Khresmoi – multilingual semantic search of medical text and images

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Abstract and Objective

The Khresmoi project is developing a multilingual multimodal search and access system for medical and health information and documents. This scientific demonstration presents the current state of the Khresmoi integrated system, which includes components for text and image annotation, semantic search, search by image similarity and machine translation. The flexibility in adapting the system to varying requirements for different types of medical information search is demonstrated through two instantiations of the system, one aimed at medical professionals in general and the second aimed at radiologists. The key innovations of the Khresmoi system are the integration of multiple software components in a flexible scalable medical search system, the use of annotation cycles including manual correction to improve semantic search, and the possibility to do large scale visual similarity search on 2D and 3D (CT, MR) medical images.

Keywords:

Medical information search, medical image search.

Introduction

The Khresmoi project[1] is developing a multilingual multimodal search and access system for medical and health information and documents. It addresses the challenges of searching through huge amounts of medical data, including general medical information available on the internet, as well as 2D and 3D radiology images in hospital archives. The latter includes Magnetic Resonance (MR) and Computed Tomography (CT) images. The system allows text querying in several languages, in combination with image queries. Extensive medical knowledge bases support semantic search. Results can be translated using a machine translation tool specifically trained on medical text.

The system is aimed at three main end user groups: members of the general public, physicians and radiologists (a group of physicians for which image search is of immense importance). Extensive user requirements analysis for these user groups has been done through online questionnaires and interviews. An outline of the Khresmoi concept is shown in Figure 1.

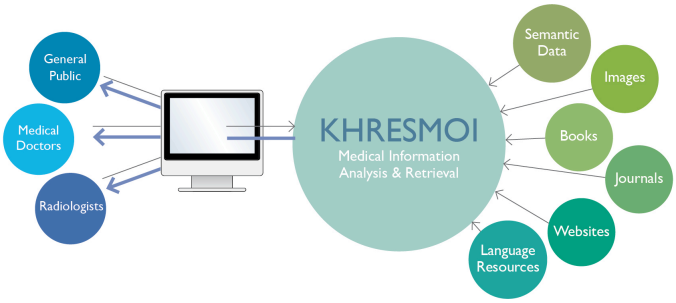
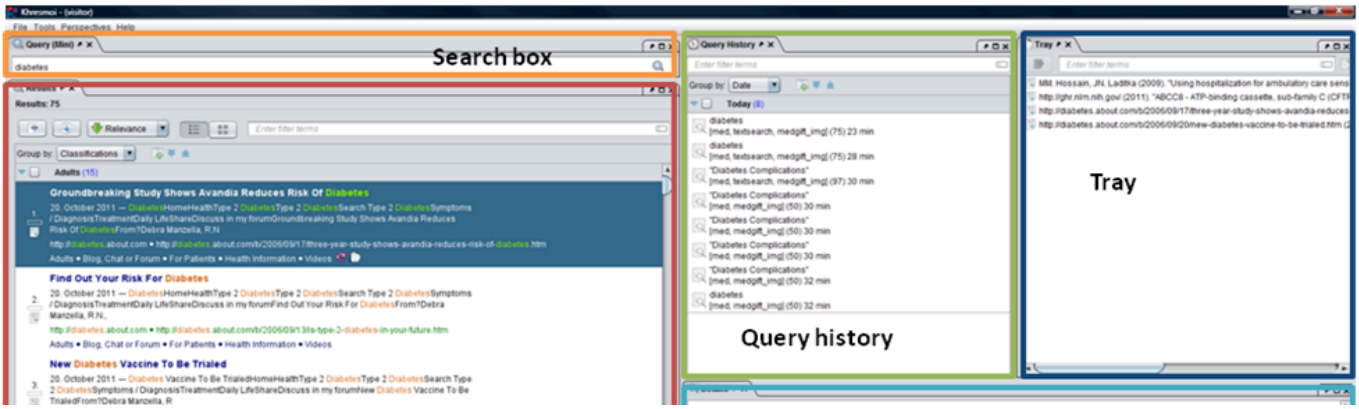


Figure 1 - The Khresmoi Concept

[1] http://khresmoi.eu



Description

Khresmoi is built of a number of software components integrated into a scalable cloud-based architecture. Various instantiations of this prototype allow search in web documents and the medical literature, as well as in radiology images (for both 2D and 3D images).

Khresmoi Technology

The open source software that Khresmoi is built upon has undergone significant advancement through work in Khresmoi. The open source software is listed below, along with the advances achieved in Khresmoi:

- **GATE**[2]: The General Architecture for Text Engineering (GATE) is used to annotate documents at word, section and document levels. Through work in Khresmoi, its capabilities for annotating medical documents have been expanded. The use of cycles of human correction to improve the automatic annotation has also been extensively tested.
- **Mimir**[3] uses GATE annotations to perform semantic search. The major achievement was the release of Mimir 4, including the ability to rank returned documents.
- **ezDL**[4] is a framework for interactive search applications. It has been extended with the capability to display image search results, as well as extensive tools to facilitate collaborative search, such as the ability to share documents and queries between users.
- **ParaDISE** is a new visual search engine developed in Khresmoi as a successor to the GNU Image Finding Tool (GIFT). It is more scalable than GIFT due to the use of Hadoop/MapReduce, and contains state-of-the-art image features and visual similarity calculation.

