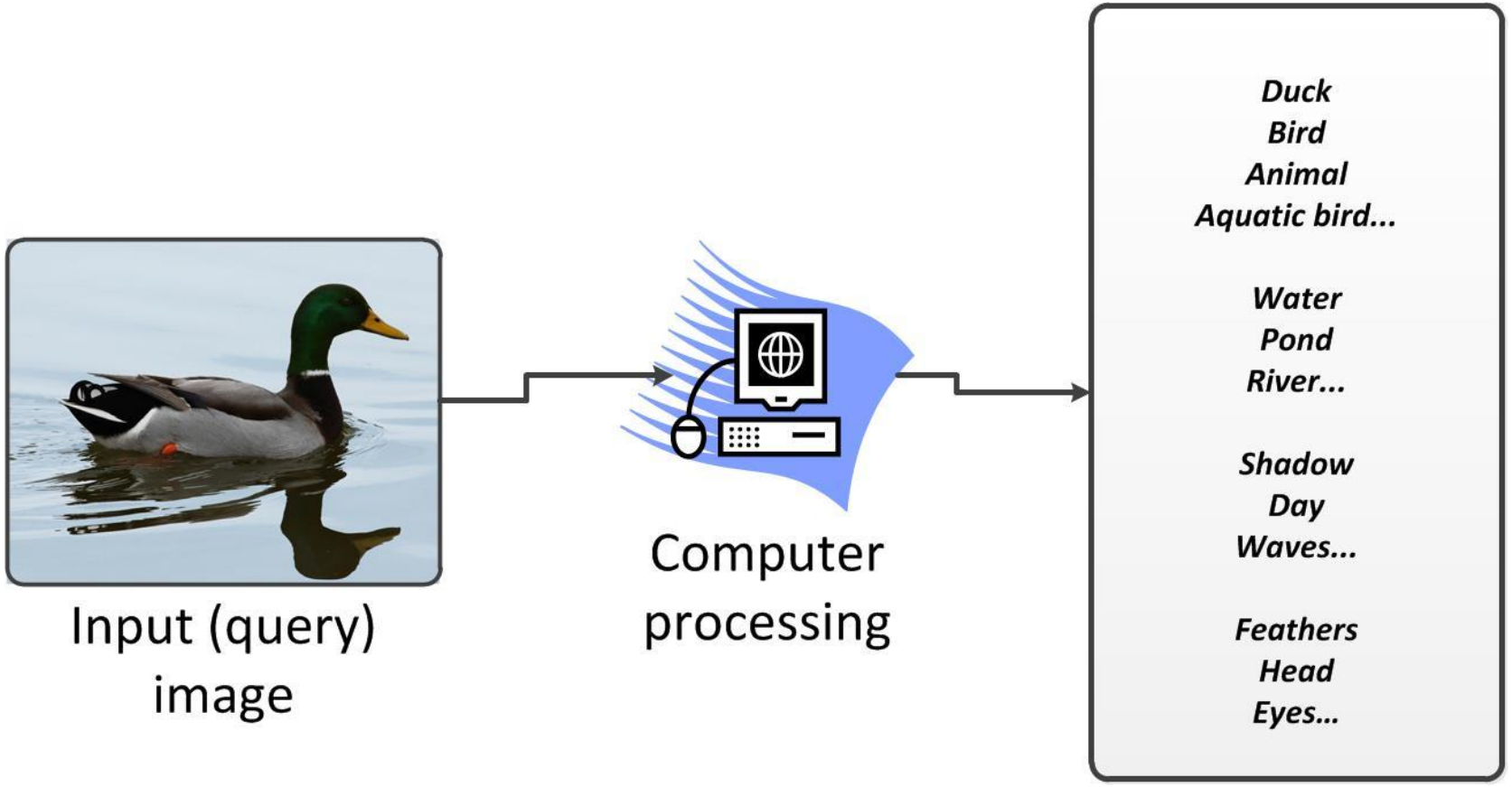
Outline of the presentation

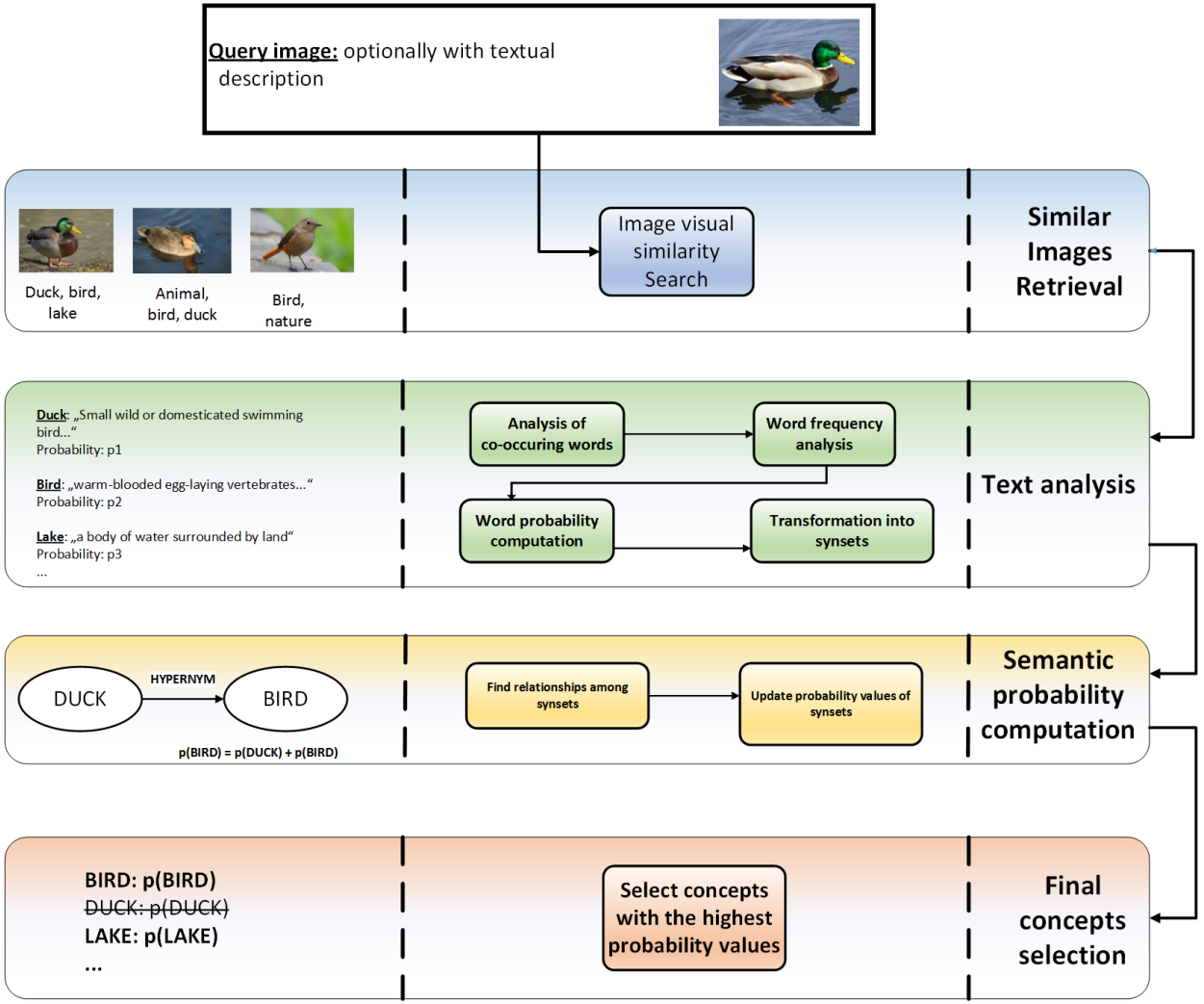
- 1) MUFIN Annotation Tool
  - Current situation, future direction
- 2) Relevance Feedback
  - General overview
  - Approaches
- 3) RF for MUFIN Annotation Tool
  - Specific requirements
  - RF Tool design

MUFIN Annotation Tool I.

