(IPI) Image Processing & Informatics Laboratory

Department of Radiology
Staff & Collaborators

2005 RSNA
Presentations & Scientific Exhibits

November 27 – December 2, 2005
McCormick Place, Chicago

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*Sun thru Fri 8:00AM thru 5:00pm*

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Use of Fat Saturated Spoiled Gradient Echo Recalled Sequences in Magnetic Resonance Imaging of Spine

Tao Chan, MBCHB, Hong Kong ● Kwok Chun, Cheng, BS ● Chiu Man Lee, MBBS ● Ka Fai Ma, MBBS ● Man Chiu AuYeung, MBB

PURPOSE
To evaluate and validate the use of fat saturated spoiled gradient echo recalled sequences for contrast enhanced magnetic resonance imaging of spine.

METHOD AND MATERIALS
Ten consecutive patients referred for contrast enhanced magnetic resonance imaging (MRI) of spine were included in this prospective study. Different regions of spine including cervical (2), thoracic (6), and lumbar (5) have been studied. All the examinations were performed on a 1.5T imager. Post Gadolinium T1 weighted images were obtained using spoiled gradient echo recalled (SPGR) and spin echo (SE) sequences, both with fat saturation. Tissue contrast and contrast to noise ratios were calculated from region of interest measurements. The sequences were also compared against each other by three radiologists, with regard to their clarity in depiction of anatomic details and pathology.

RESULTS
Average contrast ratios between cord/CSF and marrow/CSF were significantly higher in the SPGR FS images compared with the SE images (p<0.05). Average contrast to noise ratios between cord/CSF, marrow/CSF, and cord/marrow in the SPGR images are higher than those in the SE images(p<0.001). In subjective evaluations by consensus amongst three radiologists, the SPGR images are considered superior in 6 cases (60 %), similar in 4 cases (40 %), and none as inferior comparing against their SE counterparts in depiction of anatomic details. Concerning visualization of pathology in the 8 patients with identifiable lesions, the SPGR are considered superior in 4 cases (50%), similar in 3 cases (37.5%), and inferior in 1 case (12.5%). The SPGR protocol (including sagittal and axial sections) took an average of 3 min 45 sec to perform, which is far less than the mean time of 7 min 16 sec needed for the SE images.

CONCLUSION
Despite the much shorter time needed for image acquisition, post-gadolinium SPGR images fare better than the corresponding SE images, in terms of both objectives.

A Workflow Study from Results Obtained by a Patient Tracking and Biometric Verification System in a Clinical Environment

Bing Guo, MD, Marina Del Rey ● Jorge Document, BS ● Brent Liu, PhD ● Han Huang, DSc ● Edward Grant, MD, Los Angeles ● Rasu Shrestha, MD

PURPOSE
Patient workflow involves complex processes which require interdisciplinary teamwork among registration clerks, technologists, and physicians. In an effort to improve and optimize workflow processes, a workflow study was conducted focused on areas where mis-identification and extensive waiting times occur for the patient undergoing a radiological examination. To capture this data, we implemented a novel location tracking and verification system using Wi-Fi and Facial Biometrics Technology at an outpatient imaging facility, Healthcare Consultation Center 2 (HCC2) of USC.
METHOD AND MATERIALS
The patient workflow study was first collected via an observation period at HCC2. Each modality type workflow was observed (e.g., CT, MR, CR, US) including any interaction with the integrated HIS/RIS/PACS/VR (voice recognition) system at HCC2. From this study, baseline measurements were collected such as productivity, which was measured as the rate of patient throughput from normalized timing studies of a given typical workweek. The overall length of time for service was calculated from the time when the patient was registered in the RIS to the time that the image is available on the PACS. Once the baseline workflow study was complete, a location tracking and verification system was implemented. Data from the same parameters mentioned above were collected and compared and any interesting observations were documented.

RESULTS
Based on the comparison of the baseline workflow measurements and the measurements collected once the location tracking and verification system was implemented, numerous benefits were achieved: 1) The workflow processes of patients at HCC2 were streamlined and optimized reducing overall patient procedure time; 2) Unnecessary patient waiting times were reduced; 3) Improvement in overall productivity based on patient throughput; and 4) Mis-identification of patients undergoing a radiological procedure was virtually eliminated.

