NEWSLETTER

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TOPICS
in this issue

Editorial

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The Khresmoi project has had a very eventful and successful third year. The prototypes have been consolidated into three versions catering to the three end user groups targeted by Khresmoi. *Khresmoi for Everyone* is aimed at members of the general public, while *Khresmoi Professional* provides a comprehensive professional search environment for medical professionals. The specific image search needs of radiologists are met by the *Khresmoi Radiology* prototype, which is the main focus of this newsletter. Georg Langs first describes the technologies developed to allow search by visual similarity in MRI and CT clinical images, and a scenario in which such a search could be useful. Henning Müller goes beyond search in clinical images, and describes how visual search can also be done for images published in the medical literature. In order to ensure that the Khresmoi technologies meet the needs of radiologists, an extensive user-centred evaluation was done with radiologists, as described by Dimitrios Markonis. In the next months, there are opportunities to see the Khresmoi prototypes live and discuss them with their developers at the events listed at the end of this newsletter.

- Khresmoi for Everyone prototype: http://everyone.khresmoi.eu
- Khresmoi Professional prototype: http://professional.khresmoi.eu

Efficient visual image search in clinical radiology

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Imagine the following: you're looking at a high resolution CT and see a pattern you are uncertain about. You click on the image and within a few seconds get all cases in your department, or region, containing similar patterns, together with the corresponding report; that's all before you even enter a search keyword. The patterns that match your query are highlighted, and you can quickly browse through them and the attached reports. Wouldn't that be helpful?

Search and information retrieval is an active area of research. Since the advent of internet search engines we know that they are a driving force in knowledge acquisition, and have become central to our daily work. We understand that retrieval is only useful if it is able to deliver reliable information efficiently, and if it answers a specific need for information. Recent findings have highlighted the potential of fast, efficient and accurate information retrieval to contribute substantially to improving radiological reporting.

A central user group on which the Khresmoi project focuses is radiologists and their information needs during daily routine, research, or teaching. Queries in such a search system can be based on a few keywords, an image, or both. The system presents results together with relevant information that facilitates quick browsing, and provides transparency regarding the source and its quality. Sources range from literature databases and secondary sources to image databases (PACS) within hospitals.