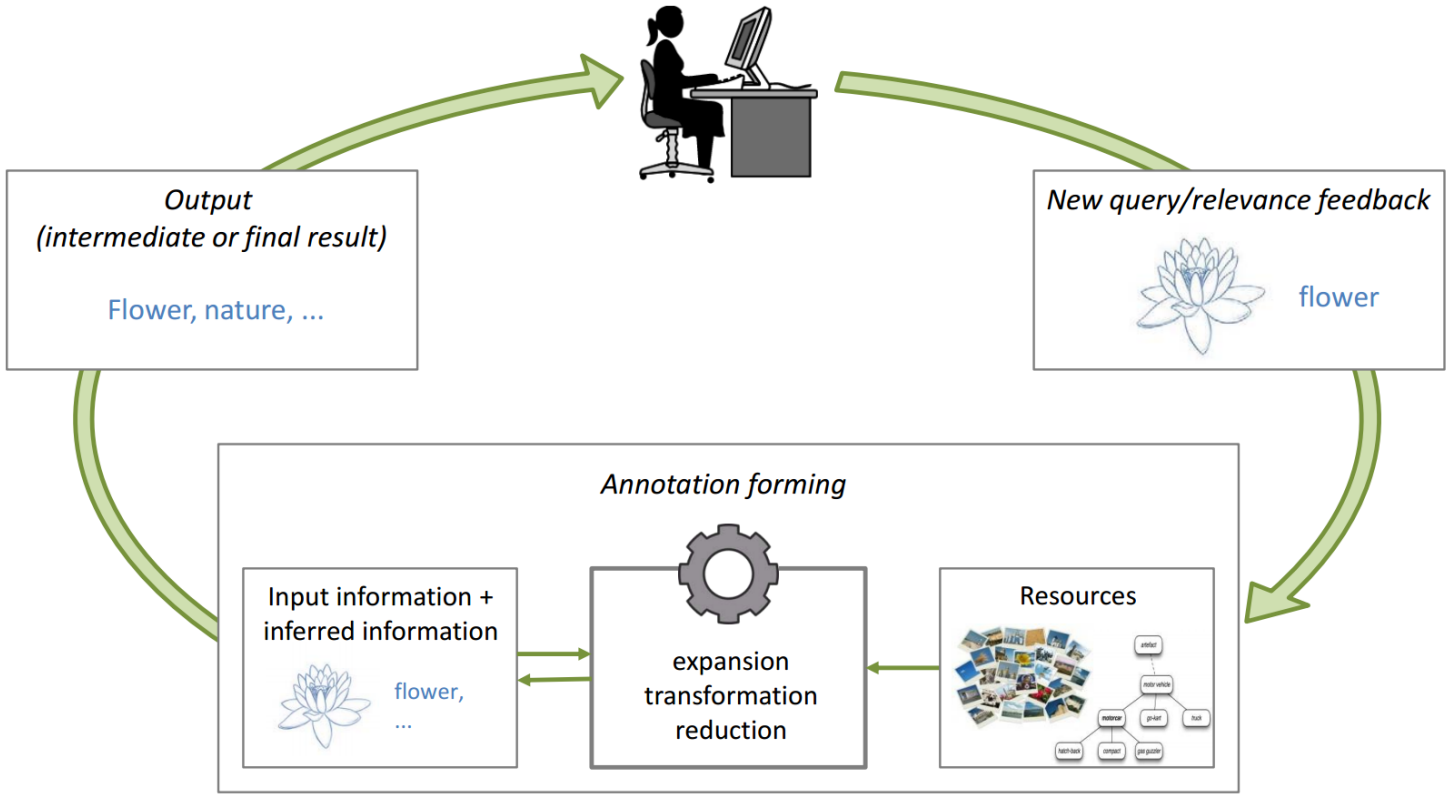


- Main goal = automatically annotate unknown images with relevant descriptive words

MUFIN Annotation Tool II.