CONCLUSION
The workflow study shows that by implementing a location tracking and verification system for patients and clinical staff, an outpatient imaging facility can reap the benefits of improving workflow efficiency, productivity, and accuracy.

CODE: LPH14-01
SESSION: Radiology Informatics (Practice Management)

DATE: Tuesday, November 29 2005
TIME: 12:15 PM - 12:25 PM
LOCATION: Theater 7B

Cost Comparison of Patient Tracking Technologies for an Outpatient Radiology Center

Nelson King, PhD, Beirut Lebanon ● Bing Guo, MD ● Jorge Documet, BS ● Brent Liu, PhD ● Han Huang, DSc

PURPOSE
Tracking of patients in a clinical setting is more than finding patient location in a busy facility. Patient location can be linked to workflow which enables verification of patient identity, controlling access to restricted areas, and improved efficiency by quantifying time spent at each location. Two-dimensional (2D) tracking of patients in real-time is a necessity when patient location is to be integrated with the clinical workflow. Most approaches require each patient tag to be within range of multiple sensor devices. However, radiology sites require shielding for modalities including CR/DR, CT, MR, and PET which blocks the propagation of signals from the tag to a sensor increasing the number of sensors required. A cost comparison of three technological choices for a 2D tracking system in a 13,000 square foot outpatient radiology center is described.

METHOD AND MATERIALS
Numerous location tracking products applicable to a clinical setting have reached the market. Passive RFID has received the most publicity (e.g., Walmart) but impractical for 2D patient tracking due to limited signal strength of the tag. Other technologies are active RFID, many variants of active wireless and infrared. Cost estimates for three technological approaches were made for a patient location module integrated with a clinical workflow system based on active RFID, passive RFID, and wireless 802.11 b/g using radio fingerprinting.

RESULTS
Our clinical site might require four to six sensor devices for tracking patient location without shielding but 20 or more with shielded rooms. A wireless 802.11 b/g product based on signal strength measurements was the clear choice based on costs. A wireless access point is an inexpensive sensor device compared to proprietary devices of other tracking technologies. The study also found that the annual cost of re-usable active tags worn by patients was less expensive than disposable tags. While 100 times more than an active tag, this center would require 25,000 disposable tags annually but only 50 re-usable tags.

CONCLUSION
Cost drivers in a patient tracking system are choice of location technology, type of tag, and placement of sensors in a shielded facility.
Carpal Bone Segmentation and Features Analysis in Bone Age Assessment of Children

Aifeng Zhang, MS, Marina Del Rey • Arkadiusz Gertych, PhD • Brent Liu, PhD • Han Huang, DSc • Sylwia Kurkowska-Pospiech, PhD, Poland

PURPOSE
A computer-aided diagnosis (CAD) method has been developed based on features extracted from epiphyseal regions of interest (ROI), which provides accurate bone age assessment of children 12 to 18 of age. For children below 12 of age, the features of carpal bone ROI are required to achieve similar degree of accuracy. Past work on carpal bones segmentation has been done using dynamic thresholding. However, due to various stages of carpal bones development and the limitation of the segmentation algorithm itself, feature analysis of carpal bones has not been successful implemented. The goals of this study are: 1) To implement active contour model (snakes) to segment the carpal bones and extract pertinent features, 2) To refine the feature space using the data mining technique, 3) To combine the features from both epiphyseal and carpal ROIs for bone age assessment.

METHOD AND MATERIALS
The preprocessing of the hand image was preformed to automatically locate carpal bone ROI. Before an active contour model was applied to segment out carpal bones, prior knowledge about the centers of the bones was needed. The Gibbs random field procedure to locate the center of each carpal bone was developed. The number, size and separation features of all carpal bones were extracted. A feature selection procedure determined the most important features while eliminated the redundant ones. This reduced feature space was used to assess the bone age. The separation of carpal bones was useful for bone age assessment of children 0-9 of age and the amount of bone overlapping for children 9-12.

RESULTS
The new method was tested initially on 30 cases and is being applied to over 500 cases in our collection. Size and shape features of each carpal bone were extracted from each image successfully and applied to bone age assessment.