Furthermore, the **MOSES** statistical machine translation software[5] has been trained to translate text in the medical domain. The **OWLIM** semantic repository[6] has received performance and functionality upgrades, and has also had its medical knowledge base expanded through the addition of new medical vocabularies and new links between the medical vocabularies.

Finally, technology for analysing 3D CT and MR images is being developed. This allows structures in the images to be automatically identified and mapped to a standard vocabulary. It also allows retrieval of images to be done based on the visual similarity between images.

Khresmoi Prototypes

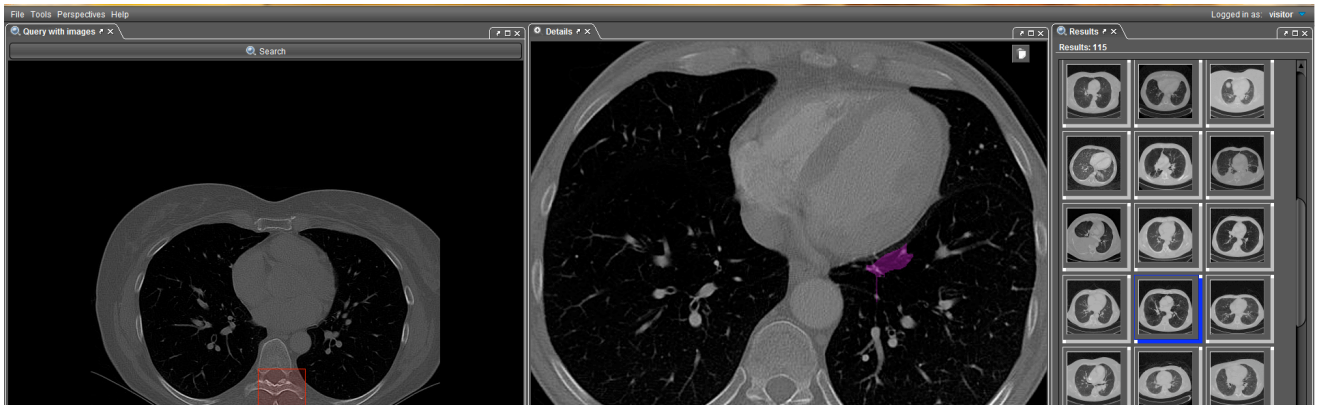
The Khresmoi components outlined above can be combined in multiple ways into prototypes. Two prototypes are described here, one aimed at medical professionals in general and one aimed at radiologists.

Medical information search for medical professionals

This interface, shown in Figure 2, is aimed at medical professionals. It has the following features:

- **Search box**: The simple search box is shown. Advanced search is also available, allowing for example the choice of the time span for publication date.
- **Result list**: A summary of each document is given. Controls at the top allow the results to be reordered or grouped by various criteria and filtered by terms. The icons indicated by the arrow show when a document has been viewed (eye icon) and moved to the tray (clipboard icon).

[2] https://gate.ac.uk/
[3] https://gate.ac.uk/mimir/
[4] http://ezdl.de/
[5] http://www.statmt.org/moses/
[6] http://www.ontotext.com/owlim



- **Tray**: Documents can be dropped here to be stored for future use. Logged in users have access to personal libraries, allowing more flexibility in organizing documents, including the capability to add tags to documents and share documents with colleagues.
- **Query history**: Lists details on all queries entered (including date and time) and allows queries to be repeated.
- **Document view**: All data available on the document selected in the results list are shown, including a link to the full document. It is also possible to translate the text shown using the machine translation tools.

Medical information search for radiologists

Figure 3 presents the interface instantiated for use by radiologists (also noticeable by the colour scheme adapted to the radiology requirements). Note that this is the same interface framework shown in Figure 2, but with different tools visible. Here the query is the selected area of the image slice shown in the left panel. The images in the panel on the right are returned based on their visual similarity to the region marked in the query. In the central panel, the selected image is shown, along with the associated radiology report. For this application, only the images stored in the archives of the hospital in which the system is used are indexed. However, the possibility to do a visual search of 2D images from the medical literature is also provided.

A use case for this system is that a radiologist faced with an unusual or unknown structure in an image can query the hospital archives for images containing a similar structure, and use the (anonymised) radiology reports associated with these images to guide the reading of the image.

Statement of Innovation

The Khresmoi system is innovative in multiple ways. Below is a summary of the key innovations:

- **Integration**: The Khresmoi system consists of multiple software technologies integrated in a modular way, allowing flexibility in designing the user interface, as demonstrated by the two prototypes shown in this paper.
- **Semantic search**: The medical documents are annotated in a cycle including manual correction of the annotations. This manual correction allows the automatic annotation software to learn to correct its errors. The annotations are used for semantic search.
- **Large-scale image search**: Search based on visual similarity of images is supported for both 2D images (X-rays and images in publications) and 3D images (CT and MR).

Conclusion

This paper described the Khresmoi medical information search system after two years of development in the Khresmoi project. The system is built from software components, the majority of which are available under open source licenses. The possibility to flexibly combine these components to meet requirements of different types of medical search is demonstrated by the two prototypes shown in the paper.

It is important to know how well the technology developed in Khresmoi is functioning. For this reason, an evaluation strategy has been developed. Each of the components of Khresmoi has already undergone individual evaluation. The next step is to perform global evaluations, which will take two forms: the *global empirical evaluation* will measure how the components work together in the Khresmoi system, while the *user-centred evaluation* will get end users from all three Khresmoi target user groups to perform tasks on the Khresmoi prototype.

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