Visual queries: searching the PACS for patterns in image data

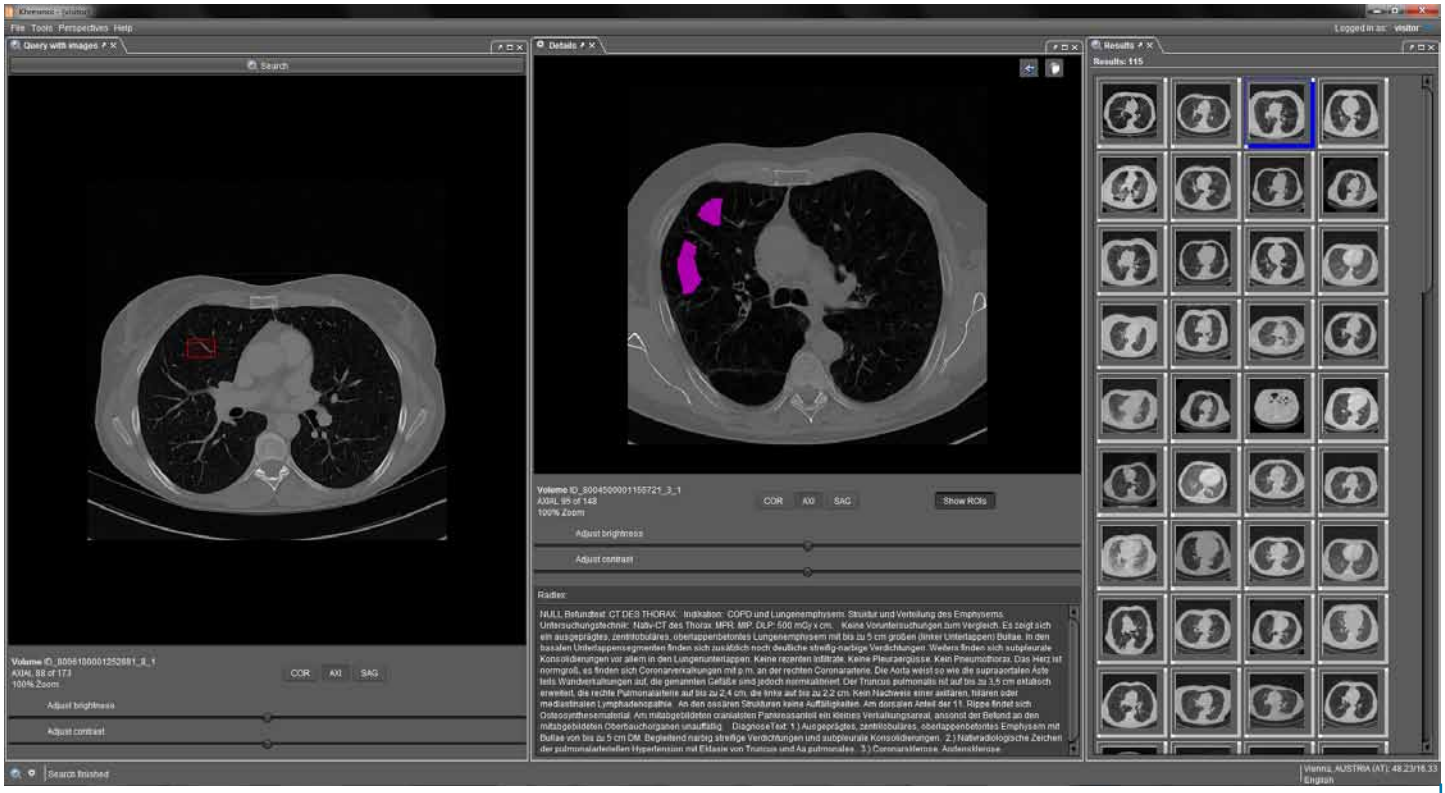
A particularly relevant area of radiological research is content-based image retrieval (CBIR). The aim is to use image data itself – for instance a region of interest in a CT volume marked by the user – to query large image databases for similar patterns, and to provide the user with quick access to the corresponding data, such as images, reports, or even outcomes. The key to successful content-based image retrieval is the extraction of visual features that capture relevant characteristics of the imaged structure, together with fast matching and ranking algorithms that robustly identify similarities across millions of samples. CBIR, in the context of radiology, raises additional challenges to those in other domains. The visual information relevant to matching pathological features is often subtle compared to differences across organs. The variability of anatomical appearance, even in a healthy population, renders the learning of models challenging. Nevertheless, search results from realistic samples of several terabytes of medical imaging data have proved promising. The automatic identification of anatomical structures and the location of images work accurately. Initial results on the retrieval of anomalies suggest that methodology developed at the interface of machine learning, computer vision and medical imaging can provide clinically relevant search results. Current research is focusing on further improving the accuracy of the search.

Scaling methods to make use of large data

A central insight is that transitioning from hundreds of data examples to millions changes many established paradigms. On the one hand, it makes efficient algorithms for matching and representation essential. On the other hand, the enormous amount of variability represented in the data allows for far more comprehensive models to be learned, while at the same time attracting attention to unsupervised modelling approaches. The methodological challenges touch on interesting mathematical problems ranging from basics such as graph theory, or algebra, to machine learning and pattern recognition. While methodological research continues, there is agreement regarding the goal. The knowledge that can be gained from millions of radiological imaging data, which have only been examined once so far, is tremendous. Making it more accessible, and gaining structure from this data are key to helping clinicians, researchers and teachers take full advantage of it.

Adapted from the ECR Today edition of 11 March 2013

• Video demo: http://tinyurl.com/ck6vm53



The Khresmoi Radiology Prototype, showing the query case (left) and search results (right) together with the selected search result image (centre) and corresponding radiology report data.