CONCLUSION
This research describes an image segmentation method on carpal ROI by active contour model with adaptive parameters. Preliminary results show that the accuracy of bone age assessment of children 0-12 of age is improved with the inclusion of carpal ROI, especially when the epiphyseal ROI analysis originally had failed.
head injury or neurological symptoms. We have developed a computer aided diagnosis (CAD) system that can identify even minute amount of intraaxial or extraaxial hemorrhage, as small as 3mm across on conventional axial sections of CT brain. Candidate high density intracranial contents are extracted and mapped to a standard coordinate system. Their morphological and positional features are evaluated by fuzzy classifiers, based on anatomical and pathological knowledge. Our system achieves an accuracy of 92% in the initial 64 test cases, which include cases of clinically proven but inconspicuous intracranial hemorrhage. We are in the process of extending the study to a 300 case sample for statistical evaluation.

CODE: 9903 PDA-i

PDA Mobile Application for Distribution of Medical Images and Patient / Staff Tracking / Verification

Jorge Documet, BS, Marina Del Rey • Brent Liu, PhD • Bing Guo, MD • Nelson King, PhD, Beirut Lebanon • Luis Documet, Santa Monica

LEARNING OBJECTIVES
1. Demonstrate the capability to manage and distribute PACS image data from a PDA with a wireless network connection.
2. Integrate a patient/staff tracking/verification capability to the application.
3. Demonstrate a hands-on experience of patient/staff tracking/verification.

ABSTRACT
Last year an application to perform wireless remote control of PACS image distribution utilizing a Personal Digital Assistant (PDA) was presented. It was shown that this application is a powerful tool to distribute PACS exam data to diagnostic/review workstations, a PACS web server, a teleradiology system and a CD burning device. The ease-of-use of the application simplifies PACS exams distribution by allowing the user to perform remote control distribution from the PDA, making it a very attractive option especially when dealing with many DICOM nodes added to a clinical environment with PACS. In addition, a new management feature that allows the hospital personnel to obtain precise information about patient/staff location and verification/identification through biometrics has been integrated to the PDA application. This new feature will help to reduce unnecessary patient mis-identification and waiting time during a Radiology procedure.

CODE: 9129 DS-i

A CAD System for Diagnosis of Normal Pressure Hydrocephalus Based on Brain MR Images

Arkadiusz Gertych, PhD, Marina Del Rey • Brent Liu, PhD • Chi-Shing Zee, MD, Los Angeles • Tao Chan, MBCHB Hong Kong

LEARNING OBJECTIVES
1. To identify the imaging features of NPH relevant to CAD.
2. Learn about image processing analysis of intracranial volume structures.
3. Study collected control group cases and pathological cases of NPH.

ABSTRACT
Normal pressure hydrocephalus (NPH) is an uncommon but potentially treatable cause of dementia. A CAD tool for automatically measuring compartments based on processing of MR images and making volumetric measurements of cerebral spinal fluid containing spaces (CSFCS) is developed. T1/2-weighted 5mm axial MR sections are acquired by a 1.5T Scanner and used as tool input. A 3D reconstruction of the ventricular system is followed by hybrid non-interactive image segmentation procedure including random fields and active contours techniques. Standardized parameters reflecting hydrocephalus and ratios between CSFCS in 17 diagnosed NPH cases are evaluated for comparison to a reference dataset of 75 normal adults. Appropriate cases are available for display. The whole process for one series of MR images takes approximately 5 min. to complete on a P4 2 GHz PC. CSFCS and relative ventricular volume ratios are confirmed to be useful parameters in CAD assessment of NPH.
Patient Tracking and Facial Biometrics Integrated in a Clinical Environment for HIPAA Security Compliance

Bing Guo, MD, Marina Del Rey • Jorge Documet, BS • Brent Liu, PhD • Han Huang, DSc • Nelson King, PhD, Beirut Lebanon • Edward Grant, MD, Los Angeles

LEARNING OBJECTIVES
1) Learn about real-time, high accuracy tracking systems, 2) Learn about ID Verification through Facial Biometrics, 3) Implementation pitfalls and challenges to the system integration, and 4) How to create a security zone in a clinical environment utilizing the proposed system integration to manage and locate patients and staff.