Relevance Feedback I. (Motivation)



- Incorporate a human factor to the annotation process
- „Iterative evaluation of particular system behavior conducted by system users“

Relevance Feedback II.

- Relevance Feedback idea:
  - *take results that are returned from a given query processing*
  - *provide results to users for relevance evaluation*
  - *utilize user-provided information about whether or not those results are relevant to perform a new (improved) query*

Relevance Feedback III.

- First application: documents search
  - Relevance evaluation of retrieved documents
  - Most of RF studies aimed to text-based application
- Developed into a widely used technology
  - Text retrieval – social networks
  - CBIR – evaluation of visually similar images

Relevance Feedback IV. (Basic Terminology)

- Query object (*Qo*):
  - The „original“
  - The object that the retrieval process is based on
  - “Query subjects are meant to be as similar as possible”

- Query subjects(*Qs*):
  - Subjects of user’s relevance evaluation
- Iteration (*I*):
  - An evaluation run performed by user of the RF system
- Evaluation (*E*):
  - Relevance value assignment by user to particular query result

Relevance Feedback V. - Approaches

- Boolean model
  - The simplest one – based on the strict match of query/documents
- **Vector-space model**
  - A document is represented by a vector
  - Model is based on vector operations in particular vector space
- Probability model
  - A document is also represented by a vector BUT the vector space is replaced by a probability function
- Logic (language) model
  - Utilizes logic interference in conjunction with some knowledge source (e.g. ontology)

Vector-space model I.

- Selected as a base to our further consideration
  - Relatively simple; widely used approach to RF
- Vector space → allows vector operations

- Document (object) needs some vector representation
  - Defined by Tf-idf values of words within document space
  - Each vector has particular dimension
  - Each element of a vector represents a tf-idf value of a particular word from within a set of all words of a particular database

- Distance may be measured among documents (vectors)
  - E.g. Cosine distance

Vector-space model II.

- tf-idf
  - tf(t,d) - (Term Frequency) = integer number expressing a frequency of a term *t* in a document *d*
  - idf(t) (Inverse Document Frequency) =

$$\mathrm{idf}_t = \log \frac{N}{\mathrm{df}_t}.$$

    - *N* = number of all documents in the collection
    - *df* = number of documents containing term *t*
    - *log* = more frequent terms have lower value then less frequent ones
  - **tf-idf(t,d) = tf(t,d) . idf(t)**

Vector-space model III. (Similarity measure)

- **Cosine similarity**
  - The most fundamental approach to measure similarity of two vectors

$$\mathrm{sim}(d_1, d_2) = \frac{\vec{V}(d_1) \cdot \vec{V}(d_2)}{|\vec{V}(d_1)||\vec{V}(d_2)|},$$

  - Nominator:"dot product" / Inner product
  - Denominator: Euclidian distance
    - Normalization of vector lengths

$$\sqrt{\sum_{i=1}^{M} \vec{V}_i^2(d)}.$$

Vector-space model IV. (Rocchio)

- Rocchio's formula = baseline of the Vector model approach

$$\overrightarrow{Q_m} = (a \cdot \overrightarrow{Q_o}) + \left(b \cdot \frac{1}{|D_r|} \cdot \sum_{\overrightarrow{D_j} \in D_r} \overrightarrow{D_j}\right) - \left(c \cdot \frac{1}{|D_{nr}|} \cdot \sum_{\overrightarrow{D_k} \in D_{nr}} \overrightarrow{D_k}\right)$$

- Related/unrelated documents
- Constants *a*, *b*, *c* influence the importance of particular equation component (original, positive, negative)

Variable	Value
$\overrightarrow{Q_m}$	Modified Query Vector
$\overrightarrow{Q_o}$	Original Query Vector
$\overrightarrow{D_j}$	Related Document Vector
$\overrightarrow{D_k}$	Non-Related Document Vector
a	Original Query Weight
b	Related Documents Weight
c	Non-Related Documents Weight
D_r	Set of Related Documents
D_{nr}	Set of Non-Related Documents

Vector-space model V. (Rocchio Example)

new query vector = $\alpha \cdot$ original query vector +
$\beta \cdot$ relevant document vectors -
$\gamma \cdot$ non-relevant document vectors

0	4	0	8	0	0	$\alpha = 1$		0	4	0	8	0	0
2	4	8	0	0	2	$\beta = 0.5$	+	1	2	4	0	0	1
8	0	4	4	0	16	$\gamma = 0.25$	-	2	0	1	1	0	4
								-1	6	3	7	0	-3
								0	6	3	7	0	0

Typically $\beta > \gamma$, since positive feedback is more meaningful.