Searching images in the medical literature

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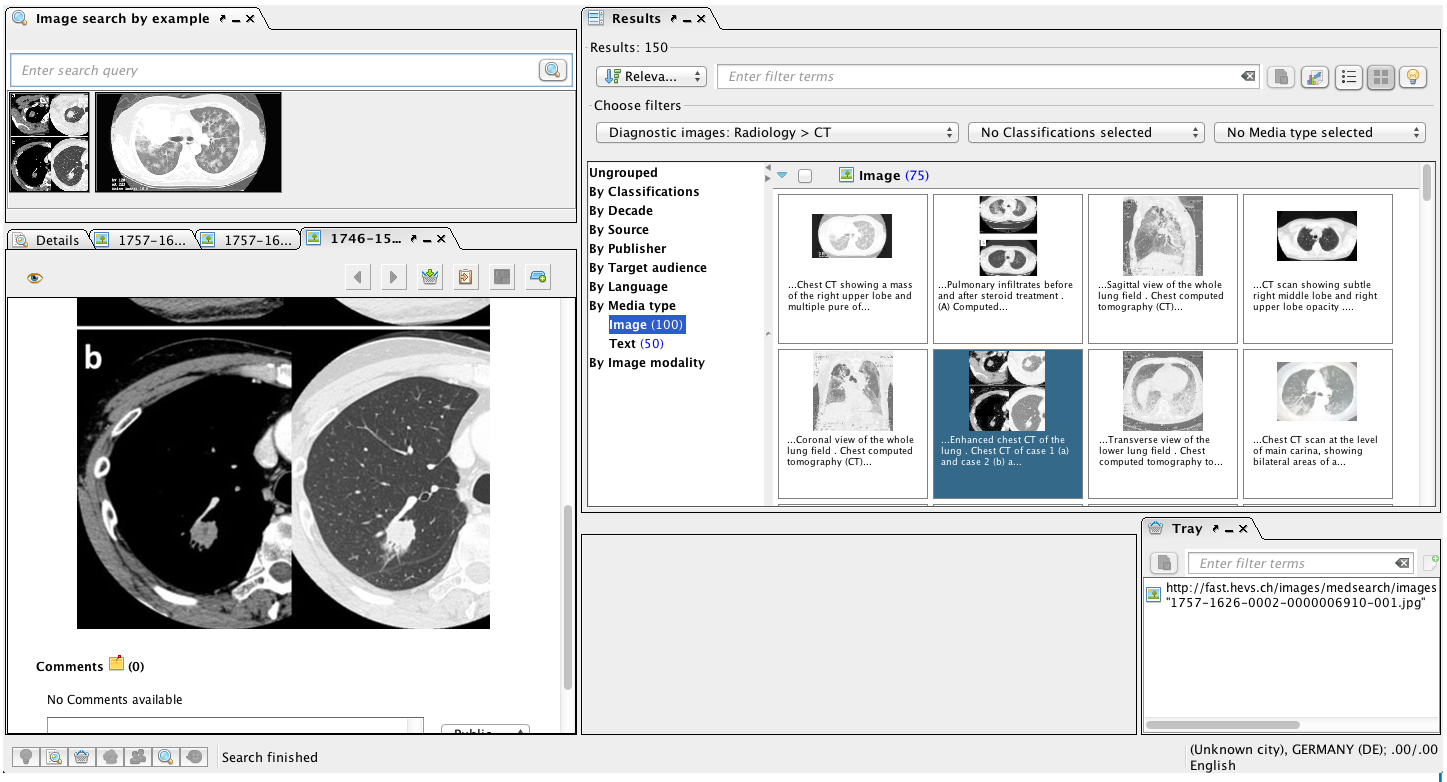
Khresmoi technology also allows images from the medical literature to be searched by visual similarity. A new and much larger database is now being used that includes all of PubMed Central with 700 000 articles and 1.5 million images, containing in particular many more radiology images. The new capability to automatically separate compound figures into their constituent sub-figures increased the number of individual images indexed to around 2.5 million. To allow for more focused search, for all images the image type or modality was determined automatically and several filters allow the search results to be restricted, for example only to radiology modalities, which account for approximately 20% of the images but are of high interest for our target group, the radiologists. It is also possible to perform keyword and visual search together — this allows images similar to an example that also contains specific keywords in the caption to be found.

