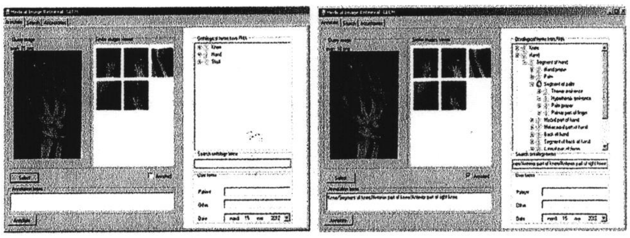

Fig. 1 Overview of the annotation system

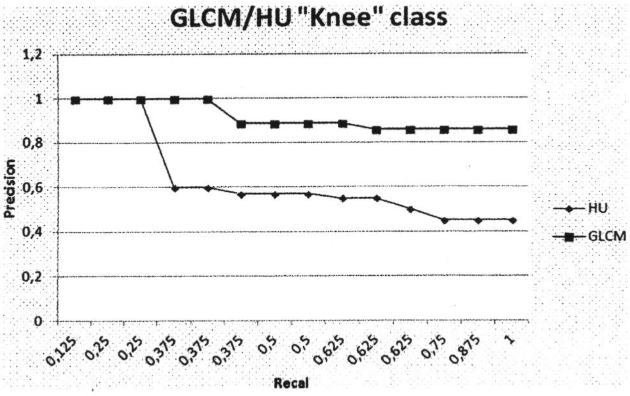

Fig. 2 Search results corresponding to the knee class are presented on the recall/precision *curves*

from the second and third order normalized central moments. These two descriptors are based on a global description of the image, and thus, they do not need any segmentation step. The proposed system allows the user to annotate each new medical image, by using the existing annotations corresponding to the most similar image to this one. In addition to this, we propose to use the FMA ontology in order to provide some additional lists of keywords, which can be used by the user to complete the annotation process.

Results

The database used in this paper was composed of 100 images classified into several families (thoracic cages, craniums, hands, knees, and mammography's). The search engine developed was evaluated by using the recall/precision curves, and has proven that the proposed retrieval methods present high retrieval accuracy for all the classes of the database. The Fig. 1 shows an overview of the annotation system proposed in this work. The search results corresponding to the knee class are presented on the recall/precision curves in Fig. 2. The main conclusion given by analyzing these curves is that the two proposed methods give good search accuracy. Indeed, it was noticed that, for all the classes, the GLCM descriptor gives higher relevance ratios compared to the Hu moments based approach.

Conclusion

In this paper, a medical image search engine was proposed in order to achieve a medical image annotation system. The proposed automated annotation approach can be used in a computer aided diagnosis system. We have also used the recall/precision curves in order to evaluate the search precision for each class in our database. We can finally notice that the proposed retrieval methods give high accuracy for all the classes.

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CHILI/Mobile: a zero footprint application for mobile devices in radiology

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Keywords Mobile · PACS · Teleradiology · Zero footprint · Security

Purpose

The first prototype of a mobile radiological viewer running on a smart phone has probably been presented by Jarmo Reponen at EuroPACS 2000 [1]. The system was running on Nokia Communicator. At the same time, the authors of this paper developed a first mobile application for handheld devices running on one of the first PDAs (iPAQ pocket PC, Compaq Computer Corp.) as part of the European MTM project [2, 3]. Application scenarios have been identified and user requirements have been carefully evaluated. The Linux- and C++ based CHILI workstation been adopted to run on the iPAQ under the Linux operating system. The user interface has been changed to become accessible with tap & hold principle of the device and to run with a screen resolution of 320 × 240 pixels. The system was designed to work with UMTS or with WLAN as a temporary workaround. Images could be stored on the device. The application provided all necessary basic functions of a radiological viewer. Radiological users evaluated the application under real clinical conditions. The project was quite successful and several prizes have been awarded. Nevertheless, it did not become a real medical product. Some of the reasons were that UMTS (3G) was not yet available at that time; regular mobile bandwidth with 2G was too slow and too expensive. The usage of a small PDA did not make so much sense inside the hospital due to the lack of complete WLAN infrastructures and the size of the device. This paper describes a new approach to provide medical images and related information available on mobile devices inside and outside of the hospital using both the experience of the last 10 years and the latest technology.

Methods

CHILI/Mobile is a zero footprint application. It has been developed on the basis of HTML5. Thus, the application is running in an internet browser and does not require any other programs installed on the mobile device. Neither Java nor any other browser extensions are necessary. All functionalities and data storage is performed on a server in the clinic or even in the cloud. The connection between mobile device and server is encrypted via https.

The mobile application is fully integrated into the HIS/RIS/PACS workflow exceeding the limitations of a viewer that can only display DICOM images. The target users are medical professionals as well as PACS administrators. The system has been designed to provide radiological information inside and outside of the hospital.