Negative term weights become 0.

RF for annotations I.

- Text object RF vector:
  - If in document collection *C(d)*, there are only 6 words (*w1.. w6*) repeating,
  - then *Vd* = (10,0,3,1,7,0) ➔ document *d* contains 10x *w1;* 3x *w3; Ix w4 and 7x w5*
  - Document is composed of text pieces = words are repeated

- Evaluation of documents as a whole
- The evaluator evaluates same objects (documents) as he/she searches for (document)

RF for annotations II.

- Image object RF vector:
  - If in image collection C(i), there are only 6 words (*w1 .. w6*) repeating,
  - then Vi = (1,0,1,1,1,0) ➔ image *c* annotation consists of words *w1,w3,w4,w5*
  - Image description is (typically) composed from separate keywords; not repeating

- Photos can be considered as a SHORT text document
  - Composed of only keywords
- Evaluation of textual descriptions of image
- Evaluators evaluate different objects (keywords) than he/she searches for (images)

RF for annotations III. (Our situation)

- Our situation: Visual query(image) + textual description
  - I. Iteration = image + (user-provided) optionally textual description
  - II. Iteration = image + (RF-based) textual description
  - III. Iteration = image + (RF-based) improved textual description
  - …

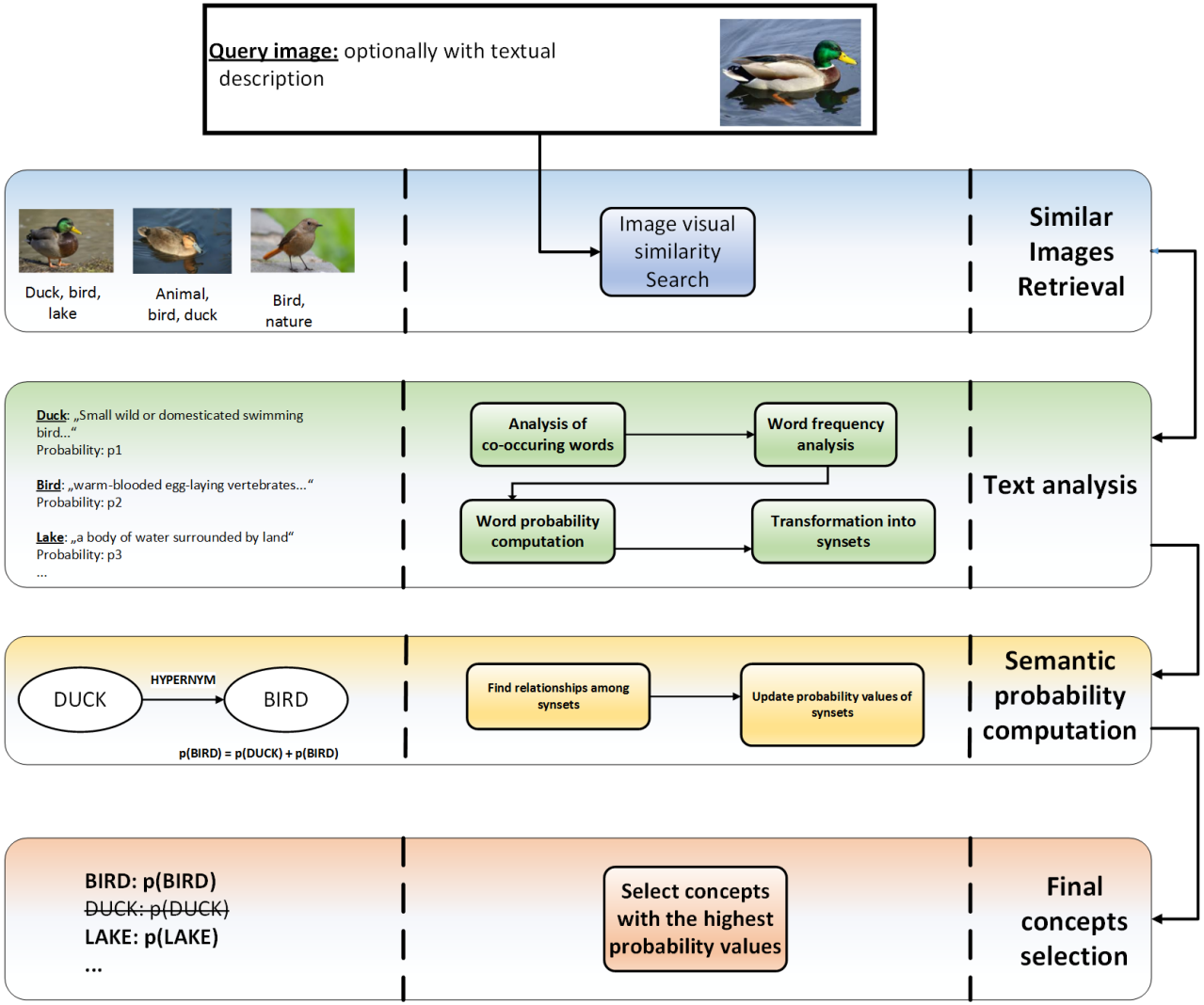
- **RF is utilized ONLY in the textual part of the query**