Up to now, the image search in the medical literature and the search in clinical images described above were two separate applications. In the new prototypes the two applications are now combined and allow searching with clinical images for similar visual data or text in

the medical literature. The speed of the search has been improved both by improving the search algorithms and by taking a new cloud infrastructure into service. Last but not least there were many small changes in the interface itself such as basic image manipulation including level/window settings and zooming into images.

• Video demo: http://tinyurl.com/nj7k3c4



The Khresmoi Professional Prototype showing the possibility to search images published in the literature by visual similarity.

User-centred evaluation of the radiology prototype

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Developing a search system without taking the user requirements into account usually does not lead to a system accepted by the end users. For this reason, we have developed the Khresmoi Radiology system with extensive consultation of the end users. At the beginning of the Khresmoi project, a survey among radiologists (described in Khresmoi Newsletter 2) led to the initial system requirements. Now that the first Khresmoi Radiology prototype is available, we again needed feedback from the end users on how we are doing.

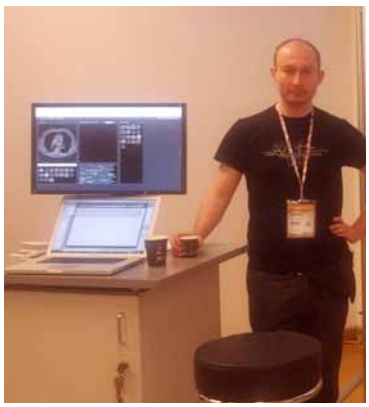
In order to assess the current state of the image search system and to guide future development, a user-oriented evaluation process was performed. During this process, several user tests took place, having radiologists perform information seeking tasks using the system. Aspects such as efficiency, effectiveness and user satisfaction were measured and evaluated. The user-system interaction was monitored and shortcomings of the prototypes were identified. Radiologists gave feedback about the use experience and suggested additional features for the system.

Analysis of the evaluation results showed that the user test participants understood well the concepts and goals of the system and identified an added value to their information finding tasks. Radiologists quickly felt comfortable with the system and reported intention of using the system regularly. Most importantly, the user tests revealed aspects of the system that were less satisfactory and needed modifications.

The results of the study were translated into system requirements and a new round of development has started, guided by these specifications. Once the technical improvements and additions are implemented and integrated into the Khresmoi system, a new round of user tests will take place in order to assess the final system.

Project News

European Congress of Radiology 2013

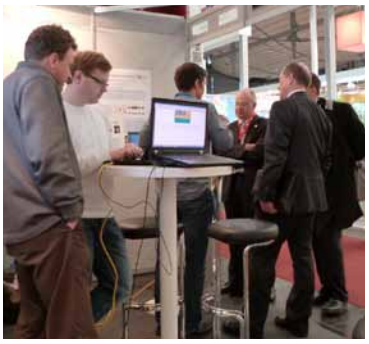


The European Congress of Radiology (ECR) attracts around 20 000 participants from over 100 countries, and includes a scientific and educational programme with over one thousand oral presentations. As part of ECR, the European Institute for Biomedical Imaging Research (EIBIR) organizes the IMAGINE exhibit, to present "novel technology that shapes radiology." Khresmoi participated in the IMAGINE exhibit, with a booth and a prototype demo during the entire congress duration. In addition we presented Khresmoi and individual technical components in oral presentations at the IMAGINE symposium and the congress. The IMAGINE exhibit is significant, since it not only aims at presenting applicable technology to radiologists, but also to communicate work in progress among the medical image analysis community. Both aspects are very valuable for Khresmoi. We could reflect on the applicability of the prototype with radiologists, while at the same time discussing methodological details among peers in the computer science field.