ABSTRACT
The purpose of this exhibit is to demonstrate a novel system for a clinical environment using wireless and facial biometric technology to monitor and automatically identify staff and patients in order to streamline the patient workflow, protect against erroneous examinations and create a security zone to prevent and audit unauthorized access to patient healthcare data under the HIPAA mandate. The USC Department of Radiology, Healthcare Consultation Center 2 (HCC2), which just implemented a fully digital environment with integrated HIS/RIS/PACS/VR (Voice Recognition) was a good initial first clinical test environment. The system is an integration of two components: a wireless real-time tag locating system to locate patients and staff and a Biometrics system to verify the patient and staff. Based on the workflow and user needs, a database with Graphical User Interface (GUI) was developed which allows users to extract real-time location information and identity verification.

A Treatment-oriented Open Architecture ePR-based Radiotherapy Information System

Maria Law, DSc, Hong Kong • Lawrence Chan, PhD • Fuk Hay • Tang, PhD • Han Huang, DSc, Marina Del Rey

LEARNING OBJECTIVES
1. The use of DICOM-RT standard for integration of radiotherapy patient image and treatment information 2. The incorporation of intelligence into the information system for monitoring progress of treatment in oncology patients

ABSTRACT
This exhibit demonstrates an open architecture DICOM-RT based radiotherapy information system. The prototype consists of a DICOM-RT Archive Server used for storage of DICOM-RT based radiotherapy information such as images, treatment plans and records and a web client/server for information distribution. The system is designed according to ePR (electronic patient record) architecture in that each patient's information is grouped under the patient's identification number. Intelligence such as comparison of a patient's pre- and post-treatment images using computer-assisted detection method can be integrated into the system. This will enable the determination of the response of the tumor towards the radiation treatment or the associated chemotherapy. Nasopharyngeal carcinoma and brain tumors patients under radiation treatment are used for demonstration.

Computer-aided Diagnosis Workstation for Detection and Volumetric Measurement of Demyelination Plaques in Multiple Sclerosis

Ewa Pietka, D.Sc., Gliwice • Jacek Kawa, MS • Dominik Spinczyk, MS • Marek Konopka, MD

LEARNING OBJECTIVES
(1) Study the design of the computer aided diagnosis system, (2) review the MS cases included in the data base, (3) review the image analysis methodology able to detect and measure the demyelination plaques, (4) review the image analysis methodology able to remove the skull and perform the 3D rendering which implements the OpenGL technology.
ABSTRACT
Multiple sclerosis (MS) is a chronic disabling disease of the central nervous system. The total estimated MS population in the United States is approximately 300,000. MR imaging is a common examination tool used to track and predict the progression of MS once the presence of the disease has been detected. The plaque segmentation is performed by implementing the kernel functions in the c-means clustering technique. The type of functions depends on the MR acquisition technique implemented at the examination procedure. Once the spots are detected, a 3D rendering technique is implemented to view the demyelination areas. It includes also an active contour procedure which removes the skull. A set of 100 studies has been successfully tested. A graphical user interface shows the volumes of each plaque and sums up the total. If a false positive occurs in the image, the user is able to remove it.

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CODE: 9607 PACS-i

Novel Architecture of HIPAA Compliant Automatic Monitoring System for RIS-integrated PACS Operation

Jianguo Zhang, PhD, Shanghai ● Xiaomeng Chen ● Jianyong Sun, PhD ● Yuanyuan Yang, MS ● Jin Jin ● Han Huang, DSc

LEARNING OBJECTIVES
1. Novel architecture of AMS monitoring RIS-integrated PACS with DICOM defined auditing trail mechanism; 2. Monitor and control security status of the entire PACS operation in real time from anywhere; 3. Track patient and image data flow and RIS work flow automatically; 4. Identify and respond any failure in any PACS process.

ABSTRACT
RIS-integrated PACS (PACS) is a large system consisting of many components. Chances of any of these components fail at a given period of time are high. Also, the HIPAA requires security services being implemented in healthcare information systems, and DIOMC defines a mechanism to collect the Auditing Trail Messages generated by applications to facilitate detection of improper creation, access, modification and deletion of Protected Health Information. For this reason, we present a HIPAA compliant automatic monitoring system (AMS) with a novel architecture to monitor PACS operation. The AMS consists of two parts: monitoring agents and a Monitor Server. Monitoring agents connect to all services in each PACS component. The Monitor Server tracks the status of individual component, and verifies image/reports being used in accordance with the healthcare provider’s security requirements. The PACS manager can monitor the PACS operation from anywhere with AMS.