RF for annotations IV. (Our demands)

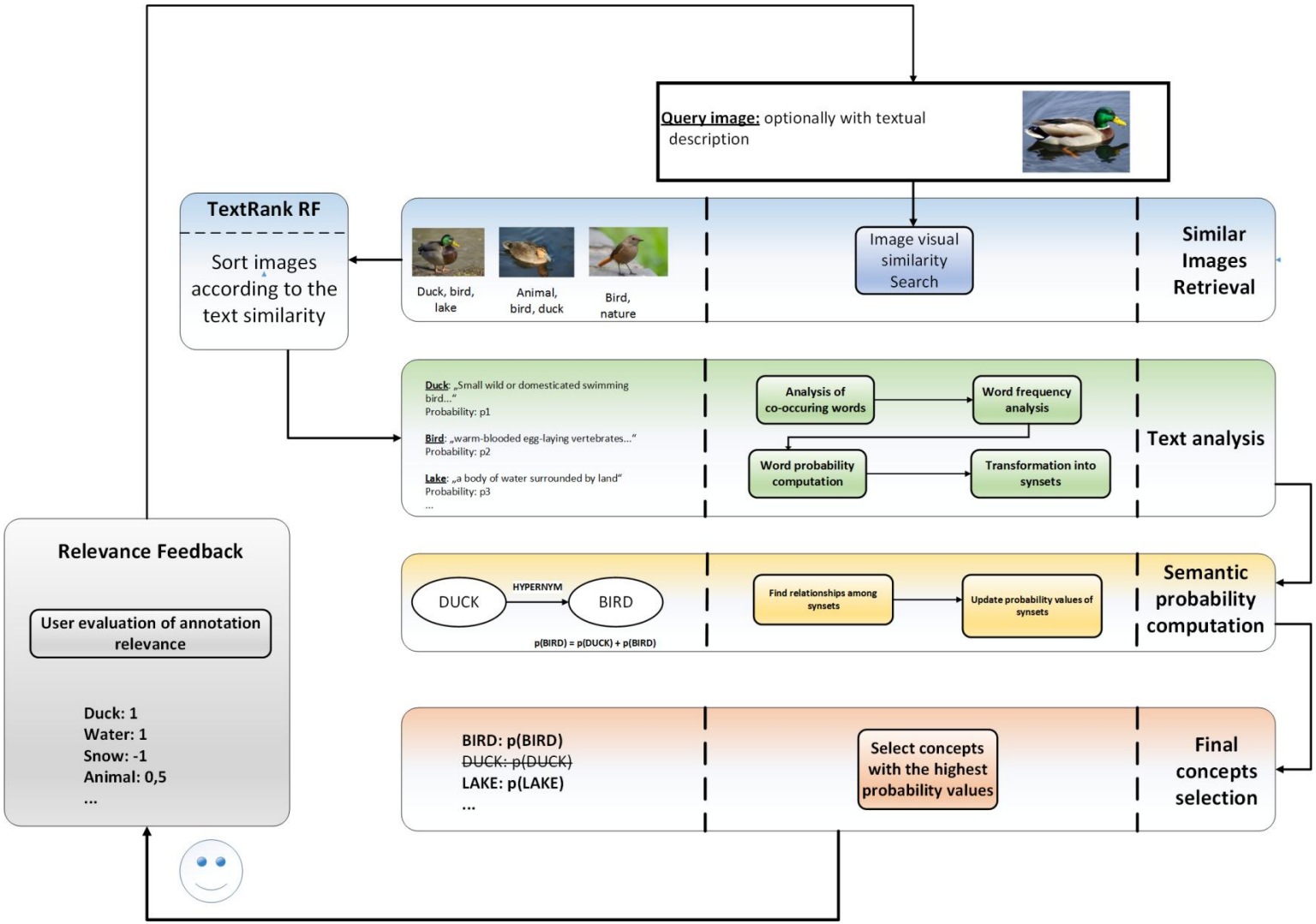
- Include also negative RF
  - Short description → only positive evaluation probably is not sufficient; it is desired to handicap the non-relevant concepts