Furthermore, the application is independent of hardware and operating systems. Only a web kit-based internet browser (e.g. Safari, Chrome, Android Browser, BlackBerry Browser) is necessary. It is also nearly independent of the screen resolution. The software can be controlled with finger gestures on a touch screen.

Results

A user can access the application directly after logging in. Optionally, it can be integrated it into other mobile information systems, e.g. the HIS, RIS or an EHR. Single sign-on methods have been implemented which pass on authorization from the leading application to the radiological application.

Data privacy is a critical aspect of a medical mobile application. Thus, the data transfers are encrypted using https; in many cases combined with a virtual private network (VPN). Furthermore, client certificates can be used to ensure that only registered devices access the web server. In general, no data is stored on the device. As indicated previously, users need an account and password for the application or the leading application which passes the authentication to the radiological system. Additionally, we implemented a user role and rights concept controlling data access and functionality permissions considering specific users.

Several studies have measured the diagnostic accuracy on mobile devices, such as iPhone and iPad, with very positive results. Nevertheless, we have not authorized our application for diagnostic purposes. In Germany, radiological applications for diagnostic purposes are required to use diagnostic monitors complying with national norm DIN 6868-57 and national quality guide line (QS-RL). These regulations indirectly prohibit the usage of mobile screens for diagnostic purposes.

Examples of devices in use are the iPad (Apple) (Fig. 1), Tablet PCs running the Android operating system or Windows 8 (Microsoft). Smaller devices, such as the Galaxy Note (Samsung) (Fig. 2) are also being evaluated for clinical use.

The system specified is being used in several German hospitals. The mobile application consists of a dedicated web server providing the functionality that is as entirely web based and the medical data.

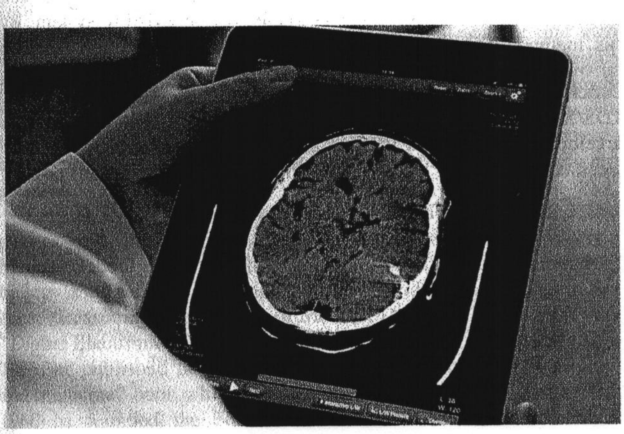

Fig. 1 CHILI/Mobile application in a clinical setting (iPad, Apple Inc.)

Fig. 2 CHILI/Mobile application on the move (Galaxy Note, Samsung Electronics Co Ltd.)

The system is completely integrated within an HIS/RIS/PACS infrastructure including medical modalities. IHE profiles are used whenever possible and appropriate, including XDS. Users include radiologists, clinicians and PACS administrators. Typical scenarios when using the application are: mobile image access by a radiologist and bed-side presentation of medical images to patients by clinicians. The PACS administrators can control important functionalities of the system. The application is also used outside of clinical settings. Based on our observations, a notebook or PC is preferred at home whereas the small application on a tablet (or smart phone) is the preferred device on the move.

The general feedback of the users has been very positive. All comments and users' requirements are systematically collected, evaluated and considered for the next release. Four releases have been issued during the last year.

Conclusion

A prerequisite for the introduction of mobile radiological devices is that the appropriate infrastructure has been established. At least, UMTS (3G) is recommended for the network outside the hospital, WLAN should be available inside the clinic. Beside these technical requirements, the hospital has to organize such networks and also the security infrastructure to protect the internal systems and patient data. This proves to be a real challenge for the IT department and is often underestimated by medical users who bring their private equipment and want to use it for professional medical application, maybe with a freeware radiological viewer which stores medical patient data on the private device. Thus, from our experience IT departments are hesitant when medical doctors approach them for mobile radiological applications and devices.

Many prototypes and Apps have been developed suitable to display DICOM images on mobile devices. It has been proven that performance and display capabilities of modern tablet PCs are sufficient for this kind of application. However, the technical feasibility of the mentioned aspects alone is not sufficient. The introduction of mobile applications needs to be planned and executed such as other projects for clinical application requiring time and resources. Many aspects have to be taken into account, such as network infrastructure, hardware devices, integration with other information systems, security and data privacy.

The concept of a zero footprint application is an important system feature as no software has to be installed on the mobile devices. This is extremely helpful for the IT personnel and warrants low maintenance. The advantages of having no data stored on the devices, generally encrypted communication and other implemented security measures allow for a high degree of data security and privacy.

Considering the fast technological progress during the past 10 years, the time has come for mobile radiological applications to meet the demands of an increasingly mobile medical community. Medical and technical users as well as patients will profit from the flexibility and availability of radiological information anytime, anywhere.

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