EDUCATIONAL EXHIBITS

CODE: 2379CE-e

An Illustrative Application of CAD in Neuroradiology: Intelligent Automated Detection System of Intracranial Hemorrhage

Tao Chan, MBCHB, Hong Kong ● Han Huang, DSC, Marina Del Rey

LEARNING OBJECTIVES
1. To recognize that CAD is valuable for diagnosis of acute intracranial hemorrhage. 2. To illustrate how various CT artefacts can hamper diagnosis of intracranial hemorrhage. 3. To learn some basic principles and techniques of CAD.

ABSTRACT
Application of computer aided diagnosis (CAD) in neuroradiology has not been well established. Here we introduce a CAD system that detects acute intracranial hemorrhage on CT. This everyday task remains elusive to inexperienced clinicians and computer alike. CT numbers of intracranial hematomas significantly overlap those of brain parenchyma. Artefacts like partial volume averaging and beam hardening further complicate the problem by obscuring or simulating small blood clots. Basic concepts and techniques that enable CAD for handling such difficulties, including artificial intelligence and use of a priori knowledge, will be discussed. Results on the initial 64 test cases were promising (sensitivity 96%, specificity 90%). It only missed one out of the six cases of hemorrhage that were rated as difficult by experienced radiologists. A large database containing various acute intracranial hemorrhage cases is being collected to test the robustness of the system.
Data Mining for Average Images in a Large-scale Digital Hand Atlas

Aifeng Zhang, MS, Marina Del Rey ● Arkadiusz Gertych, PhD ● Brent Liu, PhD ● Han Huang, DSc ● Sylwia Kurkowska-Pospiech, PhD, Poland

LEARNING OBJECTIVES
1) Learn data mining methodology and its applications, 2) Study feature selection procedure in a large-scale CAD medical application, 3) Study the average feature vector matching method, 4) Understand the significance of objectively selected average images in a digital hand atlas.

ABSTRACT
A digital hand atlas contains hand radiographs of 1,152 normally developed children. For each image, 11 bony features were extracted from each of 6 regions of interest. A data mining procedure was developed to objectively select the average image which is the best representative of skeletal maturity for each age group. A feature selection procedure was performed to reduce the feature dimension from the initial 66-dimension feature space and determine the weight vector which indicates the discriminative power of the feature. To find the average image objectively, the data of an image representation in the features domain was mined. This was done by an average feature vector (AFV) matching based on the weight vector. The closest match in terms of Euclidean distance to the AFV among all the images in a specific age group was chosen as the average image. The average images, functioning as teaching files, are available for radiologists to evaluate in clinical practice.

Integration of Lossless Digital Signature Embedding (LDSE) and Patient Tracking and Biometric Verification (PTV) Logs with a HIPAA Compliant Auditing System

Zheng Zhou, Ph.D., Marina Del Rey ● Brent Liu, PhD ● Han Huang, DSc ● Bing Guo, MD ● Jorge Documet, BS ● Nelson King PhD, Beirut Lebanon

LEARNING OBJECTIVES
1. Learn HIPAA Security Rules, 2. Learn how to generate HIPAA audit trails of image data access on demand through the HCAS, 3. Gain knowledge on image integrity protection through LDSE methods, 4. Gain knowledge how to track and verify patients in clinical environment through patient tracking methods.

ABSTRACT
HIPAA Security Rules require healthcare providers to protect the privacy and integrity of health data and demonstrate examples of mechanisms that can be used to accomplish this task. Also required is the ability to provide on demand audit trails of data access for a specific patient. In 2004 RSNA, a HIPAA Compliant Auditing system (HCAS) for facilitating the generation of HIPAA compliant audit trails on image data access in PACS was presented. This year, two new components are integrated with HCAS: LDSE for image integrity assurance, and PTV for clinical systems security access and identification verification. PTV creates a security zone to locate patients in clinical environment and verify a user with facial biometrics during access to a clinical system. Log data from LDSE and PTV is captured and added to the HCAS. The integration of the LDSE and PTV with HCAS can provide additional information for image data access audit trails and assure image integrity and data access privacy.