- Better scalability of evaluation
  - Incorporate more levels of evaluation
  - Ability to emphasize the positivness or negativness of particular word
  - So far (Rocchio) only 2 scale levels = we require more general approach

Proposed Image Annotation RF Approach I. (reminder)



Proposed Image Annotation RF Approach II.



Proposed Image Annotation RF Approach III.

- RF: First iteration:
  - Initial vector Q_0 is empty → former query was not evaluated
  - User evaluates words → relevant (Q_r) & non-relevant (Q_{nr}) query vectors are constructed directly

  - 1) Animal: 0,5
  - 2) Dog: 1
  - 3) Plant: -1

  ➔ Q_r : (0.5, 1, 0)

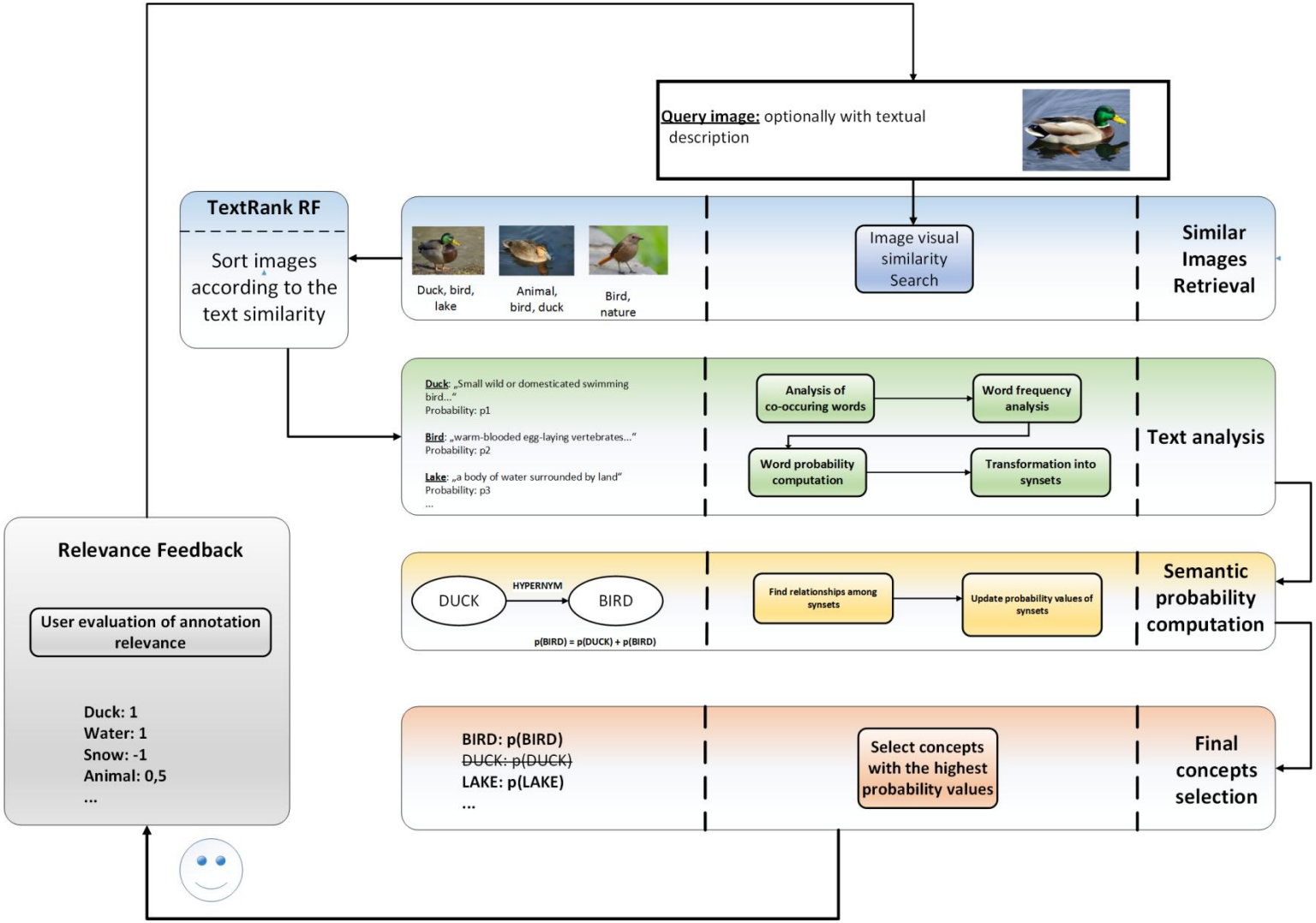
  ➔ Q_{nr}: (0,0,1)

$$\overrightarrow{Q_m} = (a \cdot \overrightarrow{Q_o}) + \left(b \cdot \frac{1}{|D_r|} \cdot \sum_{\overrightarrow{D_j} \in D_r} \overrightarrow{D_j}\right) - \left(c \cdot \frac{1}{|D_{nr}|} \cdot \sum_{\overrightarrow{D_k} \in D_{nr}} \overrightarrow{D_k}\right)$$

Proposed Image Annotation RF Approach IV.

- RF: Subsequent iterations:
  - Initial vector Q_0 is NOT empty → former queries were evaluated
    - Qr : (0.5, 1, 0) – (animal, dog, plant)
    - Qnr: (0,0,1) – (animal, dog, plant)
  - Q_r‘ and Q_{nr}‘ are constructed as follows:
    - If new word occurs, is added into Q’
    - If already presented word is evaluated → average value is constructed
  - 1) Animal: 1
  - 2) Plant: 0,5
  - 3) Poodle: 1
  - Q_r‘= (0.75, 1, 0, 1) Q_{nr}‘=(0, 0, 0.25, 0)
    - (animal, dog, plant, poodle)

Proposed Image Annotation RF Approach V.



Proposed Image Annotation RF Approach VI.

- Text Ranking:
  - Visually similar images **are transformed into word vectors** → visually similar images LIMITS the scope of text ranking
  - *Cosine similarity* is computed between the query vector and similar image vectors
    - Both for relevant and non-relevant initial vectors
  - According to the similarity values similar images are ranked into two lists: by **relevance** and by **non-relevance**
  - Output of the Text Ranking component is formed by combination of constructed two ranked lists

Proposed Image Annotation RF Approach VII.