Retrieval of Brain CT Reports and Images Using Interaction Information Retrieval

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Abstract. The application of Interaction Information Retrieval to retrieve brain CT images is presented. After describing briefly the method and the architecture of the Web application, experimental results are reported and discussed.

Introduction

In brain CT imaging the image sets differ only through subtle, domain specific clues [1], [2], [3], [4], and usually radiology reports are used for indexing and retrieval.

This paper presents our ongoing applied research and results. The goal is to find medically meaningful similar images. Thus, (a) the quality of specialist consultation as well as medical education can be enhanced; (b) general practitioner medical doctors may confirm a diagnosis, or explore possible treatment plans through a consultation to the CT retrieval system over the Web; (c) medical students may have images and would like to explore possible diagnoses, or would like to see images corresponding to different pathological cases such as lesion, bleed or stroke, and (d) specialist research can be supported.

1. Approach

CT images are analysed by the physician, who produces a report. Relevant medical concepts are identified and used as indexing terms [5], [6]. Usually four approaches can be identified and combined to describing and using CT images:

(a) Representation based on the patient's personal data (demographic and procedure information),
(b) Representation based on clinical image reports (semantic information),
(c) Representation based on knowledge (knowledge-based information),
(d) Representation based on image features (content-based information).

In this paper, the semantic information approach is adopted. The reports are written in Hungarian. At present, NLP techniques for Hungarian are hardly able to cope with specific problems like composition of words (e.g., ’liquortér’ = ’liqour’ + ’tér’ meaning ’space occupied by liqour’), compound synonyms (e.g., ’szürkeállomány’ = ’grey matter’), spelling (e.g., ’hipofízis’ = ’hypohysis’), postfixes (e.g., ’atrophias terület’ = ’region with atrophia’ or ’vérzéses terület’ = ’region with bleed’ Thus, a controlled vocabulary is used (spelling, accuracy and consistency of concepts) for indexing. As regards retrieval, the interaction method is implemented [7].

2. Method

Any report o_i, $i = 1, 2, ..., M$, is assigned a set of identifiers (relevant medical terms) denoted by t_{ik}, $k = 1, 2, ..., n_i$. There are weighted and directed links between any pair (o_i, o_j), $i \neq j$, of reports. The one is the relative *frequency*, denoted by w_{ijp}, of a term given a report, i.e., the ratio between the number f_{ijp} of occurrences of term t_{jp} in report o_i, and the length n_i of o_i, i.e., total number of terms in o_i: $w_{ijp} = f_{ijp}/n_i$, $p = 1, ..., n_j$. The other weight is the *inverse document frequency*, denoted by w_{ikj}, and represents the extent to which a given term reflects the content of a report. Let f_{ikj} denote the number of occurrences of term t_{ik} in o_j, and df_{ik} is the number of reports in which t_{ik} occurs, then w_{ikj} is given by the inverse document frequency formula: $w_{ikj} = f_{ikj}\log(2M/df_{ik})$. The reports are represented as an interconnected network, every report is linked to every other report. The query is conceived as being a report, too (much shorter and without the complexity of a real report of course), and is interconnected with the already interconnected other reports causing some of the already existing connections to change because M and df_{ik} change (the query 'interacts' with the reports, which give the name of the method). Retrieval is defined as local 'memories' recalled by the report-query, i.e., those reports are said to be retrieved which belong to 'reverberative circles' (self-stimulating circles) triggered by a spreading of activation started at the report-query.

The interaction retrieval method allows for a (relatively) high precision [8] within within 50%–70%, which is a desideratum in CT retrieval.

3. Application

The application (Figure 1) consists of a number of computer program modules written in several languages (C, HTML, Visual Basic, MathCAD) as well as related documentation. The communication between the Web server and the search program is based on the CGI protocol. The *Report Editor* makes it possible to create/edit reports. The *CT Base Editor* makes it possible to create and modify the database containing the images and reports. The *Validation Module* consists of programs which carry out formal and consistency validation, and statistics. The *Search Module* is used online on the Web. It consists of user interfaces and search programs. The query is formally analysed and interconnected with the database. Then activation is initiated at it, which spreads on according to a winner-take-all strategy giving rise to a reverberative circle whose members form the response.

A test database was created (in English using training material) containing 40 cases. Each case has two parts: (i) CT images (each case contains from 10 to 14 image slices), (ii) textual information: scanning time, patient age, patient sex, patient notes, paresis information, and case report (the demographic data is not necessarily real to ensure anonymity). A controlled vocabulary was created based on both textual reports and standard specialist queries. A few examples for terms are: aphasia, brain swelling, disturbed consciousness, eye deviation, hemiparesis, hyperdensity, infarct increase, right-sided hemiparesis, somnolence, thrombolysis, undisturbed consciousness.