René Donner demonstrating the Khresmoi Radiology prototype.

CeBIT 2013

Khresmoi was present at the booth *EU Language & Big Data Projects* at the CeBIT, the world's largest and most international computer expo, from the 5th to the 9th of March 2013 in Hannover, Germany. Other EU projects present at the booth were PROMISE, X-LIKE and RENDER. The Khresmoi prototypes were demonstrated to many visitors. This also gave us the opportunity to exchange information and results with other research projects, in particular German national projects. This event also premiered the Khresmoi golf shirts and Khresmoi pens.



Demonstrations at the CeBIT 2013 booth.

MedInfo 2013

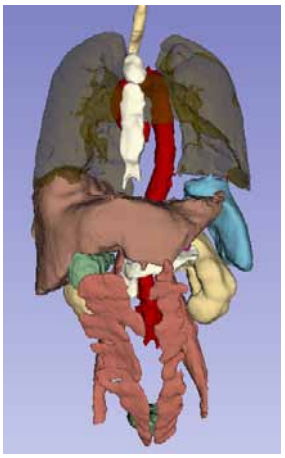
The three Khresmoi prototypes were shown in a 45 minute demo presentation at the 14th World Congress on Medical and Health Informatics (MedInfo) held in Copenhagen, Denmark from August 20th to 23rd, 2013. Furthermore, a presentation on the end user evaluations with radiologists was given, and posters on the end user evaluations with physicians and on the automated classification of health web pages were shown.

Henning Müller presents the Khresmoi Radiology prototype at the MedInfo 2013.

VISCERAL Benchmark

The VISCERAL Benchmark is evaluating automatic whole body labelling in 3D medical imaging data. MRI and CT images that have been manually annotated by radiologists have been made available to participants in the benchmark, where 15 organs in each image are annotated. The participants in the VISCERAL Benchmark should program algorithms to automatically segment the organs, where the available manually annotated data can be used for training and tuning these algorithms. After the algorithm submission deadline, these algorithms will be tested on images that the participants have not seen, and participants will be informed about the performance of their algorithms. The VISCERAL Benchmark is currently open for participation, and registration is still possible. The deadline for submitting algorithms is the 30th of November 2013.

More details are on the web page: http://visceral.eu



The ground truth of an image used in the VISCERAL benchmark.

Upcoming events

- Khresmoi will be present at the Innovation days in Paris, France from October 7th to 8th 2013. The event is a major matchmaking event to bring partners in the eHealth domain together. See: http://www.lifescience-outlook.com/innovationdays

- The Khresmoi Professional prototype for medical practitioners will be shown at a booth at the 44th Congress for General Medicine in Graz, Austria from November 28th to 30th, 2013. Attendees will have the opportunity to try and solve medical questions using the prototype. More information at: http://www.stafam.at/

- The Khresmoi prototypes will be shown at a booth at the ICT 2013 event in Vilnius, Lithuania from November 6th to 8th, 2013. The event is the official start of Horizon 2020 and will bring together over 4000 researchers and policy makers.
  More can be found at: http://ec.europa.eu/digital-agenda/en/ict-2013

- Henning Müller will present on the structuring of radiology information (lexicons, semantics, ontologies, …) with Elmar Kotter at the Radiology Management course on the 9th of October, before the Management in Radiology meeting in Barcelona, Spain on October 10th to 11th, 2013.

- The Khresmoi Radiology prototype will be demonstrated at the International Conference on Multimedia Modeling (MMM) in Dublin, Ireland from January 8th to 10th, 2014.

Read more on the Khresmoi webpage: http://khresmoi.eu

Follow Khresmoi on Twitter: https://twitter.com/khresmoi

Join the Khresmoi group on LinkedIn: http://www.linkedin.com/groups/KHRESMOI-project-3745929

To order the newsletter and receive regular updates:
http://www.khresmoi.eu/contact-us/keep-me-updated/

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