The title page is shown in Figure 2. Two versions are available: Hungarian and English. The top of screen contains a header. The area underneath is divided into two halves: the left half contains the terms of the controlled vocabulary, whilst the right half the search buttons and the query. The medical terms can be selected from the vocabulary, or freely entered from the keyboard in the query line. The user has two choices for selecting searching strategies by clicking on the ″SEARCH associative″ (interaction information retrieval) or on the ″SEARCH terms″ (OR-ed Boolean retrieval) button. The advantage of

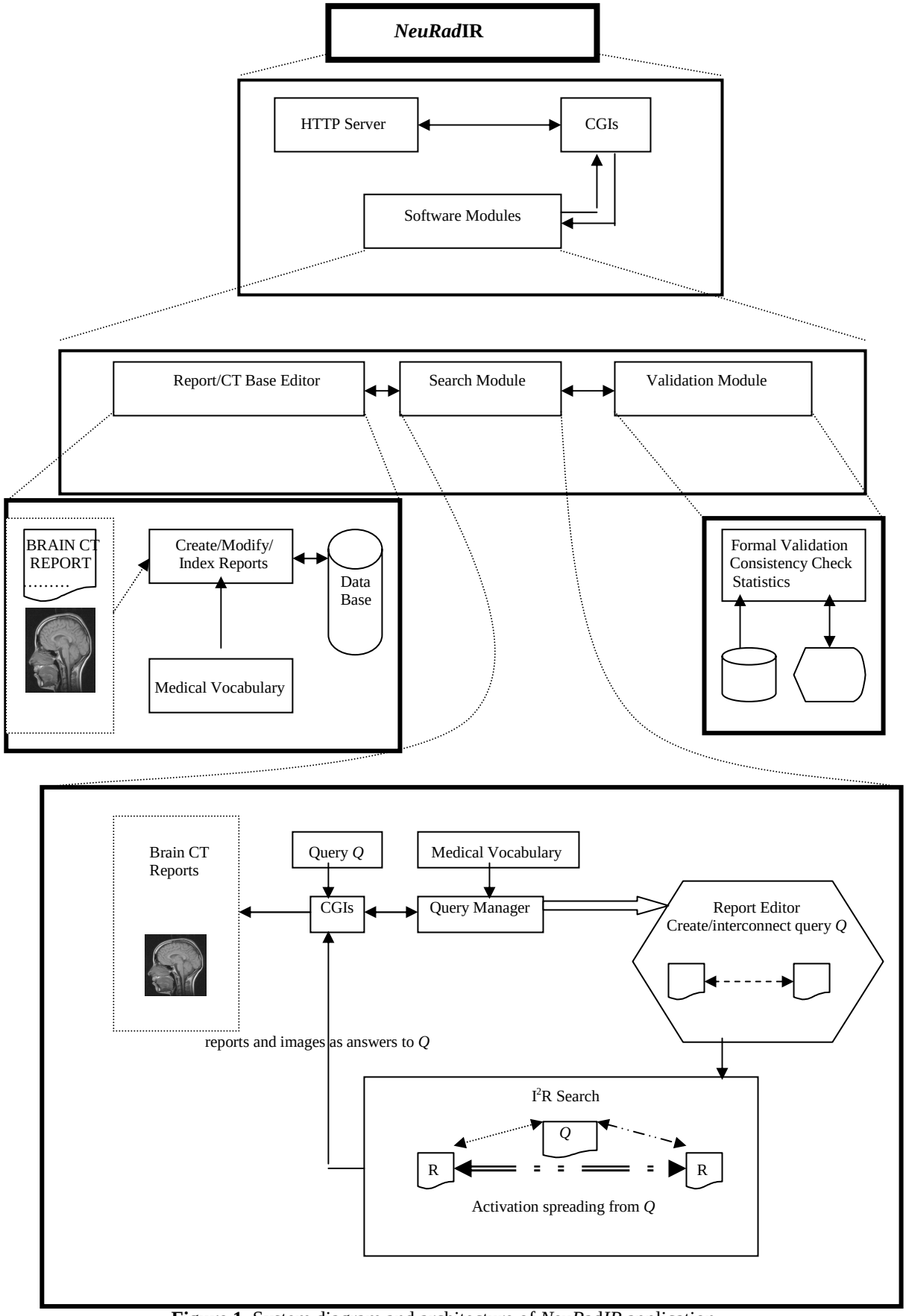

Figure 1. System diagram and architecture of *N*eu*R*ad*IR* application.

using both search strategies is that they complement well each other: the Boolean search retrieves every case containing at least one of the query terms, whilst the interaction search returns the cases most associated with the query. A hit list is returned, and by clicking on any hit the textual information as well as the CT images are displayed.

Since we did not find any dedicated test collection in neuroradiology, a radiologist (the primary user) was involved in evaluating the relevance effectiveness of the application. The medical doctor performed a series of searches as described above, and judged the returned images and reports from his own specialist point of view. The relevance effectiveness was assessed as good. Also, suggestions to extend the application to searching demographic data, too, were made.

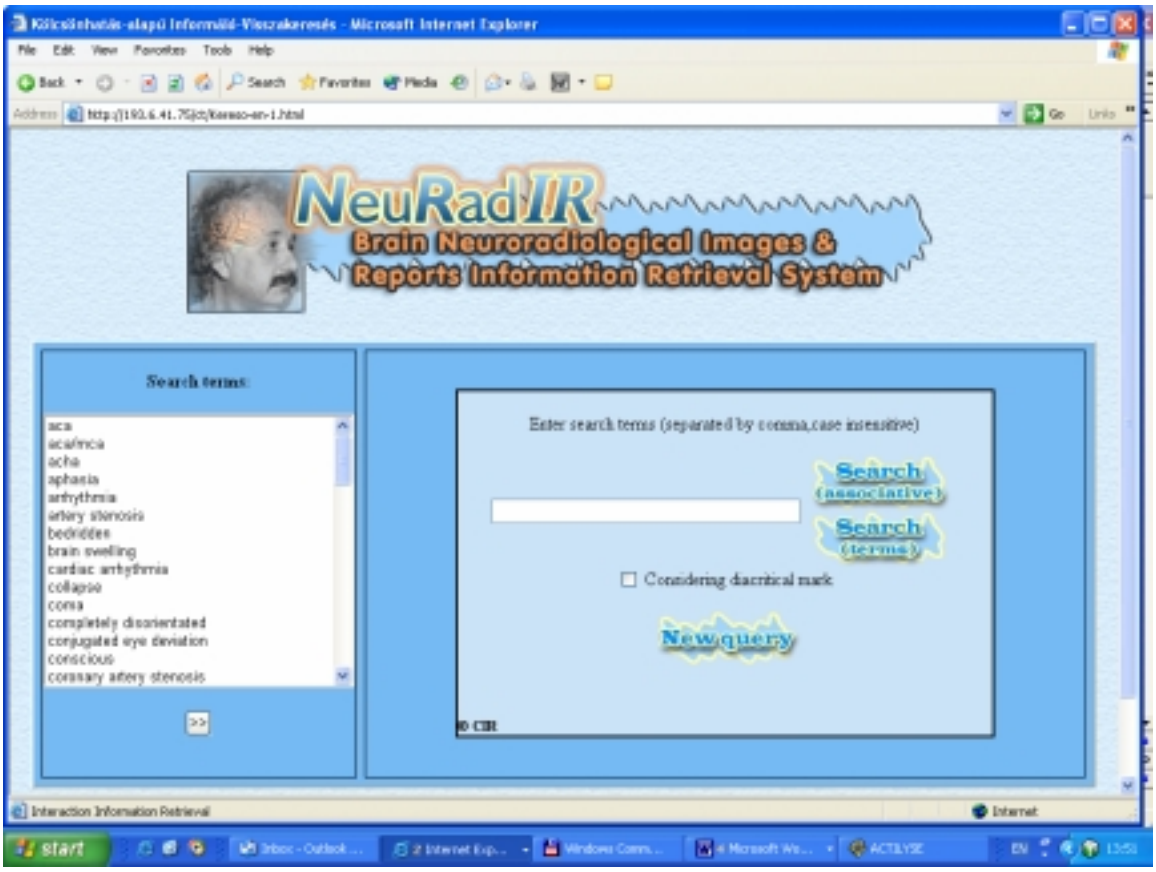

Figure 2. Search screen of *N*eu*R*ad*IR*.

4. Conclusion

The application of the Interaction Information Retrieval method to retrieving brain CT images was presented. An application, called *NeuRad*IR, was developed, which can be accessed over the Web. Cases most similar to the query are retrieved. There is also the possibility to retrieve those containing at least one query term in order to have complementary search. The relevance effectiveness of the application was assessed as good by the radiologist (the future user). The application should be extended so as to enable demographic search, and make use of feature extraction modules to index images.

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